A COMPREHENSIVE REVIEW
OF SCIENCE-BASED METHODS AND PROCESSES
OF THE
WILDLIFE AND PARKS DIVISIONS
OF THE
TEXAS PARKS AND WILDLIFE DEPARTMENT

A Report to the Executive Director of Texas Parks and Wildlife Department

By the

Wildlife Management Institute

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EXECUTIVE SUMMARY

The Wildlife Management Institute (WMI) was chosen in late 2003 as the organization to evaluate science-based processes within Texas Parks and Wildlife Department (TPWD) Wildlife and Parks Divisions. WMI was asked to conduct a review to determine 1) whether the agency is using the best science available for monitoring and managing wildlife resources in Texas and 2) whether there are critical data gaps to address that will improve the ability of the agency to manage wildlife resources in Texas.

There were 4 basic objectives for the review as follows:

Objective 1: Obtain, review, and evaluate the scientific basis and application of all key activities and methodologies that are employed to obtain scientific information for management decisions by TPWD.

Objective 2: Ascertain opinions and insights of selected TPWD staff on use of, and gaps in, science available for monitoring and managing wildlife resources to determine how well science is integrated into management decision processes.

Objective 3: Evaluate existing TPWD processes for on-going evaluation of their science-based activities and propose modifications as needed to improve this evaluation and allow for the most effective use of data in management decision-making.

Objective 4: Summarize findings and make recommendations based on those findings.

The review was conducted in chronological order of the 4 objectives, from April 1, 2004 to January 31, 2005. Information for objective 1 was first obtained from selected oral interviews of agency leadership, staff members from the Austin headquarters, and from regional and field employees. Next, following oral interviews, WMI identified 10 program staff members interviewed previously to fill out a questionnaire on 25 specific methodologies covering several wildlife species. This questionnaire requested detailed written information on basis of each method, statistical and sampling design, how the method is implemented in the field, and data acquisition, analysis, interpretation and use. Results of these surveys were used to supplement information obtained from the oral interviews.

Objective 2 was addressed with the development and mailing of a 30-question written survey to 188 selected employees within the Wildlife Division. Employees receiving a survey represented job titles of Program Specialist VI and below in field and headquarters positions, which deal with science-based activities on a continual basis. Specifically, the position classifications were Managers IIs, Program Specialists III-VI, and Natural Resource Scientists III-V. Not all grades for each position were represented in the survey.

The questionnaire format was the basic Likert-scale with 5 categories of response (strongly agree, agree, disagree, strongly disagree, and no opinion) divided into 5 sections: data gathering, summary, and analysis procedures, scientific basis of land management decisions, employee training, culturing and rewarding of scientists, integration of science into the management decision process of the agency and additional written comments the respondent felt important to help WMI evaluate science activities within the agency. Of 188 questionnaires mailed to Wildlife Division employees, a total of 145 were returned to WMI. Individual respondents were not identified and were guaranteed all responses were confidential. No follow-up surveys to non-respondents were done.

To ascertain opinions of Parks Division employees, WMI developed a questionnaire with 27 questions designed to be relevant to science issues in the state parks. Twenty-four employees received questionnaires, including state park managers, regional resource coordinators and regional directors. Eighteen surveys were completed and returned to WMI. No follow-up surveys to non-respondents were done.

During the course of this review, we identified a number of broad issues or "overarching themes" that needed to be addressed for many, if not most, of the methodologies examined. They included: determination of data need, consideration of scale, sampling design, efforts to reduce bias and improve methodology, distance sampling, written protocols and standardized data reporting forms, training, use of statistical parameters to describe data, reporting limitations of data, data storage, coordination, supervision and standardization, and harvest surveys.

Numerous individual inventory methods were evaluated in depth with recommendations for improvement made for many. A common criticism was the absence of a sound statistical design for allocation of sampling efforts and lack of statistical analyses for the data obtained. One of the major findings was that the type and number of surveys conducted needs to be driven more closely by management objectives, and that greater attention should be paid to the quality, rather than the quantity, of the surveys conducted.

WMI found repeated themes in staff member descriptions of problems associated with harvest surveys. The first problem was the necessary constraint of the sampling universe to those hunters who actually intend to hunt for the species being sampled. Another common overarching problem with harvest surveys identified by TPWD staff members was declining response rate. Regardless of the reason for the decline, low response rates are indicative of vulnerability in making scientifically sound estimates.

Among TPWD employees, WMI found broad interest and participation in efforts to improve the science foundation of agency operations. Employees generally demonstrated a solid understanding of the scientific process and a commitment to practice sound science. Employees commonly are seeking opportunities to learn more, to receive better training, and/or to gain additional access to science materials. Employees clearly appreciate agency programs to provide training, access and outside consultation on science, and they requested agency leaders increase availability of these efforts wherever possible.

Many employees also expressed concern about the design of studies or the reliability of interpretations that they were asked to make regarding data collected. Unique to the Parks Division, we noted concerns about the absence of natural resource stewardship plans, and where plans were in place, the slow implementation of plan recommendations. A need was found for all science applications in the agency to be better coordinated and elevated in key decision-making processes.

The third objective of the WMI review was to evaluate existing TPWD processes for on-going evaluation of their science-based activities and propose modifications as needed to improve this evaluation and allow for the most effective use of data in management decision-making. Key science processes identified included: strategic planning, operational planning, research selection process, program staff, field supervisory leaders, management, research and inventory on WMAs and state parks, statistical services, hunting regulation changes, electronic databases, and ad hoc research and science. WMI presented a schematic diagram representing 1 potential organizational approach aimed at improving the coordination or management of science activities within the agency was presented. A key recommendation was that a Science Standards Committee made up by program leaders formally conduct ongoing evaluation of agency science standards and processes and work to make sure science training for employees is a priority.

TPWD clearly understands that agency actions must be grounded in science, and the agency has made it a priority to obtain an independent science review of the agency's programs. However, the review concluded that TPWD must now determine whether there is a need for the type and scale of data currently being collected, and whether that need is sufficiently important to require reliable information. Collection of reliable information will require the agency to do a better job of designing sampling strategies prior to data collection and making greater use of other science-based methods to improve accuracy and precision of estimates. The ability to retrieve, use and understand information gathered in these inventories depends heavily on a well-supported home for electronic data storage.

INTRODUCTION

On July 24, 2003, Texas Parks and Wildlife Department (TPWD) leadership contacted the President of the Wildlife Management Institute (WMI) inquiring if WMI was interested in conducting a comprehensive review of all science and management-based processes used by the Wildlife and Parks Divisions of TPWD to ensure the quality of management of Texas' natural resources.

Following development of a formal proposal, WMI was chosen in late 2003 as the organization to evaluate selected science-based processes within TPWD Wildlife and Parks Divisions. WMI was asked to conduct a review to determine 1) whether the agency is using the best science available for monitoring and managing wildlife resources in Texas and 2) whether there are critical data gaps to address that will improve the ability of the agency to manage wildlife and habitat resources in Texas. WMI conducted a previous study for TPWD in 1988, when organization and administration of the agency were reviewed.

Basis for the agency to conduct scientific activities is provided in several chapters of the Texas Parks and Wildlife Code including 1) Subchapter C. SPECIAL ACCOUNTS 11.033 (8), which states that the Game, Fish, and Water Safety Account may be used for "research, management, and protection of the fish and wildlife resources of this state, including alligators and furbearing animals;" 2) Subchapter D. SPECIAL NONGAME AND ENDANGERED SPECIES CONSERVATION ACCOUNT 11.054 (2) and (4), which state that the Special Nongame and Endangered Species Conservation Account may be used for "scientific investigation and survey of nongame and endangered species for better protection of conservation" and "research and management of nongame and endangered species;" 3) Subchapter H. LAND AND WATER RESOURCES CONSERVATION PLAN 11.103(a), which states that "the department shall inventory all land and water associated with historical, natural, recreational, and wildlife resources in this state that are owned by governmental entities or nonprofit entities that offer access to the land or water to the public;" 4) Subchapter B. REGULATIONS GOVERNING PARKS AND OTHER RECREATIONAL AREAS 13.101 and 13.102, which state "the commission may promulgate regulations governing the health, safety, and protection of persons and property in state parks, historic sites, scientific areas, or forts under the control of the department, including public water within those areas' and ' the regulations may govern the conservation, preservation, and use of state property whether natural features or constructed facilities;" 5) Subchapter B. WHITE-WINGED DOVE STAMPS 43.014 (b), which states "white-winged dove stamp sale receipts may be spent only for research and management for the protection of white-winged dove and ..;" 6) Subchapter J. TURKEY STAMP 45.254 (b), which states "turkey stamp sale net receipts may be spent only for research, management, and protection of turkeys and ..;" 7) Subchapter K. WATERFOWL STAMP 43.305 (b), which states "waterfowl stamp sale net receipts may be spent only for research, management, and protection of waterfowl and ..;" and 8) Subchapter C. REGULATORY DUTIES 61.051 (a), which states "The department shall conduct scientific studies and investigations of all species of game animals, game birds, and aquatic animal life to determine supply, economic value, environments, breeding habits, sex ratios, and effects of any factors or conditions causing increases or decreases in supply."

For purposes of this review, WMI used the following basic attributes of science and data gathering as we evaluated the various methodologies and processes within the agency. When studying natural systems (biological populations) truth or absolute facts about that system is hardly ever known. Therefore, to study natural systems, some element of sampling is needed to extract information from the biological population under study to which the investigator wants to make inferences. It is hoped that the sample extracted truly represents the biological population under study. How well this is done is the primary element of this review.

There are 2 basic descriptors of data—accuracy and precision. Both help interpret "truth". Accuracy refers to presence or absence of bias in the sample. Precision is a measure of variability of the data. Obviously, the most desirable situation is when the outcome is both accurate and precise.

The only measure of the "goodness" of the data resulting from most sampling efforts is a measure of variability or precision of those data. Accuracy or truth is rarely known. The fields of mathematics and statistics have provided tools to describe and quantify the measure of variance and to help interpret when and if bias exists. These tools help scientists evaluate "goodness" of their data.

There are basic assumptions and requirements about how data are obtained that must be followed before it is legitimate to apply those tools. If those assumptions are not met and appropriate measures of variance are not calculated, it becomes difficult, if not impossible, to judge objectively relative merits of data presented. Without variance measures, only subjective evaluations of data can be made. However, only having a measure of precision without a measure of accuracy (bias) can be very misleading. Highly precise, but inaccurate measures are dangerous if the observer does not understand the effects of existing biases in methodologies employed.

Without appropriate attention to bias, conclusions can be off target and the user of the data faces the risks of inappropriate decision-making. Even though it is difficult to assess "truth" in most sampling problems, there are approaches that can and should be taken to improve likelihood of accurate results. It is first important to identify sources, magnitude, and direction of the bias. Bias can result in either under or over estimates of the parameter under study. For instance, in estimating numbers of animals it is well known that most estimates derived via observers are under estimates. This results because observers tend to miss more animals than they double count. Degree or extent of bias is complex as it has also been widely observed that number of animals missed varies among observers. Thus, it is important that efforts be made to elucidate source, direction, and extent of bias of the method being evaluated.

The most direct way to determine bias in animal detection is to have known number of animals in a controlled environment (e.g., large pasture) and then conduct a series of inventories employing the method of choice to determine number of animals detected. This produces a sighting or detection value that can be used as a correction factor for measures made by those observers where accuracy is unknown. Obviously, other causes of bias beyond detection exist in inventory methodologies and it is important for observers to recognize these biases exist, and when possible take steps to learn the extent and direction of those biases and then correct as necessary. One other approach to assess bias is to perform a completely independent and separate measure using a different methodology and then compare results. Unfortunately, if the 2 methods differ, it is not possible to determine which is the most accurate. If it is not practical to estimate sources, direction and extent of bias in a method, then efforts should be made to use alternative methods that provide meaningful parameter estimates, measures of their precision, and other forms of reliable information.

It is these basic tenets and premises of science and data gathering that WMI considered in its evaluation of the relative soundness or validity of data obtained from various inventory methodologies employed by TPWD.

REVIEW METHODS

WMI in consultation with TPWD developed 4 basic objectives for the review:

Objective 1: Obtain, review, and evaluate the scientific basis and application of all key activities and methodologies that are employed to obtain scientific information for management decisions by TPWD.

Objective 2: Ascertain opinions and insights of selected TPWD staff on use of, and gaps in, science available for monitoring and managing wildlife resources to determine how well science is integrated into management decision processes.

Objective 3: Evaluate existing TPWD processes for on-going evaluation of their science-based activities and propose modifications as needed to improve this evaluation and allow for the most effective use of data in management decision-making.

Objective 4: Summarize findings and make recommendations based on those findings.

The review was conducted in chronological order of the 4 objectives. Objectives 1 and 2 were accomplished by the following steps: All pertinent written documents, including strategic plans, operation plans, training manuals, method protocols, Federal Aid reports, brochures, and other materials dealing with science activities in the agency were assembled and provided to WMI. These documents provided a broad overview of science activities in the agency and identified responsible staff members.

After review of the documents, WMI interviewed approximately 21 staff members during the week of April 19, 2004. Employees from both the Wildlife and Parks Divisions were interviewed, but central focus of the interviews was placed on Wildlife Division Program staff members in the headquarters office. Purposes of the Phase I interviews were 3-fold: 1) meet key staff members and identify specific methodologies to be evaluated, 2) determine staff members responsible for further information on each method and 3) learn about science activities within the agency. Following these interviews requests for additional documents identified in the oral interviews were forwarded to appropriate contacts.

The second phase of interviews occurred after all documents had been read and the first set of interviews summarized. Phase II interviews focused on Area Managers, Technical Guidance Biologists, District Biologists, and Wildlife Diversity Biologists. In addition, selected staff members from the quail, turkey, and big game programs were interviewed or re-interviewed. Main purpose was to fill in knowledge gaps identified from Phase I interviews and to broaden understanding of field application of various methods. Twenty staff members were interviewed.

Following the second round of interviews, WMI identified 10 program staff members interviewed previously to fill out a questionnaire on 25 specific methodologies covering several wildlife species (Appendix A, sent by e-mail). This questionnaire requested detailed written information on basis of each method, including key literature citations. Information was requested on statistical and sampling design, how the method is implemented in the field, including identification of written protocols and training necessary for implementation. Information also was requested on data acquisition, analysis, interpretation and use. Finally information on how results are documented and reported was requested. Questionnaires were requested to be completed by July 15. Results of these surveys were used to supplement information obtained from the oral interviews.

The next step was development and mailing of a 30-question written survey to 188 selected employees within the Wildlife Division (Appendix B). Employees receiving a survey represented job titles of Program Specialist VI and below in field and headquarters positions, which deal with science-based activities on a continual basis. Specifically, the position classifications were Managers IIs, Program Specialists III-VI, and Natural Resource Scientists III-V. Not all grades for each position were represented in the survey. Employees were asked to indicate their duty assignment as either field or headquarters and to identify their position title and classification.

The questionnaire format was the basic Likert-scale with 5 categories of response (strongly agree, agree, disagree, strongly disagree, and no opinion) divided into 5 sections (Appendix B). Strongly agree responses were recorded as 1 and no opinion responses were assigned a 5. The 5 sections of the survey focused on data gathering, summary, and analysis procedures, scientific basis of land management decisions, employee training, culturing and rewarding of scientists, integration of science into the management decision process of the agency and finally any additional written comments the respondent felt important to help WMI evaluate science activities within the agency.

A total of 188 questionnaires was delivered via U.S. Postal Service and included a self-addressed and stamped envelope for return to WMI. Individual respondents were not identified and were guaranteed all responses were confidential. The survey was mailed on July 14 and respondents were asked to complete it by August 13. A total of 145 surveys were returned. No follow-up surveys to non-respondents were done.

To ascertain opinions of Parks Division employees, WMI developed a questionnaire with 27 questions designed to be relevant to science issues in the state parks (Appendix C). Twenty-four employees received questionnaires, including state park managers, regional resource coordinators and regional directors. The survey was mailed on October 18 and respondents were asked to complete it by November 5. Eighteen surveys were completed and returned to WMI. No follow-up surveys to non-respondents were done.

Statistical analysis of questionnaire responses was conducted within the Statistix software program. The mean response for each question was calculated for the total data set, and for the data set following exclusion of employees who stated no opinion. For the Wildlife Division, analysis of variance tests were conducted to determine if there were differences in mean response between employee's duty station, position or position grade. Because of the small size of the Park Divison's sample, no attempt was made to break down responses by duty station, position, or position grade.

All review activities were coordinated by Wildlife Division Deputy Director Ron George.

FINDINGS

OBJECTIVE 1: REVIEW OF METHODS

Overarching Themes

During the course of this review, we have identified a number of broad issues common to many, if not most, of the methodologies examined. We present these overarching themes as a means of summarizing and highlighting those findings that are repeated frequently in our review of methods.

Determination of data needs: Many of the findings and recommendations of this review are conditioned by a suggestion to determine first whether the type of data being collected are important and necessary for adjusting harvest regulations, providing information to hunters, or other purposes. If TPWD determines that data based on sound science are needed, then we recommend that any weaknesses in current approaches be recognized and corrected by means of a number of measures. The report by the Coordinated Bird Monitoring Working Group (2004) is a useful reference concerning evaluation and monitoring of migratory birds and other species and determination of data needs. Observational data from surveys of appropriate temporal and spatial scale need to evaluate a management objective or action in order to provide the greatest information on how any ecological system works. Critical data gaps are only apparent in the context of the agency's management objectives.

Consideration of scale: One of the first measures that needs to be taken for many of the reviewed methodologies is determination of the scale (i.e., ranch, county, ecoregion) that is appropriate for measurements and needed for management decisions. We caution that sampling designed for statewide or ecoregional scales should not be extrapolated to finer scales, such as counties.

Sampling design: A commonly identified need in this review is implementation of sampling protocols that incorporate sound statistical design and clearly specify sample sizes required to achieve the precision and power needed by decision-makers. We emphasize the need for sampling methods that employ probability theory and make possible valid inferences to biological populations of interest and assessments of precision or accuracy of estimated parameters. Probabilistic sampling strategies include: 1) simple random sampling, 2) stratified random sampling, 3) systematic sampling, and 4) stratified systematic sampling. Our suggestions frequently call for survey efforts to be allocated on the basis of optimum allocation procedures to reduce variance of estimates for the biological population of interest. Taken together, these sampling design recommendations would significantly strengthen results and allow for much stronger data analyses. Greater reliance should be placed on TPWD statisticians for guidance on experimental design and sampling considerations. We recommend further that TPWD place additional research emphasis on addressing the problems of convenience sampling, in which the selection of units from the population is based on easy availability and/or accessibility.

Efforts to address bias and improve methods: WMI found that more attention should be paid to biases inherent in methodologies used by TPWD. Annual collection of data based on a sound sampling design should be accompanied by routine collection of data designed to estimate detection probability and to identify sources of variation. Probability of detection is known to be affected by weather, changing land use patterns and habitat conditions, level of vehicle traffic, reproductive status, season of the year, time of day, observer performance, biological and behavioral aspects of detectability, and a number of other variables. We note the need for greater efforts to estimate detection probabilities for observers and to conduct tests with known numbers of marked animals within a variety of vegetation types to establish sightability values.

In a number of instances, we point out the need for tests designed to ascertain ability of observers to accurately identify or estimate the parameter of interest, such as classification of sex and age cohorts or identification of tracks. We also found repeated cases in which current non-response bias needs to be assessed in harvest and public hunt surveys.

Distance sampling: For many reviewed methodologies we recommend that TPWD seek more robust estimates through use of distance sampling. These techniques make it possible to develop a probability of detection function by observer and to address the effects on detectability of variation in habitat and various biological and behavioral traits. Recommended readings on use of distance sampling are provided in Appendix D.

Written protocols and standardized data reporting forms: Although many methods employed by TPWD use written protocols and standardized data reporting forms, we found other methods for which these materials have not been developed, distributed or used consistently. For these latter methods additional efforts should be made to remove some of the variation associated with observers and counting methodology by requiring and monitoring the use of written protocols and standardized data reporting forms. We also note the need in some instances to ensure that protocols outline details of the method, including procedures for any allowed modifications in sampling. Entire survey teams (new and experienced observers) should be briefed periodically on the protocols.

Training: A common theme identified in this review is the need for increased training to develop more accurate and consistent determinations by observers. We suggest use of videos and photos, marked animals of known sex and age (unknown to the observer), sessions at which multiple observers classify the same animals and compare notes, and annual testing of observers as means of improving training of new and experienced observers.

Use of statistical parameters to describe data: Almost universally we found that greater use should be made of common statistical parameters to describe reported data. While response to our methodology questionnaire indicated that means and regression are used often to describe reported data, we found little evidence of their use in reports and material provided to us. We recommend that no estimate be made and printed without a corresponding confidence interval. If the confidence intervals are larger than the agency can accept, the estimate should not be made.

Reporting limitations of data: Reports presenting data should clearly highlight and inform readers of limitations of the data, especially noting any absence of scientific basis for their acquisition. A forthright statement should accompany any report of results that indicates the scale to which the data apply, the potential sources of bias that could affect the accuracy of the data, the precision of the data (confidence intervals), and the importance of interpreting it cautiously. TPWD must instill the discipline to never report data without the corresponding confidence interval, and to resist reporting of data from scales for which the sampling is inappropriate.

Data storage: Efforts to centralize data storage and facilitate access to data should be expedited.

Coordination, supervision and standardization: Overall, we found a need for better coordination among TPWD science-based activities, increased statistical and scientific supervision in establishment and implementation of experimental designs, and greater standardization of data collection methods and formats.

Harvest surveys: In general, WMI found repeated themes in staff member descriptions of problems associated with harvest surveys. The first problem is the necessary constraint of the sampling universe to those hunters who actually intend to hunt for the species being sampled. Widespread issuance of certain stamps and permits to the public at large is seriously diluting the sampling procedure designed to assess harvest. Some of the estimates are so affected by artificial sampling pools to render them useless to the manager. TPWD has the authority to constrain who receives certain hunting permits. Agency action is needed to correct these problems associated with sample dilution.

The second overarching problem identified by TPWD staff members is declining response rate. Regardless of the reason for the decline, low response rates are indicative of vulnerability in making scientifically sound estimates. Without sound procedures to assess non-response bias, agency decision-makers should not place confidence on estimates produced by a sample with low response rate. TPWD is not alone in this dilemma, and WMI recommends dialogue with other state agencies to evaluate alternative methods.

Spotlight Surveys

Background: Spotlight surveys are a key methodology for estimates of abundance of white-tailed deer, mule deer, and alligators in Texas. In addition, spotlight surveys are used to produce occurrence information for various furbearers and javelina on surveys being conducted for deer.

Peer-reviewed literature citations documenting validity of the method are few. Several agency publications are used as primary citations for basis of the method. Methodology employed in Texas has evolved over time. The fundamental element for the measurements is a strip transect of known width determined by frequent assessments of visibility using a hand held spotlight at night to detect eye shine of individuals. Observers ride in a moving vehicle traveling 7-10 miles per hour. Data are recorded on standard forms or on portable tape recorders to be transformed to data sheets later.

Written protocols exist and are distributed. New observers are mentored by experienced employees and in general, spotlight surveys are relatively rapid and easy to apply (Young et al. 1995).

Analysis: Basic assumptions for the spotlight technique are: 1) animals are evenly distributed; 2) only animals within the calculated visibility are counted; 3) all animals are equally visible; and 4) animals are counted only once (Young et al. 1995). Most of these assumptions are difficult or impossible to achieve. Application of the method involves use of a moving vehicle and land-based applications require presence of a road. Location and characteristics of the road itself introduces additional biases that are difficult to ascertain. A huge limitation of the road-based sample is dependence upon accessible and suitable roads. Water-based applications provide greater opportunity for allocation of randomly based survey lines, and thus offer more potential for producing sound data.

Ability to determine number of animals missed on the survey line is also a limitation, and is a common weakness of many estimators. The widespread and long-term use of this method requires that it be applied with consistent and rigorous attention to details. It is easy for observers to develop their own variations of the methodology and over time application of the method becomes considerably different than originally intended and/or designed. Individual units of the agency need to be diligent in monitoring use of all methodologies, but spotlight counts are especially susceptible to this need.

Spotlight Surveys: White-tailed deer

Background: Spotlight surveys for white-tailed deer were begun during the 1960's and 1970's.   The desire for a rapid and affordable assessment tool for deer led to implementation of the technique throughout the state (Harwell et al. 1979). In 1993, a total of 308 spotlight surveys were conducted for white-tailed deer (Young and Richards 1994). In 2003, 503 spotlight surveys were conducted in the state, with an average of 2.5 routes per county surveyed (Lockwood personal communication). Use of spotlight surveys has increased while use of the Hahn survey lines (walking) has decreased. Data obtained are used for harvest regulation changes.

Survey routes for white-tailed deer were originally 20 miles in length. Cook and Harwel (1979) recommended lengths of 15 miles. That is the standard today. Original survey routes for deer were chosen primarily depending upon accessibility with a goal of having at least 2 per county. Over time some routes have changed because of urban development or other loss of habitat. White-tailed deer spotlight surveys were mostly designed to be summarized at the ecoregion level as opposed to the county level. However, use of the data is common at the county level.

Spotlight surveys for deer are to be made from July 15 to October 15 each year and started 45 minutes to 1 hour after official sunset. Due to time constraints, replicate measurements on individual surveys are not done. Written protocols exist and are followed for the most part. New observers are mentored by experienced employees.

Visibility of the area in which a deer can be observed is calculated either beforehand or during the survey (Young et al. 1995). Observers with hand-held spotlights estimate distance at which a deer can be observed at right angles from the path of the vehicle on both the left and right. Distances are either estimated by the observers or measured by a range finder. Visibility distance estimating procedures have varied from 0.1 to 0.5 miles over time and among ecoregions.

Today, estimates at 0.1 mile are the standard. Once visibility distances are determined, number of square yards on the survey is determined by multiplying length of the survey by the average visibility width to determine number of visible acres. Total acreage of visibility is divided by the total observed animals to provide a density estimate of acres/deer (or other species).

Deer (or other species) sightings are called out to the recorder (usually the driver) who either records the data on a form or on a hand-held tape recorder. When only a deer's eye shine is detected, binoculars are used to verify the species and/or sex and age. Numbers of bucks, does, and fawns are recorded when the deer in a group can be differentiated. When sex and age cannot be distinguished, the observation is recorded as undetermined.

Means are calculated but no variance parameters are computed. Data are stored electronically in a centralized database with scheduled backups. Data are reported primarily in Federal Aid reports but some districts report county data when providing harvest recommendations in their local newspapers. The data are also reported on the TPWD website.

Analysis: Basic assumptions for the spotlight technique are: 1) deer are evenly distributed; 2) only deer within the calculated visibility are counted; 3) deer are equally visible; and 4) deer are counted only once (Young et al. 1995). Most of these assumptions are difficult or impossible to achieve.

Location of survey lines in the absence of sound sampling principles is one of the key limitations to the method. In the case of deer surveys, bedded animals result in visibility biases. Obviously, identification of species at night can be problematic. Number of surveys for the scale of management need is an issue. Roads per se may be biased sampling units because of attractiveness of vegetation in rights of way. In addition, the assumption that deer are evenly distributed is more fiction than fact. Consequently, the need for a sound sampling scheme is obvious.

During this review it was mentioned by employees often that several of the survey lines have degraded significantly due to encroachment or habitat alteration. It was not clear in the interviews if standard protocols exist or are communicated to survey teams when a survey line should be abandoned.

Interviews also revealed that in some cases employees have become "blasé" regarding conduct of these surveys (especially for white-tailed deer) and as a result attention to standard protocols may be lacking. Other interviewees expressed concern that adequate annual training was not being done. We also detected considerable variation in rigor of data scrutiny before being entered into databases. Employees also indicated concerns about validity and value of the data, especially at the county level and opinions of validity of the measures vary considerably from region to region.

We detected variability in how visibility is measured and tested. Some reported visibility distance of a white handkerchief in the back pocket of an observer as the standard. There is also variation in how distances are estimated. Many of the more experienced observers seemed to indicate they did so mostly from experience. Other survey teams are consistently using range finders.

Considerable human and fiscal resources are expended annually to conduct these surveys. In 2003, a total of 436,103 visible acres were surveyed by spotlight (Lockwood personal communication). The agency is currently conducting a "Deer Survey Reduction Analysis." Use and validity of data from spotlight counts are a key part of this review. The desire to be more efficient in use of fiscal and human resources is clearly understood and appreciated.

Given advent of the Managed Lands Deer Program and the conduct of spotlight counts by various private landowners within each county, legitimate questions regarding potential for use of these data for measures of white-tailed deer densities by county are also being asked.

Absence of a sampling basis for location of the original routes results in the inability to determine relative "goodness" of the data generated. As with most sampling procedures, there are only 2 ways to measure validity and that is precision and accuracy. In absence of complete counts and absolute truth, it is impossible to measure accuracy, so precision remains as the only valid measure of methodology performance.

Measures of precision for routes, counties, and ecoregions would be most helpful in judging adequacy of the sampling methodology. Even in recognizing statistical limits of the data, we were disappointed that little to no analyses of variability among spotlight survey routes are done. These analyses would assist decision-makers in determining the future of spotlight counts.

<u>Recommendations</u>: We believe the spotlight count method applied on a sound sampling basis with strong written protocols could be an adequate estimator. Achieving this however, would be difficult, if not impossible due to availability of potential survey lines and available resources to conduct the surveys.

We recognize value of the long-term data set these surveys provide but users must fully understand limits of the data produced and appreciate the scale at which they are most applicable. Specific and detailed written instructions on what to do when a survey route is lost due to human encroachment or other habitat fragmentation is needed and should be provided to all survey teams.

We suggest the most appropriate question should be to determine what is the primary need (use) of the data to be gathered? Once this need is identified, then it should be determined what scale of application (ranch, county, ecoregion, state) is desired and the level of precision needed to allow decision-makers to feel comfortable using those data. Answers to these questions would greatly aid in developing an appropriate deer density estimator.

If it is determined that deer density data based upon sound science and a sampling base is needed, it would be first necessary to reallocate survey routes based on a sampling design with sample routes allocated on the basis of optimum allocation procedures for various expected densities of deer (i.e., low, medium, high). This process would reduce expected variances and improve estimates generated. This design would also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test. These statistics would improve the scientific basis of the spotlight counts immeasurably.

The method appears to be reasonably applicable across varying vegetation types and in comparison to other potential methods is relatively easy to apply. There is an obvious need to "tighten" protocols for estimating visibility and distances by survey teams. We feel the use of a training video highlighting all aspects of spotlight surveys is needed and would do much to improve consistency of the method. The potential for use of modern technology such as GPS mapping, use of laser rangefinders to estimate distances, and GPS units to document locations should be investigated and incorporated into the methodology as appropriate.

Tests of the method as done by Harwell et al. (1979) and Progulski and Duerre (1964) are needed and should be encouraged. We also suggest there is opportunity for additional analyses of existing data with the goal of better understanding how variable or repeatable these data are. A thorough look at some of the databases by a competent statistician would be revealing and useful.

However, given conservative deer seasons, precise estimates of deer density may not be necessary and cost and expense to obtain such may not be justified. This is a question beyond the scope of this review and must be addressed in another forum.

Spotlight Surveys: Mule deer

Background: Spotlight counts for mule deer were first attempted during the 1970's (Litton 1972). Basic methodology follows that described for white-tailed deer. In 2003, approximately 49 spotlight survey lines for mule deer were conducted (Brewer, personal communication). Literature cited for basis of the method is mostly internal TPWD documents. Training on use of the method is provided by experienced personnel.

Data are taken to determine trend in number of animals in sample areas, Data are gathered at various scales but primarily aimed at management compartments with similar habitat types. There are standardized data sheets and the data are stored in electronic format in a centralized database. The only statistical parameter calculated to describe the data is a mean. Data are reported in Federal Aid reports and in local newspapers.

Young et al. (1995) concluded that spotlight counts for mule deer did not provide a means for predicting future events nor objective evaluation of management decisions. They concluded that modeling tools provided a better approach to mule deer management.

Availability of suitable roads for spotlight surveys is more limited in mule deer range than for white-tailed deer. Access to private land is more difficult and some private roads in the Trans-Pecos follow water sources resulting in overestimating biases (Brewer, personal communication).

Analysis: Basic assumptions for the spotlight technique are: 1) deer are evenly distributed; 2) only deer within the calculated visibility are counted; 3) deer are equally visible; and 4) deer are counted only once (Young et al. 1995). Most of these assumptions are difficult or impossible to achieve.

As discussed with spotlight surveys for white-tailed deer, absence of a sampling basis for the survey routes is a major weakness. Undoubtedly, opportunity for biases from survey roads are higher than experienced for white-tailed deer since some of the roads in mule deer habitat follow water sources and those would bias estimates higher. As discussed with white-tailed deer, inability to calculate variances from survey routes prohibits any meaningful analyses of the scientific validity of the method.

Recommendations: Spotlight surveys for mule deer seem to provide little valid data for mule deer management decisions. Aerial surveys, applied under a sampling protocol would provide much better data. We recommend that resources expended for spotlight counts for mule deer be transferred to helicopter surveys if possible.

Spotlight Surveys: American Alligator

Background: In 1971, 98 spotlight lines statewide were chosen according to accessibility and possible presence of the American alligator. Now, approximately 50 lines varying from approximately 10 to 20 miles in length are surveyed annually in select areas of alligator habitat. Counts are conducted via motorized boat by at least 2 persons, an observer and a driver. Speed is maintained from 5 to 10 mph and all counts are made at air temperatures of 70 degrees or warmer. All observed alligators are categorized into size classes. Total alligators observed are recorded. No estimate of distance to the sighted animal is recorded. Often, total acreage of a water body is surveyed. Visual sightings of alligators are categorized along the route into size classes. The observer estimates a head length from the nostril to the eye. These estimates are translated into total body estimated lengths (up to 7 feet). If the observer is unsure of the length, the observation is to be recorded as an unknown.

Data are taken in areas where alligators exist and samples are allocated for each area as resources allow. Written protocols exist and memos are sent out annually by the alligator program to all personnel conducting the counts highlighting key aspects of the inventory. New employees are trained by more experienced employees at the regional or district level. Standardized data sheets are used in both hard copy and electronic formats. Data are entered into Excel spreadsheets and updated annually. The alligator program staff maintain, store, and back up the data. Data are reported in a CITES document.

The data are analyzed using regression techniques following (Taylor and Neal 1984). In addition, a size frequency model is used (Taylor 1980) to determine minimal estimates by multiplying adult alligators observed per linear mile by the adult multiplier.

Data from these surveys along with data from aerial nest surveys are used to determine trend and abundance, as well as to document presence. These data are also used to establish annual harvest recommendations within surveyed areas.

<u>Analysis</u>: Basic assumptions for the alligator spotlight technique are: 1) alligators are evenly distributed; 2) all alligators are seen; 3) all alligators are equally visible; and 4) alligators are counted only once. Most of these assumptions are difficult or impossible to achieve. Basis for the methodology is established via several literature citations. The method has been modified to fit varying ecosystem types and agency needs. Several known biases are recognized including a lack of randomness for line locations, an under estimate of approximately 75%, varying weather conditions and vegetation densities for counts. Standard written protocols are followed and the same observers for individual areas are used year after year. Scale of the measurements seems appropriate.

Recommendations: The greatest weakness of the method is lack of randomness for survey lines. Establishing transect lines based on a sound sampling basis would significantly strengthen results and allow for much stronger data analyses. It is also suggested that opportunities to employ distance sampling methodologies be investigated for alligator measurements, especially estimates of alligator nests.

The reader is referred to Appendix D for key literature citations describing distance sampling techniques.

Spotlight Surveys: Furbearers and Javelina

Background: Numbers of furbearers and javelina encountered on spotlight surveys for deer are routinely recorded, summarized, and reported. This is done to provide some measure of relative abundance of these species over time. It was ascertained by the review team that a main purpose for this effort is found in subchapter C (61.051) of Texas Parks and Wildlife Laws which states "The department shall conduct scientific studies and investigations of all species of game animals, game birds, and aquatic animal line to determine …" No specific literature citations related to these surveys were produced.

Since these data are taken secondarily on other inventory efforts such as deer spotlight counts there is essentially no sampling design or designated scale for the data other than those in place for the deer spotlight counts. Standard protocols do not exist for data recording, storage, or retrieval. Little training on conduct of these surveys is done. Data are reported in Federal Aid reports.

Analysis: For the method to be scientifically valid for any of the furbearers or for javelina all of the previous assumptions discussed for the spotlight method would apply. In the case of furbearers and javelina, potential for assumptions to be met is less than for species such as white-tailed deer where a basis of white-tailed deer habitat was used to locate survey lines. Little to nothing is known about sightability of the various species nor of their distribution relative to roads etc.

Obviously, all limitations described for this methodology previously apply here. At the very best, these data are no more than frequency of occurrence from which inferences of abundance cannot be made.

It was also found that protocols for recording, summarizing, and reporting data for these species were inconsistent among agency units. Little training in species identification, standard protocols, or purpose of these measures was identified in this review. Issues of scale relative to these surveys were not identified.

Recommendations: If it is determined need of occurrence data is sufficient to justify efforts required to obtain them, it is recommended that all survey teams be periodically briefed on standard protocols for data gathering, recording, summary, and reporting. Reports presenting the data should clearly highlight and inform readers of limitations of the data, especially noting absence of scientific basis for their acquisition.

Aerial Counts: Game Animals

Background: Various aerial counts are flown by the agency. Aerial counts are done for white-tailed deer, mule deer, pronghorn, bighorn sheep, American alligators nests, and waterfowl. Both helicopter and fixed-wing surveys are conducted, however fixed-wing counts are more common. Helicopters are used for bighorn sheep, alligator nest surveys, and occasionally for white-tailed deer.

Aerial counts were done for white-tailed deer as early as the 1950's. Aerial surveys are primarily used to count numbers of individuals or to determine sex and age composition. A key advantage of aerial counts is that access to private land for application of the method is much improved (Young et al. 1995). Aerial counts are expensive but Harwell et al. (1979) found them the most cost-effective technique for estimating deer numbers in

Texas. Obviously, density of vegetation is a key factor in determining observability of white-tailed deer from an aircraft.

Surveys are typically flown via transects using a standard width of visibility. One hundred yards on each side of the aircraft is common (Young and Richards 1994). However, depending upon species and vegetation types, width of transects can vary widely.

Two observers are normal and flights are flown as close to the ground as practical (100-150 feet) and at approximately 65 miles per hour. Flights are normally flown beginning at sunrise and terminating approximately 1.5 hours later, and in the evening from 1.5 hours before sunset to sunset. Experience of observers and position of the sun relative to flight direction are key factors in sightability of targeted species.

Analysis: Basic assumptions of aerial counts include 1) animals are evenly distributed; 2) only animals within the calculated visibility are counted; 3) all animals are equally visible; 4) animal behavior is not affected by the noise or sight of the aircraft; and 5) animals are counted only once. If surveys are conducted on a sampling basis (i.e., not a total count or total coverage) it is also assumed that the individual sample units (transects) are randomly located and that sample sizes are adequate to provide estimates of suitable precision.

Aerial Counts: White-tailed Deer

Background: The most routine use for aerial surveys in Texas has been to determine white-tailed deer trends using fixed-wing aircraft (Young et al. 1995). However, aerial flights have also been used to determine effects of specific management practices such as buck permits on deer densities (Gore et al. 1983).

Transects are surveyed from a fixed-wing aircraft traveling approximately 65 miles per hour at an altitude of approximately 150 feet. Typically 2 observers count deer within

100 yards of the aircraft resulting in a total of 73 acres being surveyed for each mile of transect flown (Young and Richards 1994). Aerial deer surveys are conducted annually from August 15 through October 15. Herd composition (sex and age) is also frequently determined from these surveys. Written protocols for the method exist. They were distributed annually in the 1970s, and much less frequently since. Plans call for annual distribution of written protocols in the future. (Lockwood personal communication).

Sample size is primarily determined by budget. In 1993, there were 622 aerial surveys for white-tailed deer conducted. In 2003, 478 aerial surveys (547,008 acres) were flown in Texas, with an average of 12 transects per county surveyed (Lockwood personal communication).

Data are summarized at the county, reporting unit, ecoregion, and state-wide level. Standard data recording forms are used. Most data are entered electronically and maintained in a central database. The primary statistical parameter calculated is a mean. Training of observers is primarily done during their first survey. Data are reported in Federal Aid reports

<u>Analysis</u>: Basic assumptions for aerial surveys are: 1) deer are evenly distributed; 2) only deer within the calculated visibility are counted; 3) deer are equally visible; and 4) deer are counted only once (Young et al. 1995). It is also assumed that sample sizes are adequate to achieve suitable levels of precision. For determination of precision levels it is also assumed that data are generated from a statistically sound sampling basis. It is also assumed for annual counts to be comparable there is no difference in observers. Most of these assumptions are difficult or impossible to achieve.

Accuracy of aerial counts for white-tailed deer in Texas using a helicopter has been tested (DeYoung 1985). Approximately 65 percent of marked animals were counted on the Zachry Ranch and 36 percent of marked animals were sighted on the Chaparrral Wildlife Management Area (DeYoung 1985). Fafarman and DeYoung (1986) concluded that repeated spotlight surveys were more reliable than a single helicopter survey to determine deer numbers. Since most white-tailed deer surveys in Texas are conducted from a fixed-wing aircraft, information from this study is not directly applicable, but numerous other investigators have found that typically about 66 percent or two thirds of known numbers of animals are observed from aerial surveys (Bear et al. 1989). It is much less common to produce over estimates of animals from aerial counts than underestimates. However, clumped distributions of animals with inadequate sampling intensities can produce overestimates (Cooke 1993, 1997).

Obviously, there are several factors that impact reliability of aerial counts such as animal distribution (i.e., degree of "clumping" or aggregation of animals, independence of individual animals, vegetative cover, scale of the individual observations relative to the projected estimates, weather and observer competence). Investigators must be cognizant of these factors in evaluating bias of aerial counts.

The agency recognizes violations of many of the assumptions for the method but little is done to minimize or account for these biases. Consequently, valid use of the acquired data is limited.

Recommendations: First the scale (i.e., ranch, county, ecoregion) needed for management decisions should be determined and then all potential sampling areas within that geographical unit should be determined. Transect lines sampling those areas should then be allocated using a sound sampling design. This would allow calculation of valid statistical parameters and allow users to determine the relative "goodness" of their data and would produce data needed at the appropriate scale.

Density of vegetation is the key factor determining applicability of the method. More tests with known numbers of marked deer within a variety of vegetation types would be helpful in establishing sightability values for deer from aircraft. These data could then be used to "correct" for under sighting biases of the method. Marked deer would also provide valuable information on sightability biases of various sex and age classes to aid in interpretation of herd composition measures.

Increased training of observers in application of aerial surveys is also needed. It is recognized that differences between observers is common. Experienced observers are much better at detecting deer from the air and steps should be taken to improve consistency among observers. Finally, cost efficiency values should be calculated comparing aerial surveys to spotlight surveys. This information would be useful in evaluating the current agency study on "deer survey reduction analysis." WMI Recommendations: Staff members reported in our method evaluation questionnaire, "No standardized data sheet is necessary. The use of pencil and note pad is sufficient. Some observers like to use digital voice recorders as well." Nevertheless, staff members reported in comments on the draft of this report that standardized data sheets do exist. It is recognized that annual counts are typically completed by the same experienced observers each year but it is recommended that basic protocols of the method be highlighted and distributed each year. Standard data forms must be used, and filed for historical and verification purposes. WMI suggests TPWD concentrate more on "quality" of surveys as opposed to "quantity" of surveys.

Aerial Counts: Mule Deer

Background: In 2003, 39 fixed-wing aerial transects were conducted for mule deer (Brewer personal communication). Transects are flown during the first and last 2 hours of daylight in September and October. Transects are allocated to mostly mule deer habitats but it is recognized that there is a problem with co-occupation by white-tailed deer resulting in a potential problem for species identification (Brewer personal communication).

Data are collected at the management compartment level. Means are the only statistical parameter calculated. Data are used to determine trends, make harvest recommendations, and for decisions regarding regulation changes. Standardized and written protocols exist and new observers are trained in the use of the method by experienced personnel. Data are reported in Federal Aid reports and newspapers.

Analysis: Basic assumptions for aerial surveys are: 1) deer are evenly distributed; 2) only deer within the calculated visibility are counted; 3) deer are equally visible; and 4) deer are counted only once (Young et al. 1995). It is also assumed that sample sizes are adequate to achieve suitable levels of precision. For determination of precision levels it is assumed that data are generated from a statistically sound sampling basis. It is also assumed for annual counts to be comparable there is no difference in observers. Most of these assumptions are difficult or impossible to achieve.

Lack of a sound sampling basis for location of survey transects is a serious limitation to the mule deer aerial surveys. Another concern is that trend data for mule deer are calculated by combining data from 49 spotlight lines and 39 aerial transects. It is doubtful these data are sufficiently similar to be combined. Again, in absence of a sampling design it is not possible to calculate the necessary statistical parameters to make this determination.

Little or no information is known about sightability biases for mule deer in the habitats surveyed. Mule deer are classified to appropriate sex and age classes when possible. No information is available on accuracy of observers in classifying sex and age classes and the issue of species identification is a concern in some habitats. Inconsistencies exist between scale of measurement and use of data.

Recommendations: We recommend the scale (i.e., ranch, county, ecoregion) needed for management decisions be determined. We also recommend all potential sampling areas within that geographical unit be determined and transect lines sampling those areas be allocated using a sound sampling design. This would allow calculation of valid statistical parameters and allow users to determine the relative "goodness" of their data and would produce data needed at the appropriate scale.

Tests with known numbers of marked deer within mule deer habitats would be helpful in establishing sightability values for deer from aircraft. These data could then be used to “correct” for under sighting biases of the method. Marked deer would also provide valuable information on sightability biases of various sex and age classes to aid in interpretation of herd composition measures. We therefore recommend use of known numbers of marked deer in various habitats to verify sightability values.

It is also recommended until it can be determined that data from mule deer spotlight surveys and aerial surveys are similar, that combining the data sets not be done. It is likely that this practice simply compounds and increases biases known to exist in the 2 methods and results in poorer data than would be realized if the databases were kept separate.

Finally, modeling techniques commonly used by other mule deer investigators should be utilized to assess biological population status. More emphasis would then be made on obtaining valid herd composition and survival data as opposed to density data. This recommendation was previously made by Young et al. (1995) and is still valid.

Aerial Counts: Pronghorn

Background: Estimates of pronghorn numbers and herd compositions are obtained by aerial strip surveys of selected ranches and farms in the Panhandle, Tran-Pecos, and Possum Kingdom Districts. Surveys are conducted annually during mid-June through July. In 2003, approximately 243 total hours of flight time were expended.

Pronghorn are counted on transects spaced to achieve full coverage of units and transect width is 0.25 miles or about 250 yards either side of the aircraft. Pronghorn are counted from fixed-wing aircraft on strips spaced to achieve total coverage of selected ranches or management units. All animals within that strip are counted. Total coverage of selected ranches or management units is the objective. Lengths of transect vary according to ranch or habitat boundaries. Observed pronghorn are classified into sex and age categories as feasible. Data obtained from the surveys are used to determine trends, permit issuance, and for decisions regarding regulation changes.

Data are gathered at the herd unit level. Written protocols exist and employees are provided with instructions on how to conduct the count. Standardized data forms are used and data are stored electronically in a centralized database. Experienced observers provide training to new observers. Means are the statistical parameters calculated. Data are reported in Federal Aid reports and in local newspapers.

Analysis: Basic assumptions for aerial surveys are: 1) total coverage is achieved with no overlap or missed areas; 2) only pronghorn within the calculated visibility are counted; 3) pronghorn are equally visible no matter direction of flight; and 4) pronghorn are counted only once. It is also assumed for annual counts to be comparable there is no difference in observers. Most of these assumptions are difficult or impossible to achieve.

It is not clear from information provided on this method if total coverage is achieved or how this determination is made. Also no documentation exists on how observers are trained to ascertain the 0.25 mile on each side of the aircraft. Accuracy of this method is dependent upon consistent determinations of transect width so total coverage without overlap or gaps is achieved. No information on sightability of pronghorn is available so it is not possible to estimate under-estimating biases. Inconsistencies exist between scale of measurement and use of data.

Recommendations: Little is known about accuracy or efficacy of this method with regard to achieving total coverage of the areas surveyed. More rigid written protocols are needed to guide observers in conduct of these surveys. In addition, information on sightability biases is needed. It is recommended that tests with known numbers of marked animals be conducted to address this lack of knowledge. Helicopters are recommended over fixed-wing aircraft for pronghorn surveys because of improved sightability values. However, fixed-wing aircraft have been used successfully elsewhere for pronghorn surveys and will be less expensive. It is also recommended that the agency seriously consider application of distance sampling techniques as an alternative method for estimating pronghorn numbers. Distance sampling approaches could be done from fixed-wing aircraft. Pertinent literature citations for distance sampling are presented in Appendix D.

Aerial Counts: Bighorn Sheep

Background**:** Bighorn sheep in Texas are restricted to the Trans-Pecos region. Helicopter surveys have been determined to be the most effective aerial platform for bighorn surveys (Simmons and Hansen 1980). A complete count of each bighorn herd is attempted and individuals are recorded by sex and 4 horn classes (males). Two observers perform the counts. Timing of the surveys (late summer-early fall) is done to coincide with the peak of rut reducing bias in measurements of ram to ewe ratios.

Areas to be surveyed are broken into square miles and flown 1 at a time. Typically a square mile can be searched in about 5 minutes (Fisher and Humphreys 1990). Surveys are done to determine numbers of animals for issuing hunting permits, and for decisions regarding regulation changes

The scale for the measurements is at the management unit (individual herd) level. Standardized data sheets are used and data are in electronic format and stored in a central database. Observers are provided written protocols and training is provided by experienced observers. Data are reported in Federal Aid reports and newspapers.

Analysis: Key assumptions include: 1) total coverage is achieved with no overlap or missed areas; 2) bighorns are equally visible no matter direction of flight; and 3) bighorn are counted only once and 4) all bighorns are seen without bias to sex and/or age. It is also assumed for annual counts to be comparable there is no difference in observers. Most of these assumptions are difficult or impossible to achieve.

It is not clear from information provided on this method if total coverage is achieved or how this determination is made. Also no documentation exists on how observers are trained to identify or mark boundaries of the individual square miles searched to achieve complete coverage without overlap. Sightability values for bighorns in these habitats are also unknown and if they existed would be useful in correcting for under estimates. However, given the relatively conservative harvest rates for bighorn sheep, these biases are probably not a big problem.

Recommendations: Given the limited distribution of bighorns in Texas it appears that the method as applied is effective for purposes of the survey. It would be enlightening to determine sightability values via known numbers of marked bighorns. Marked animals would also help determine if total coverage of bighorn habitats is achieved. As with all methods, development and issuance of standard protocols and training is a must and must be consistently monitored. We recommend tests designed to measure detectability of marked bighorns to add validity to these surveys.

Aerial Counts: American Alligator Nests

Background: Approximately 74 aerial nest transects of alligator habitat in the counties of Jefferson, Chambers, Galveston, Orange, and Liberty along with total area surveys in select portions of Harris, Fort Bend, Brazoria, and Matagorda counties are conducted annually. Counts are made with a helicopter flying selected transect lines in coastal habitats. Transects are 1 mile apart. Counts are made from approximately 300 feet elevation and at speeds of 60 miles per hour. Two observers are used in the survey, 1 spots and records alligator nests within a certain distance from the centerline. In written materials provided to the review team the distance was reported as 0.25 mi. In review of the draft report, staff members indicated the survey distance as 100 meters. The second observer documents nest locations using a GPS and directs course of travel of the helicopter. Counts are done at the same time each year.

Data obtained from the survey are used to determine the breeding potential of a given area, determine alligator trend and abundance, and are used to set harvest quotas. Scale of the measurement is basically each management area where alligators are found. A nest multiplier (60) is used to determine minimum numbers (Taylor 1980).

Regression techniques are used to analyze the data. Data are stored in electronic format and the Alligator Program Staff maintains the data. Efforts are being made to store this information suitable for use by GPS, Arc View, and GIS software. Data are reported in a CITES document.

Analysis: Basic assumptions for this method are: 1) all nests within the transect boundaries are detected and recorded; 2) 0.25-mile widths of transects are accurately determined; 3) transects are allocated based upon a valid sampling scheme; observers are consistent in recognizing nests; and 4) transects are accurately located and flown each year.

Once again there is no sound sampling basis for location of transects. Consequently, it is not possible to calculate various statistical parameters that would be useful in evaluating this method. It is also unknown if nest detection tests are done to verify accuracy of observers and to determine factors most important in next detection.

Written protocols exist and are made available to observers. Observers are mostly experienced and are the same from year to year. These precautions are helpful in reducing some biases of the method. No information was provided on how observers are trained to estimate the 0.25 mile width of transects.

Recommendations: This method is especially suitable for distance sampling methodology. Distance sampling would allow for more accurate and precise estimates of alligator nests and would not involve a tremendous cost to implement. It would be best if all potential transects were identified and then a portion of these randomly selected for sampling to allow for valid calculation of statistical parameters. It is recommended that distance sampling be investigated and implemented for estimating numbers of alligator nests. Pertinent literature citations for distance sampling are provided in Appendix D.

Aerial Counts: Goose Regulatory Survey

Background: According to written materials provided to the review team this survey is an annual effort to obtain a total count for all goose species and their subspecies that over winter in Texas. Comments by staff members in review of the draft of this report indicated that the only species or subspecies considered in this survey are Canada geese and that total counts of geese are obtained only in certain areas. Given that this survey is basically a total count, there is no sampling involved. All areas where geese are located are surveyed via fixed-wing aircraft by the same pilots and observers each year. Annual training is provided to observers each year by the most experienced observers and a software program named "Wildlife Counts" is used as a training tool for each observer. The literature basis for this methodology is Trost et al. (1990).

No standardized data forms or written protocols for this technique were provided during the review. Data are recorded via paper and pencil or with portable tape recorders. After the survey, each observer sends their data to the Waterfowl Program Staff where it is entered into a spread sheet. Recently, each observer enters their data into their own spread sheet and then sends the information to the Program Staff.

The scale of the data is at the ecoregion level and totals for ecoregions are summarized to arrive at estimates for the state. Data obtained from this survey are used to determine numbers of geese in Texas each winter so trends over years and from ecoregion to ecoregion can be calculated. These data help serve as the main source of information for some goose populations in North America. Management plans for Tall Grass Prairie and Short Grass Prairie Canada geese are driven by the midwinter counts. The data are reported to the appropriate flyway representatives and are published in the Central Flyway Data Book. Thus, they are used by the Fish and Wildlife Service and the Flyways on an annual basis to set hunting seasons and bag limits. Data are also used by the agency to provide information to the public on goose numbers and distribution.

Analysis: The method assumes: 1) counts by observers are consistent from area to area and from year to year; 2) pilots are consistent in flight protocols each year; 3) observers are consistent in species identification over years and among areas; and 4) total coverage is achieved each year. Since this survey is aimed at a total count, assumptions related to sampling protocols do not apply. However, for counts to be comparable from year to year it is critical that observers and protocols are consistent. Importance of these data to other states and to the Fish and Wildlife Service has resulted in consistent and rigorous implementation of this method. These characteristics have strengthened validity of the method. Standardized data sheets or recording methods are not used.

Various statistical parameters such as mean, variance, and regression coefficients are used to compare data. Data are stored electronically and available for prompt recall.

Recommendations: Staff members reported in our method evaluation questionnaire, "No standardized data sheet is necessary. The use of pencil and note pad is sufficient. Some observers like to use digital voice recorders as well." Nevertheless, staff members reported in comments on the draft of this report that standardized data sheets do exist. It is recognized that annual counts are typically completed by the same experienced observers each year but it is recommended that basic protocols of the method be highlighted and distributed each year. Standard data forms must be used and filed for historical and verification purposes.

Aerial Counts: Midwinter Waterfowl Survey

Background: Estimates of wintering ducks are used to monitor changes in distribution and abundance and to guide hunting recommendations. These surveys are part of the nationwide coordinated estimate of ducks and are done in conjunction with the Fish and Wildlife Service. Texas is divided into 7 ecoregions (Brush Country, Sand Plains, Coastal, Pineywoods, Oak woodlands/Blackland prairie, Rolling Plains, and High Plains) for duck surveys. Counts are normally done during January. No supporting literature for the method was provided.

Surveys are made from 99 permanently established transects allocated across ecoregions. Total transect numbers vary, but in most ecoregions a 1% sample of each is surveyed. All waterfowl observed in a quarter mile wide transect are counted. Linear distance of survey lines is approximately 60 miles. In addition to total waterfowl observed, unoccupied habitat is also recorded for use in developing density estimates.

In the High Plains ecoregion, playa lakes are the primary habitat and are sampled by a random 2 percent of the playas (approximately 220). Playas are located via GPS coordinates and all waterfowl on the playa are counted. Upon completion of the surveys data are submitted to agency statisticians to compute estimates of waterfowl by ecoregion and on a statewide basis. Density estimates are also calculated for each species in each ecoregion accompanied by standard errors, coefficients of variation, and confidence levels for each ecoregion and statewide. These scales are appropriate for the data obtained. Experienced observers conduct the counts. Data are reported in Federal Aid reports and provided to the U.S. Fish and Wildlife Service for use in the nationwide coordinated waterfowl surveys.

<u>Analysis</u>: Basic assumptions for this method include: 1) observers are consistent from area to area and from year to year; 2) pilots are consistent from area to area and from year to year; 3) transect widths are estimated accurately and consistently; 4) species identification are consistent between areas and among years; 4) sample sizes are adequate; and 5) random basis for transect and playa locations are valid.

Involvement in the design and application of this survey by agency statisticians strengthens this method. Calculation of confidence intervals by ecoregion and statewide allow users to understand limits of the data. Use of GPS technology further strengthens application of this technique. No written protocols or standardized guidelines for this method were provided to the review team.

Recommendations: Standard procedures outlining details of the method, including how transect widths are to be determined, should be prepared and distributed to all observers. Overall, the midwinter waterfowl survey is a good example of use of sampling design and survey rigor. Consultation and involvement of agency statisticians is beneficial and adds much to the scientific validity of the data. We recommend other agency units follow this example.

Herd Composition Counts

Herd Composition Counts: White-tailed Deer

Background: Herd composition counts are done to determine makeup of white-tailed deer herds by sex and age categories. These data are used to determine trends, to establish annual hunting seasons, and for making regulatory changes. Bucks are differentiated from does and fawns are recorded separate from adults. Typically herd composition measurements are made from either ground or aerial counts. The most common ground counts where herd composition data are taken are spotlight counts and mobile surveys. However, composition data are also taken as possible from various incidental observations.

The review team was not given any specific protocols for herd composition measures beyond those presented in the 1995 Federal Aid report (Young et al. 1995). Absence of updated, written protocols limits our ability to fully evaluate the measurements. They seem to be mostly “by-products” of other surveys. However, their use in harvest regulation setting is important and thus a key inventory method for the agency. Information on methodologies for herd composition counts mainly came from Federal Aid reports and individual employee interviews. No specific training was identified.

The 1995 Federal Aid report (Young et al. 1995) provided the following guidelines for herd composition measures while investigators are conducting mobile white-tailed deer surveys: “Surveys should be driven at a speed of 7 to 8 mph. In addition to recording total deer seen, record the age and sex of observed deer when possible. When a group (2 or more) is observed, the entire group should be classified as unknown unless all deer in the group were identified. Binoculars should be used only to identify sex and age classes of deer."

In some ecological regions such as the Pineywoods, herd composition estimates are derived from spotlight surveys due to inadequate incidental observations (Wolf 2003). However, there is concern by biologists that fawns are underestimated on spotlight counts (Wolf 2003).

Where feasible, aerial counts as described elsewhere in this report, are also used to obtain herd composition data. Observers attempt to classify all deer seen as to the appropriate sex and age category. In general, aerial counts provide the largest sample sizes and potentially the best distribution coverage.

Incidental sightings of does, fawns, and bucks are also made in some districts in August, September and October (Wolf 2003). Herd composition data are tabulated and reported to the White-tailed Deer Program Coordinator by November 15 each year. Data are stored electronically in a central database. Percent fawns, bucks, and does are calculated as are does per buck, fawns per doe and fawns per adult. Federal Aid reports annually present herd composition data and deer density data for each ecological area in Texas (Wolf 2003).

Analysis: Key assumptions include: 1) deer seen and classified are representative of the biological population; 2) observers accurately classify deer; 3) adequate sample sizes for each sex and age category are obtained; and 4) unclassified deer do not bias the estimates. Once again there is no sound sampling basis for acquisition of these data. Consequently, it is not possible to calculate various statistical parameters that would be useful in evaluating this method. There is also a real need to clearly define the scale where the data will be used (i.e., ranch, county, ecoregion, state) and then design a sampling scheme to meet this scale. There is a definite need for the agency to determine importance of these data in management decisions. If they are important, then efforts should be made to develop sampling methods that will produce reliable data at the scale specified.

The assumption that deer observed (statistical population) are representative of the biological population is very difficult to achieve without thorough coverage of the area to be estimated. Incidental counts, mobile counts, and spotlight counts restricted to limited roads are by design likely to not adequately sample the intended biological population. Aerial counts address this concern much better than do limited ground counts.

Observer errors are another concern. All people are not created equal with regard to visual acuity. Factors like changing animal size and vegetative cover require scheduling of measurements by the same experienced observers at approximately the same time of the year. Observers need training on techniques of determining age and sex categories.

The practice of combining data from incidental counts with aerial or mobile counts is questionable and results in data with unknown and undoubtedly mixed biases. There is no basis for evaluating data from incidental counts and unless it is demonstrated statistically that data are similar from separate surveys, they should not be combined. Sex and age parameters are variable and difficult to measure even when specific surveys are designed to do so. In some ecological areas number of deer identified "incidental" to other surveys greatly exceeds the number of deer seen on surveys (Wolf 2003).

In absence of statistical data it is not possible to determine necessary sample sizes but from experience elsewhere, herd composition measures require large samples before differences could be detected. Sample sizes of deer classified as to specific sex and age class for the various estimates are not readily available but it is suspected that sample sizes for many estimates across Texas are grossly inadequate.

Herd composition parameters are difficult to measure accurately. The problem of unclassified deer is a significant problem. It is impossible to know if there is a consistent bias in those deer classified as unknowns. For instance, it is easier to classify certain animals (i.e., antlered) than it is for others. The problem of distinguishing fawns from adults is a difficult problem, especially under poor visibility such as on spotlight counts. There is no evidence that the guidelines of Young et al. (1995) stating, "When a group (2 or more) is observed, the entire group should be classified as unknown unless all deer in the group were identified" are followed. Absence of close scrutiny to this problem by observers is troubling.

Recommendations: First, it should be determined if herd composition data are important and necessary for regulatory purposes. If they are then it is recommended that the agency recognize weaknesses in their current approach and identify the appropriate scale for the measurements.

The current approach of taking herd composition data as possible while doing other surveys is not advisable and the practice of combining herd composition data from incidental counts and from surveys should be discontinued unless and until it is clearly demonstrated that data are representative and of adequate quality to justify the combination. Attention must be given to sampling protocols specifically designed to measure herd composition that will ensure broader coverage of the biological populations from which inferences are being made. Once these sampling protocols are in place, then various statistical calculations will facilitate further design modifications.

Herd composition data taken from spotlight surveys need special scrutiny. Tests need to be designed to ascertain ability of observers to accurately classify sex and age cohorts under reduced visibility that occurs in these surveys. In absence of knowing these biases, or without correction factors, it is probable that fawn abundance is under estimated. The potential to use marked animals of known sex and age (unknown to the observer) should also be examined as a way to train observers.

Minimum sample sizes required for each sex and age category that would produce detectable differences need to be determined. Utilizing sample size recommendations in the published literature from other states would be a logical starting point.

Written specific protocols for making herd composition measurements need to be developed and distributed to all observers. Specifically, the problem of unclassified deer in a group needs attention and protocols for handling unclassified deer needs to be spelled out. Efforts to develop more accurate and consistent determinations by observers are needed. Training sessions where multiple observers classify the same animals and then compare notes are useful and should be encouraged. Development and use of videos and photos demonstrating key factors that observers should focus on when classifying deer are recommended.

Herd Composition Counts: Mule Deer

Background: Herd composition counts are done to determine makeup of mule deer herds by sex and age categories. These data are used to determine trends in herd structure, to establish annual hunting seasons, and for making regulatory changes. Bucks are differentiated from does and fawns are recorded separate from adults. Typically herd composition measurements are made from either ground or aerial counts. The most common ground counts where herd composition data are taken are spotlight counts and mobile surveys. However, composition data are also taken as possible from various incidental observations. Data are stored electronically in a central database. Percent fawns, bucks, and does are calculated as are does per buck, fawns per doe and fawns per adult. Data are reported annually in Federal Aid reports.

Much of the specific information presented in the write up on herd composition counts for white-tailed deer apply for mule deer as well and will not be repeated here. Again, the review team was not provided specific written protocols for herd composition measurements for mule deer and they too seem to be generally “by-products” of other survey efforts. Most of our information on methodology was found in annual Federal Aid reports. No specific training was identified.

In a 2003 Federal Aid report (Bone 2003) wrote that "mule deer herd composition counts (incidentals) of buck, does, and fawns will be made throughout all habitat types to provide a representative sample for each identifiable subpopulation or antlerless deer harvest compartment." Bone went on to write that "the desired samples from each unit shall be 100 does and accompanying bucks and fawns." He further explained "herd composition data includes all identified deer observed during aerial and spotlight surveys." Herd composition counts are to be conducted during September to October annually (Bone 2003).

Analysis: Basic assumptions of the method are 1) deer seen and classified are representative of the biological population; 2) observers accurately classify deer; 3) adequate sample sizes for each sex and age category are obtained; and 4) unclassified deer do not bias the estimates.

Most of the analysis presented for herd composition measurements for white-tailed deer apply for mule deer and will not be repeated. Once again, absence of any sampling designs greatly limits value of the measurements. Many of the other concerns discussed for white-tailed deer are even greater for mule deer. Due to lower densities of mule deer, sample sizes are greatly restricted and inadequate. As discussed previously, many survey lines for estimating densities of mule deer that frequently follow water sources bring special biases to the measurements and further challenge the assumption of obtaining data that are representative of the biological population to which inferences will be made.

Samples for mule deer herd composition measures are hard to obtain for several management compartments (Bone 2003). A total of 11 compartments had 10 or fewer deer classified in 2002 (Bone 2003).

There is also a need to clearly define the scale where the data will be used (i.e., ranch, county, ecoregion, state) and then design the sampling to meet this scale. There is a definite need for the agency to determine importance of these data in mule deer management decisions. If they are important, then efforts should be made to develop sampling methods that will produce reliable data at the scale specified.

Absence of written and widely distributed protocols detailing sample size requirements and instructions for observers on how to handle unclassified deer limits continuity of the measurements. The review team found no evidence that the sample size requirement of 100 for each management unit specified by Bone (2003) is known or expected to be achieved. Aerial surveys have the best potential for obtaining desired sample sizes and needed sample distribution. In general, mule deer habitats are better suited for aerial surveys than white-tailed deer habitats.

Formalized training for observers is lacking and would improve data gathering processes considerably. Efforts to determine necessary sample sizes to achieve a stated level of precision for the various sex and age components are not done.

Recommendations: First, it is important for the agency to determine if mule deer herd composition data are important and necessary for regulatory purposes. Secondly, if composition data are needed, a proper scale for those measurements must be determined.

The current approach, of taking herd composition data as possible while doing other surveys, is a basic weakness. Attention must be given to sampling protocols specifically designed to measure herd composition that ensure broader coverage of the biological populations from which inferences are being made. Once these sampling protocols are in place, then various statistical calculations will facilitate further design modifications. The publication by Bowden et al. (1984) would be a good reference for suggestions on design of herd composition measures.

Herd composition data taken from spotlight surveys need special scrutiny. Tests need to be designed to ascertain ability of observers to accurately classify sex and age cohorts under reduced visibility that occurs in these surveys. Potential to use marked animals of known sex and age (unknown to the observer) should be examined as a way to train observers.

Minimum sample sizes required for each sex and age category that would produce detectable differences need to be determined. Utilizing sample size recommendations in the published literature from other states would be a logical starting point. The current practice of combining herd composition data from incidental counts and from other surveys should be discontinued unless it is clearly demonstrated that data are representative and of adequate quality to justify the combination.

Written specific protocols for herd composition measurements need to be developed and distributed to all observers. Specifically, the problem of unclassified deer in a group needs attention and protocols for handling unclassified deer should be spelled out. Training efforts to develop more accurate and consistent determinations by observers should be developed and made available to pertinent employees. Development and use of videos and photos demonstrating key factors that observers should focus on when classifying deer are recommended.

Call Counts: Upland Game Birds

Background: Call-count surveys are used by TPWD to monitor numbers of pheasant, chachalaca, mourning doves, and white-winged doves and establish harvest regulations for these species. Vocalizations are counted over a fixed period of time and used as an index to abundance. The pheasant crow count is reportedly similar to the methodology used by Kimball (1949). The chachalaca call counts reportedly are a modification of methods used by Marion (1974) to index plain chachalaca abundance in South Texas.

Analysis: A basic assumption for call-count surveys is that vocalization rates and other factors affecting the probability of detecting calls are constant across lines and across years. Probability of detection is known or believed to vary in response to many factors, including weather, habitat conditions, season of the year, time of day, and observer performance. Some sources of variation in detection probability can be overcome by standardizing data collection procedures, but it often is not possible to address or even identify other factors that cause variability in this probability. Consequently, unless data to test the assumption of constant detection probability are collected routinely as part of a standard data collection, "a large degree of caution and skepticism" is recommended when these surveys are used and interpreted (Lancia et al. 1994, Anderson 2001).

Call Counts: Ring-necked Pheasant

Background: Call-count survey activities were initiated in the Coastal Prairie to monitor the status of pheasants and the impact of releases or pen-reared and wild-trapped birds. Dense vegetation in this region limits visibility and prevents use of pheasant roadside counts.

Call counts are conducted once each year during April along 17, 20-mile along historical routes. No information was found on calculation of this sample size. Replicate measurements on individual survey lines are not done. Each survey begins 40 minutes before sunrise. Observers stop at 1-mile intervals and listen for 3 minutes. At each stop, the observer records all pheasant crows heard, and the total number of pheasants heard crowing. All pheasants observed during the survey are recorded by sex. Cloud cover, temperature, and wind velocity and direction are recorded at the beginning and end of each survey route. Counts are not conducted when wind velocities are greater than 10 mph.

The pheasant call-count survey data are used to determine distributions, relative densities and trends. This information, in turn, is used in conjunction with harvest estimates from the small game harvest survey in making harvest recommendations.

Analysis: Use of pheasant call-count survey data to make valid comparisons of abundance over time or across areas requires that the number of vocalizations counted during a fixed period of time must be proportional to abundance. This, in turn, requires that vocalization rates, listening time length, and effective area sampled are constant (Luukkonen et al. 1997). These factors are known to vary in response to weather, habitat conditions, interfering noise, reproductive status, season of the year, time of day, and observer performance. TPWD has adopted a number of standardized data collection procedures to address sources of variation in detection probability. For instance, to minimize known factors that can cause variation in detection probabilities, the survey line protocol requires that lines be conducted 1) beginning 40 minutes before sunrise, 2) during April each year, and 3) when wind velocities are less than 10 mph. We did not find evidence of measures that would reduce variation among observers, such as standardized forms for recording data, written observer protocols, or uniform training programs. The absence of these materials likely contributes to variation in detection probabilities.

In contrast to Kimball (1949), Luukkonen et al. (1997) found in Michigan that there were rapid temporal changes in crowing rates and emphasized the importance of maintaining consistency in the timing of surveys. They suggested beginning surveys 30 minutes before sunrise and ending 30 minutes after sunrise. This interval bracketed the morning peak in crowing and eliminated the early period of the survey when crowing rates are low and count variation is relatively high. These results suggest that it could be important to determine the relationship of crowing activity to time of day over the course of the morning in the Coastal Prairie. In addition, it often is not possible to address or even identify sources of variation in detection probability. These problems can result in seriously erroneous interpretations of data (Anderson 2001). Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in numbers. Probability of detection needs to be measured (empirical estimate) to allow the incomplete count of an index value to have meaning.

As with other surveys, location of survey lines in the absence of sound sampling principles is 1 of the key limitations to the method. Pheasant call-count survey lines are conducted from roads located along historic routes. Roads per se may be biased sampling units because of attractiveness of vegetation in rights of way. In addition, the method of locating survey lines assumes that pheasants are evenly distributed across the ecoregion being sampled, which is unlikely.

Absence of a sampling basis for location of call-count survey lines results in the inability to determine relative "goodness" of the data generated. As with most sampling procedures, precision and accuracy are the only 2 ways to measure validity. In absence of known biological populations, it is impossible to measure accuracy, so precision remains as the only valid measure of methodology performance. Measures of precision for routes, counties, and ecoregions would be most helpful in judging adequacy of the sampling methodology.

We do not agree with the TPWD's Federal Aid reports (e.g., DeMaso et al. 2001) that there currently is sufficient basis on which to conclude that the data from pheasant call-count surveys are drawn from adequate sample sizes or that they provide the necessary information on distributions, relative densities, and trends for use in management.

Recommendations: Given that numbers of pheasants in the Coastal Prairie have experienced a steady decline since the initial releases of birds and that there is a corresponding decline in hunter interest, a determination should be made as to whether continued trend count data for pheasants is needed to adjust harvest regulations or provide information to hunters. Consideration should be given to alternate means of achieving these goals, such as use of information on changes in habitat condition. If it is determined that trend count data is necessary to achieve TPWD's objectives, then a second determination should be made concerning the scale of desired application (county, ecoregion, state) and the level of precision needed to allow decision-makers to feel comfortable using those data. Following these decisions, a number of changes to the current protocol should be made to place it on a more sound scientific footing.

First, survey routes should be reallocated based on a sound sampling design with sample routes allocated on the basis of optimum allocation procedures for various expected densities of pheasant (i.e., low, medium, high). This process would reduce expected variances and improve estimates generated. This design would also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test. These statistics would improve the scientific basis of the call counts immeasurably.

Second, the annual collection of call counts based on a sound sampling design should be accompanied by routine collection of data designed to test the assumption of constant detection probability and identify sources of variation. As noted above, absent this second effort, a large degree of caution and skepticism should be exercised in using and interpreting these surveys, particularly in interpreting changes in counts from 1 year to the next.

Third, additional efforts should be made to remove some of the remaining variation associated with observers and counting methodology by requiring uniform training for observers, written protocols and standardized data reporting forms, if these do not already exist.

Finally, a forthright statement should accompany any report of the results of the pheasant call-count survey that indicates the scale to which the data apply, the potential sources of bias that could affect the accuracy of the data, the imprecision of the data, and the importance of interpreting it cautiously.

Call Counts: Chachalaca

Background: Chachalaca are surveyed on a representative sample of hunted and non-hunted tracts of native brush within the species' occupied range in Cameron, Hidalgo, Staff, and Willacy Counties. No information was found on sampling design or calculation of sample size, although DeMaso et al. (2001) report that sample size is adequate. The design of the survey appears to have changed in 2003. Prior to that date, it was reported that surveys were conducted once each year during the first week of May. The survey consisted of "about 40 stops" at least 0.5 miles apart in suitable habitat. The number of chachalaca duets heard per stop was recorded for 2 hours beginning at local sunrise. In 2003, it was reported that the surveys would be conducted during the last week of May in conjunction with white-winged dove breeding surveys, and that the survey would consist of approximately 300 stops in suitable habitat. We did not find information on the listening time length at each stop either prior to 2003 or subsequent to that time.

Data from the surveys are used to estimate chachalaca distribution, relative abundance, and trends in the Lower Rio Grande Valley. This information reportedly is used in decisions about harvest regulations and for presentation to the public prior to hunting season.

Analysis: Use of chachalaca call-count survey data to make valid comparisons of abundance over time or across areas requires that the number of vocalizations counted during a fixed period of time must be proportional to abundance. This, in turn, requires that vocalization rates, listening time length, and effective area sampled are constant (Luukkonen et al. 1997). These factors are known to vary in response to weather, habitat conditions, interfering noise, season of the year, time of day, observer performance, amount of vehicle traffic, and intrinsic species-specific factors such as matedness. TPWD has adopted a number of standardized data collection procedures to address sources of variation in detection probability. For instance, to minimize known factors that can cause variation in detection probabilities, the survey line protocol requires that lines be conducted during May for 2 hours beginning at sunrise, although there appears to have been a recent change in the number of stops and period during May in which the survey is conducted.

We did not find evidence of measures that would reduce variation among observers, such as standardized forms for recording data, written observer protocols, or uniform training programs. The absence of these materials likely contributes to variation in detection probabilities. In addition, as noted elsewhere, it often is not possible to address or even identify sources of variation in detection probability. These problems can result in seriously erroneous interpretations of data (Anderson 2001). Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in numbers of birds. Probability of detection needs to be measured (empirical estimate) to allow the incomplete count of an index value to have meaning.

As with other surveys, location of survey lines in the absence of sound sampling principles is one of the key limitations to the method. Non-random location of sample units is an important source of bias. Chachalaca call counts are conducted from roads and roads per se may be biased sampling units because of attractiveness of vegetation in rights of way. In addition, the method of locating survey lines assumes that chachalacas are evenly distributed across the ecoregion being sampled, which is unlikely.

Absence of a sampling basis for location of call-count survey stops results in the inability to determine relative "goodness" of the data generated. As with most sampling procedures, precision and accuracy are the only 2 ways to measure validity. In absence of known biological populations, it is impossible to measure accuracy, so precision remains the only valid measure of methodology performance. Measures of precision for would be most helpful in judging adequacy of the sampling methodology.

We do not agree with TPWD's Federal Aid reports (e.g., DeMaso et al. 2001) that there currently is sufficient basis on which to conclude that the data from chachalaca call-count surveys are drawn from adequate sample sizes or that they provide the necessary information on distributions, relative densities, and trends for use in management.

Recommendations: Because there is "very little hunting for chachalacas on private land in Cameron, Hidalgo, and Starr Counties, and most of the existing native brush which comprises Plain Chachalaca habitat is owned by either the U.S. Fish and Wildlife Service or TPWD," a determination should be made as to whether the current survey is needed to adjust harvest regulations or provide information to hunters. If it is determined that trend count data is necessary to achieve TPWD's objectives, then consideration should be given to re-design of the chachalaca call-count survey. It currently appears to be conducted in conjunction with the white-winged dove call-count survey, which itself is in the process of being re-designed. Attention should be paid to whether a common sampling design and methodology is appropriate to simultaneously count white-winged doves and chachalacas. In any design, a determination should be made concerning the level of precision needed to allow decision-makers to feel comfortable using data on chachalacas. Following these decisions, a number of changes to the current protocol should be made to place it on a more sound scientific footing.

First, listening stations should be reallocated based on a sound sampling design with sample routes allocated on the basis of optimum allocation procedures for various habitat strata or expected densities of chachalaca (i.e., low, medium, high). This process would reduce expected variances and improve estimates generated. This design would also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test. These statistics would improve the scientific basis of the call counts immeasurably.

Second, the annual collection of call counts based on a sound sampling design should be accompanied by routine collection of data designed to test the assumption of constant detection probability and identify sources of variation. As noted above, absent this second effort, a large degree of caution and skepticism should be exercised in using and interpreting these surveys, particularly in interpreting changes in counts from 1 year to the next.

Third, additional efforts should be made to remove some of the remaining variation associated with observers and counting methodology by requiring uniform training for observers, written protocols and standardized data reporting forms, if these do not already exist.

Finally, a forthright statement should accompany any report of the results of the chachalaca call-count survey that indicates the scale to which the data apply, the potential sources of bias that could affect the accuracy of the data, the imprecision of the data, and the importance of interpreting it cautiously.

Call Counts: Mourning Dove

Background: The mourning dove call-count survey was developed to provide an annual index to bird numbers (Dolton 1993). In the United States, the survey currently includes more than 1,000 randomly selected routes stratified by physiographic region. The total number of doves heard on each route is used to determine trends and provides the basis for determining an index to numbers of breeding birds during the breeding season. Each call-count route is usually located on secondary roads and has 20 listening stations spaced at 1-mile intervals. Current call-count procedures (Dolton and Rau 2004) provide that at each stop, the number of doves heard calling during a 3-minute period, the number seen, and the level of disturbance (noise) that impairs the observer's ability to hear doves are recorded. The number of doves seen while driving between stops is also noted. Counts begin 1/2- hour before sunrise and continue for about 2 hours. Routes are run once between 20 May and 31 May. Surveys are not made when wind velocities exceed 12 miles per hour or when it is raining. In addition, GPS coordinates have been established for all listening stations to reduce the likelihood that new observers stop at different locations and reduce the variance between habitat variables associated with counts of doves heard at that stop. In 2003, counts were completed on 127 of the 133 routes due to budget cuts and hiring freezes.

Written protocols are provided on the back of a standardized form and in a cover memo to all observers sent every year prior to the survey. Training is provided when there is a change of observer. The previous observer accompanies the new observer to identify the route, stopping points and general procedures, and answer questions.

Data are provided to the U.S. Fish and Wildlife Service for use in the coordinated Nationwide Mourning Dove Breeding Population Survey to provide spatially explicit information on trends in numbers of mourning doves nationwide.

The mourning dove call-count breeding trend data is used at the Management Unit scale. The Service records trends by state even though the survey was not designed at that scale. Federal hunting regulation frameworks in Texas and elsewhere frequently are set at finer scales than this. Data also are used by TPWD to develop harvest recommendations and management programs in Texas by hunting zone, ecological area and county. Data are reported in Federal Aid reports, to sports writers and hunters for hunt forecasts, and on request to TPWD administrators, advisory board members and Commissioners.

Analysis: The mourning dove call-count survey is conducted in accordance with experimental design and statistical procedures established by the Service. Others who have looked at this nationwide survey have concluded that it is adequate for estimating long-term trends over large areas (Baskett 1993). Evaluation of the scientific basis of the mourning dove call-count survey is not within the scope of this review.

Texas observers follow Service procedures so that collection of data is standardized using statistically consistent methods. As noted above, the survey consists of 133 randomly selected 20-mile routes. Staff members report that Gates et al. (1975) conducted the only work on sample size determination based upon anticipated variance in indices by various scales within Texas from 1 year to the next. They reportedly recommended 4 replications (or repeated surveys per route in 4 different weeks), increasing the number of routes to 169 (36 more than current) but reducing the number of stops from 20 to 5. These measures were not adopted due to the practical difficulties in carrying them out.

According to staff, over the history of the survey in Texas routes have been moved gradually from encroaching urban areas to rural areas to reduce the effect of noise due to human activity on the ability of observers to hear calls. As a result, they note that dove trends in urban areas have systematically been excluded because the survey is not conducted in larger metropolitan areas. Habitat type can affect hearing distance.

The Service uses a route regression method for determining long-term trends, which 1) allows annual indices to be estimated when some routes are not run every year; 2) removes route-to-route variability; 3) uses co-variables to control variation due to observers and environmental effects; and 4) allows calculation of variation among routes. Route regression analyses for Texas by hunt zone and ecological areas for various important time series have been completed sporadically. TPWD, however, currently does not use this methodology in making decisions about regulations prior to hunting season because the Service has not published or otherwise made available this program for its use. Consequently, TPWD uses untransformed index data, which do not have the benefits of the route regression analysis, to inform these decisions. In addition, TPWD uses data from only the first 15 of the 20 stops on each route because Gates et al. (1975) found that call-count variability increased with addition of the last 5 stops.

Staff members report that, "based upon an unpublished power analysis completed in 1994, an additional 840 20-mile routes would be needed to be completed each year (based upon trend from 1966-94) in Texas to determine that a 20% change in regression coefficient from zero over 10 years was real ($a = 0.1$, $ß = 0.2$) and not an artifact of the survey method."

To reduce variation in detection probabilities, efforts have been made to standardize procedures and timing by prescribing the following concerning the conduct of the survey: time of day (0.5 hour before sunrise), season (May 20-31), weather (<12mph wind, no rain), and effort (1 observer 3-minutes per stop at designated times per stop).

TPWD publications and responses to our inquiries clearly recognize the limitations of the mourning dove call-count survey in providing meaningful information for management decisions. As with other indices discussed in this review, the recognized limitations stem from problems of convenience sampling along roadsides (inability to make a valid inference to the biological population of interest and to assess the precision or accuracy of estimated parameters) and from not being able to assume that index values are a surrogate for total numbers or density (Anderson 2001). As TPWD staff members recognize fully in discussion of the mourning dove call-count survey, index values can be affected by variables related to observers (hearing ability, experience, interest, training, etc), survey method, and species specific intrinsic factors, such as effects of mating status on calling rate.

To monitor the effects of Texas decisions on the number of hunting zones taken and season lengths and bag limits in each zone and effects of land use changes, accurate and reasonably precise breeding trend information is needed at the scale of hunting zone.

<u>Recommendations</u>: We agree with the recommendations of Roberson et al. (2003) concerning the route regression method of analysis and the need to make it accessible to Texas and other states in a manner that will allow its use in making decisions about hunting season regulations.

We also agree that a follow-up power analysis should be conducted with benefit of the additional 10 years of call-count data since 1994. The number of additional routes needed to detect the same percentage change given the same probability levels would be reduced, but according to staff, it is unlikely that the number of routes would be reduced sufficiently to make it feasible for them to be run. We understand that the limited number of existing field staff and the short survey period of 12 days (May 20-31) preclude completion of any replication (i.e., conducting survey route more than once per season). However, current mourning dove call-count survey data does not provide sufficiently precise enough data to detect a 20% change in the index over 10 years with reasonable power. Therefore, as staff members recognize, the current data are inadequate to measure the effects of changes in either hunting regulations or habitats. TPWD should increase its efforts to obtain accurate and reasonably precise information on numbers of breeding birds at the scale of hunting zones, at a minimum.

We recommend that TPWD continue its efforts to obtain more robust estimates of mourning dove breeding density through use of distance sampling to address the effects of variation in habitat and matedness. Distance sampling is an effective means of standardizing the effects of these variables and addressing the uncertain relationship between indices and biological population demographics of interest. Pertinent literature citations for distance sampling are provided in Appendix D.

Given the importance of mourning doves in Texas, we recommend further that TPWD place additional research emphasis on addressing the problems of convenience sampling. We are aware that there is interest in pursuing these issues through research to determine what proportion of each ecological area is outside the range sampled by the roadside routes and whether density of breeding birds varies in relation to distance from roads. This research effort should be supported.

TPWD should continue its effort to counter the trend of urban areas becoming progressively under-represented in the call-count survey by conducting an urban survey of doves seen as well as heard during early mornings on weekends by volunteers.

Call Counts: White-winged Dove

Background: White-winged dove call-count surveys are conducted each year on approximately 55 routes in Central, South and West Texas to derive annual indices of numbers of breeding birds. The basic procedure of standardized survey period (May 15 to May 31), time of day (within 2.5 hours from sunrise), listening period duration (3 minutes), and weather thresholds (not conducted when winds are ≥ 15 mph or rainy conditions exist) have remained unchanged since the 1940's.

Our understanding is that the survey now consists of a combination of systematic point counts along transects within riverine systems and cities and along roadsides adjacent to all known historical breeding colonies in native brush and citrus groves. A random sample was not selected because an attempt was made to survey all brush tracts and citrus groves in the LRGV. As surveys in West Texas along the Rio Grande and urban areas were added, different procedures besides roadside stops or points counts were added. These included transects and a 9-square block urban grid system. The relation of the number of white-winged doves heard to actual nest density is based upon nesting studies in the 1950's. However, more recent evidence suggested that nest-count estimates were correlated poorly with call-count estimates (Rappole and Waggerman 1986).

The breeding bird trend information is used at the statewide and major geographic area (Lower Rio Grande Valley (LRGV), West Texas, Upper South Texas, Central Texas) scales.

There are written protocols on instructions sheets that observers can download from the TPWD intranet. We did not find any indication of listening period duration on the 2003 count instructions. New observers were trained by the white-winged dove project leader. We understand that this position has been eliminated. There has been 1 standard data sheet form used in rural and urban areas whether the survey procedure was auditory point count, transect or urban grid survey method.

Means, variance and simple linear regression are calculated for trends in white-winged dove density estimates by state and broad geographic areas. In addition, trends are estimated by habitat type (brush, citrus, urban). Density estimates are expanded to abundance estimates using estimated size of brush and citrus tracts and occupied area of cities.

Breeding bird trend data are collected, analyzed and reported in Federal Aid reports and provided to the media for hunt forecasts. We understand that in the past the data were used to close hunting season (latest in 1985) when severe freezes occurred in the LRGV that destroyed critical nesting habitat.

Analysis: There are a number of limitations to the current white-winged dove call-count survey. Samples are not randomly distributed and survey routes involve some convenience sampling along roadsides. These survey attributes preclude valid inferences concerning the number of breeding white-winged doves and limit the ability to assess the precision of estimates. As with other indices, these call-count survey estimates can be affected by variables related to observers, environmental effects on the number of birds detected, and biological and behavioral aspects of detectability.

TPWD's protocol for conducting the white-winged dove call counts incorporates a number of standardized data collection procedures to address these sources of variation in detection probability. In addition, density derived from auditory cues can be verified by estimates of actual nest densities at peak of the nesting season provided by production surveys. Efforts to correlate current breeding density estimates with actual active nests at the peak of breeding make it possible to evaluate whether observers assign density categories consistent with earlier results. Nevertheless, it should not be assumed that the survey index values are a surrogate for numbers of breeding birds. We found that staff members are fully aware of these issues and working to address them.

It is our understanding that no estimation of optimum sample size has been made for the current survey.

Staff members have identified that the different survey procedures used to obtain call counts across sampling units do not allow standardized methods of determining variance and have different inherent biases. Although estimates of variance reportedly are calculated for trends in white-winged dove density estimates by state and broad geographic areas, we did not find any reporting of these estimates in Federal Aid reports. In addition, we understand that the different survey procedures have created some confusion of interpretation and inconsistent entry of the data.

The scale at which the current survey data are applied may not be appropriate because TPWD reports the sum of the index values for the LRGV, West Texas, and selected urban areas (using different methodologies) to indicate statewide population size. Staff members report that there was too much variability in the breeding density index to determine whether hunting closures in the 1980's had any impact on subsequent number of spring breeders.

Recommendations: TPWD is in the process of converting its white-winged dove breeding survey methods and analyses to a single method applied probabilistically statewide. This effort to establish random point counts of doves seen and heard using distance sampling within all known occupied brush, citrus, riverine or urban habitats should continue and should be used as model for how other indices might be placed on a scientific footing.

Specifically, the efforts should be continued with Texas A&M University in Kingsville to develop a representative sampling scheme that is uniformly applicable statewide and to test distance sampling to reduce observer and environmental detection bias. Research on identifying sources and degree of bias is important to establishment of valid breeding surveys.

Establishment of any new method should be accompanied by standardized training for all observers.

Roadside Observation Surveys

Background: Roadside observation surveys are used by TPWD to monitor numbers of bobwhite quail and pheasant and establish harvest regulations (DeMaso et al. 2001). Peer-reviewed literature citations documenting validity of roadside observation surveys for pheasant date from 1947 to 1955, while those for quail are more recent (1969 to 2000). In either case the method reportedly has not been modified from that described in cited literature. The fundamental element for the measurements is a 20-mile strip transect along rural roads. Counts of birds are made by observers riding in a moving vehicle traveling 20 miles per hour and are recorded at 1-mile intervals on standard forms. Written protocols exist and are made available to observers. New observers normally are accompanied by experienced employees on the first run of a transect.

Analysis: A basic assumption for the road observation survey is that probabilities of detection are constant across lines and across years. Probability of detection is known to vary in response to many factors, including weather, habitat conditions, reproductive status, season of the year, time of day, and observer performance. Some sources of variation in detection probability can be overcome by standardizing data collection procedures, but it often is not possible to address or even identify other factors that cause variability in this probability. Consequently, unless data to test the assumption of constant detection probability are collected routinely as part of a standard data collection, "a large degree of caution and skepticism" is recommended when these surveys are used and interpreted (Lancia et al. 1994, Anderson 2001).

Roadside Observation Survey: Ring-necked Pheasant

Background: Pheasant survey activities were initiated in the Texas Panhandle in 1959. Crow counts were used until 1975, at which point it was decided that roadside counts provided a better indication of annual changes. Since 1976, numbers of ring-necked pheasants in the Texas Panhandle have been monitored solely by means of roadside counts in the manner generally described by Stiles and Hendrickson (1946), Fisher et al.

(1947), Kozicky (1952), and Klonglan (1955). Survey lines were set up initially to monitor releases of birds or in counties that wanted a season. No information is available on the original design of the survey or on any calculation of necessary sample size.

Roadside counts are conducted once between October 15 and November 15 each year along 44, 20-mile lengths of road in suitable pheasant habitat. Replicate measurements on individual survey lines are not done. Each survey begins 15 minutes after sunrise and all pheasants observed are recorded at 1-mile intervals. The age of broods is recorded as 1/4, 1/2, 3/4, or full grown. The route number, county, date, starting time, beginning and ending temperature, beginning and ending wind velocity, extent of dew, and name of the observer are recorded. If necessary, the vehicle is stopped and the observer may flush broods to obtain complete counts. Over time, some routes have had to be deleted and new ones established due to changes in agricultural practices and implementation of the Conservation Reserve Program. New routes are not located randomly; rather, an effort is made to locate them in suitable pheasant habitat.

The pheasant roadside observation survey lines were set up initially to monitor releases or in counties that wanted season. They now are used by staff members "to try to make regulation changes." In addition, although pheasant roadside observation surveys are intended for use at the ecoregion level, data is used at the county level to provide information to hunters. The only statistical parameter used to describe data is the mean of index values. Data are stored in electronic format but are not stored centrally. Results are reported in Federal Aid reports and in hunting season forecasts.

Analysis: A basic assumption for the road observation survey (and the mourning dove call-count survey discussed above) is that probabilities of detection are constant across lines, years and observers. Probability of detection is known to vary in response to many factors, including weather, habitat conditions, reproductive status, season of the year, time of day, and observer performance. TPWD has adopted a number of standardized data collection procedures to address sources of variation in detection probability. For instance, to minimize known factors that can cause variation in detection probabilities, the survey line protocol requires that lines be conducted 1) beginning 15 minutes after sunrise, 2) between October 15 and November 15 each year, and 3) when wind velocities are less than18 mph and when no rain or snow is falling. In addition, there is a standardized form for recording data, and written protocols for the survey are provided to observers on the back of the data sheet.

The absence of training in the use of the method, which increases the chances of differences in observer performance and compliance with the written protocol, is a factor that likely contributes to variation in detection probabilities. We also understand from staff members that conversion of habitat to cotton is occurring in the area of the survey lines, which is altering detection probabilities across lines and over time. There are other factors that cause variability in this probability. The literature indicates that the amount of vehicle traffic, presence of dew, extent of cloud cover, and low temperatures also may affect the probability of seeing birds. In addition, it often is not possible to address or even identify sources of variation in detection probability. These problems can result in seriously erroneous interpretations of data (Anderson 2001). Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in biological population size. Probability of detection needs to be measured (empirical estimate) to allow the incomplete count of an index value to have meaning.

As with other surveys, location of survey lines in the absence of sound sampling principles is 1 of the key limitations to the method. Pheasant observation survey lines are located along roads in areas subjectively determined to be good pheasant habitat. Roads per se may be biased sampling units because of attractiveness of vegetation in rights of way. In addition, the method of locating survey lines assumes that pheasants are evenly distributed across the ecoregion being sampled, which is unlikely.

Absence of a sampling basis for location of pheasant survey lines results in the inability to determine relative “goodness” of the data generated. As with most sampling procedures, precision and accuracy are the only 2 ways to measure validity. In absence of known biological populations, it is impossible to measure accuracy, so precision remains as the only valid measure of methodology performance. Measures of precision for routes, counties, and ecoregions would be most helpful in judging adequacy of the sampling methodology.

We do not agree with TPWD's Federal Aid reports (e.g., DeMaso et al. 2001) that there currently is sufficient basis on which to conclude that the data from pheasant roadside observation surveys are drawn from adequate sample sizes or that they provide the necessary information on distributions, relative densities, and trends for use in management.

Recommendations: A determination should be made as to whether trend count data for pheasants is needed to adjust harvest regulations or provide information to hunters. Consideration should be given to alternate means of achieving these goals, such as use of information on changes in habitat condition and environmental variables such as rainfall. If it is determined that trend count data is necessary to achieve TPWD's objectives, then a second determination should be made concerning the scale of desired application (county, ecoregion, state) and the level of precision needed to allow decision-makers to feel comfortable using those data. Following these decisions, a number of changes to the current roadside observation protocol should be made to place it on a more sound scientific footing.

First, survey routes should be reallocated based on a sound sampling design with sample routes allocated on the basis of optimum allocation procedures for various expected densities of pheasant (i.e., low, medium, high). This process would reduce expected variances and improve estimates generated. This design would also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test. These statistics would improve the scientific basis of the roadside observation counts immeasurably.

Second, the annual collection of roadside counts based on a sound sampling design should be accompanied by routine collection of data designed to test the assumption of constant detection probability. As noted above, absent this second effort, a large degree of caution and skepticism should be exercised in using and interpreting these surveys, particularly in interpreting changes in counts from 1 year to the next.

Third, additional efforts should be made to remove some of the remaining variation associated with observers and counting methodology by requiring training for observers through use of a CD training video or other standardized approach.

Finally, a statement should accompany any report of the results of the pheasant roadside observation survey that indicates the scale to which the data apply, the potential sources of bias that could affect the accuracy of the data, the imprecision of the data, and the importance of interpreting it cautiously.

Roadside Observation Survey: Quail

Background: In 1976 133, 20-mile routes were randomly selected throughout the state. No information was found on calculation of this sample size. To qualify, a route is required to be along an all weather road having minimal vehicular disturbance and minimal human habitation. Initially, each route was counted 4 times, twice in mid-July and twice during the first 2 weeks of August. After the first 2 years of the survey, an analysis of the methodology was conducted. According to staff, only the recommendations of that analysis remain. Those recommendations were 1) to discontinue the July counts (fewer quail observed compared to August); 2) allow lines to be counted either morning or afternoon (no significant difference); 3) allow each line to be counted once (no significant difference was found in ecoregion means when lines were counted once vs. twice); and 4) increase the number of routes from 133 to 266, which presumably was based on a calculation of sample size. Due to legislatively mandated budget cuts, all routes were discontinued in the Pineywoods, Post Oak Savannah, Blackland Prairies, and High Plains ecological areas in 1988. Certain routes in other ecological areas also were discontinued at this time. In 1993, many High Plains routes were reinitiated. The current total number of routes is 164.

Counts by a single observer on the quail survey lines are to begin exactly at local sunrise or 1 hour before local sunset. Lines run in the evening lines are run west to east, and those run during the morning from east to west. Survey lines are driven at 20 miles per hour. All quail observed are recorded by 1-mile intervals. Quail are recorded by species as singles, pairs, or broods. Coveys are recorded separately by number and age class. The age of broods is recorded as 1/4, 1/2, 3/4, or full grown. The route number, county, date, starting time, ending time, beginning and ending odometer reading, temperature, wind, percent of cloud cover, and name of the observer are recorded.

There are written protocols that are provided via TPWD's employee intranet. Training normally is accomplished by having an experienced biologist accompany new observers on their first run. All data are sent to the gamebird program database analyst.

Data are used to monitor quail numbers statewide and by ecological region, forecast the quail hunting season for the public, and formulate harvest and management recommendations. The mean number of quail observed per route per year is used as index to compare relative quail numbers among the ecological regions of the state and to compare quail numbers relative to the long-term mean statewide and within an ecological region. This information is presented in Federal Aid reports and made available to the public on TPWD's web site as a "quail forecast" for a particular hunting season to help hunters maximize utilization of the resource. Staff members report that in areas of the state where landscape scale changes have reduced available quail habitat, the data provide valuable information of significantly declining numbers at the ecoregion scale and are useful as case-building information in regional, statewide, and national quail/bird recovery initiatives (Northern Bobwhite Conservation Initiative, Texas Quail Conservation Initiative, Playa Lakes Joint Venture, Partners in Flight, etc.).

Analysis: A basic assumption for the quail roadside observation survey is that probabilities of detection are constant across survey lines and across years. Probability of detection is known to vary in response to many factors, including weather, changing land use patterns and habitat conditions, reproductive status, season of the year, time of day, and observer performance. According to staff members, the survey may underestimate quail when spring rainfall is below average and July rainfall is above average. This usually results in a late hatch and lush roadside conditions when the survey is conducted, making it difficult to see birds. Lusk et al. (2002) identified a potential bias associated with the survey in which increased counts were associated with increased maximum temperatures in July. They suggest "one might want to temper predictions of bobwhite quail abundance during the next hunting season after a particularly hot summer."

TPWD has adopted a number of standardized data collection procedures to address sources of variation in detection probability. For instance, to minimize known factors that can cause variation in detection probabilities, the survey line protocol requires that lines be conducted 1) beginning either at sunrise or 1 hour before sunset in a consistent direction that maximizes visibility and 2) during the first 2 weeks of August. To minimize bias due to observer performance, there is a standardized form for recording data, written protocols for the survey are provided to observers via TPWD's employee intranet, and training is accomplished by normally having an experienced biologist accompany new observers on their first run. Staff members report that routes are not conducted during adverse weather conditions to minimize this known bias. However, we did not find any guidance concerning adverse weather conditions in TPWD's quail roadside count instructions.

In addition to the known sources of variation in detection probability that the survey methodology attempts to address, there are likely other sources that are not possible to address or even identify. These problems can result in seriously erroneous interpretations of data (Anderson 2001). Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in biological population size. Probability of detection needs to be measured (empirical estimate) to allow the incomplete count of an index value to have meaning.

Nevertheless, findings of DeMaso et al. (2002) and others suggest that hunting success at local scales and harvest at state scales may be expressed as a linear function of the Texas quail abundance index. These findings suggest that a linear relation exists between quail numbers and the quail roadside observation survey counts. Approximately 90% of the variation in the number of northern bobwhite and scaled quail bagged annually can be explained by the mean number of quail observed per survey route in a given ecological area.

It is noteworthy that the quail roadside observation survey lines are distributed randomly. The presence of a sound sampling design should reduce expected variances and improve the reliability of the estimates generated. The statistical power of the technique has not been calculated, and it is not known what percentage change the technique is designed to detect. Power analyses conducted by Bridges et al. (2001) on TPWD survey data collected from 1978 to 1998 found that a doubling in mean quail abundance could be detected in all ecological regions at the $1\text{-}\beta \geq 0.80$ probability level ($\alpha = 0.05$). We understand that means and regression are used to describe the data, and that probability values are calculated for regressions but not for the means. Use of regression and associated probability values appears limited to external publications by TPWD staff members and others.

TPWD's quail forecast web pages clearly discuss the limitations of the roadside survey data and the scale to which the data apply.

Recommendations: TPWD has taken most of the key steps needed to ensure that the quail roadside observation survey is scientifically sound. The survey is based on a sampling design, efforts have been made to reduce variation in detection probability, and there is evidence that the index probably is correlated with abundance. In addition, TPWD has done an excellent job of explaining to the public and its employees some of the important limitations of the data and the scale to which the data apply.

Greater effort, however, should be made to calculate confidence intervals, needed sample sizes to reach some level of precision, and power of the test. These statistics would improve the scientific basis of the roadside observation counts immeasurably. For instance, confidence intervals should be calculated for the mean number of quail seen per route at the state and ecological region scales. These confidence intervals should accompany the mean values reported in Federal Aid documents and in the quail forecast tables and graphs on the TPWD web site.

Increased efforts to estimate potential bias due to variation in detection probabilities may not be warranted given that there have been little if any changes over time in quail hunting season regulations.

Turkey Hen-Poult Counts and Surveys

Background: Turkey hen-poult counts and brood card surveys are incidental observations of turkeys observed during a designated period of time. These surveys seek to provide an index to reproductive success, sex ratios, and density. Hen-poult counts are used to survey habitats of Rio Grande turkey. The brood card survey is used to survey habitats of eastern turkey.

Hen-Poult Counts: Rio Grande Turkey

Background: Summer Rio Grande turkey hen-poult surveys are conducted from June 1 to August 31 each year within the Trans Pecos, Rolling Plains, South Texas Plains, Edwards Plateau, Post Oak Savannah, and Cross Timbers and Prairies. Survey guidelines call for a minimum of 25 hens to be observed during each 2-week period in major turkey counties and a minimum of 10 hens should be observed per 2-week period in marginal turkey counties.

Written protocols are provided to observers with standardized data collection forms on which are recorded the number of hens, poults, hens with poults, poults per brood, gobblers, and unidentified turkeys. Also recorded on the forms are the county, date, time, habitat type, and the location by 10-minute latitude-longitude blocks. No training in the method is provided. The counts are conducted incidental to other duties.

Data reported in Federal Aid reports statewide and by ecological region are total numbers observed of gobblers, hens, hens with poults, poults, unidentified adults, and all turkeys and total number of observations. Derived from this data are percent gobblers, percent hens with poults, the ratio of total poults to total hens, and poults per broody hen.

Data are stored in an electronic format within a centralized location No information is available on the original design or sample size calculations. Sampling is not randomly distributed. According to staff, means and regressions are calculated. The data are used as an index of Rio Grande turkey production in Texas and to provide supplemental data to assess Rio Grande turkey trends at the statewide scale. Data storage is electronic and centralized. Data are reported in Federal Aid documents and reportedly in other unspecified venues.

Analysis: Because there is no estimate of effort in this survey, the total numbers reported of gobblers, hens, hens with poults, poults, unidentified adults, and all turkeys only provide information when used in ratios. Reportedly, the ratio of total number of poults to total number of hens has provided the most reliable index to production. For this ratio to perform as a useful index to production, probabilities of detection must be relatively constant across ecological regions and across years. Probability of detection is known to be affected by weather, changing land use patterns and habitat conditions, level of vehicle traffic, reproductive status, season of the year, time of day, observer performance, biological and behavioral aspects of detectability and a number of other variables.

As far as we are able to determine, relatively minimal measures have been taken to address these sources of variation in detection probability through standardization of data collection procedures. Survey protocol requires that the survey be conducted between June 1 and August 31 and that data be recorded on standardized forms. However, in any given year or ecological region, counts may be made at different times of the day, along roads of varying traffic level, in varying weather and habitat conditions, and with no training of observers. As a result, it is quite likely that detection probabilities differ from year to year or from ecological region to ecological region, which can result in seriously erroneous interpretations of data and provides little confidence that observed trends are real. Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in biological population size. Probability of detection needs to be measured (empirical estimate) to allow the incomplete count of an index value to have meaning.

Sampling effort is not randomly distributed and survey routes involve convenience sampling along roadsides. Because of these survey attributes, no valid inferences can be made from the index to Rio Grande turkey production, and the ability to assess the precision of production index estimates is limited.

Although it was reported to us that means and regressions are used to describe the data, we did not find any examples of their use in Federal Aid reports.

Recommendations: To be a useful index to trends in production of Rio Grande turkeys, the current hen-poult counts would require substantial revision. Hen-poult count protocols would need to be amended to establish a true survey methodology, such as the one employed for quail or mourning doves. Route location and length, time of day survey is conducted, weather conditions under which the survey is not conducted, and observer training would all need to be standardized. Survey routes would have to be distributed randomly. Absent these changes, we do not agree with conclusions in recent Federal Aid reports that the data provide reliable production trend information (DeMaso et al. 2001, Burk 2003). We, therefore, do not recommend continuation of the Rio Grande hen-poult counts in their present form.

If hen-poult counts continue in their present form, at a minimum TPWD should cease its reporting of changes in total numbers from 1 year to the next, such as decreases in total number of poults observed from 2001 to 2002 (Burk 2003). Also, any display of total numbers should note expressly that changes in total numbers do not provide trend information. As noted above, absent information on effort, these total numbers are meaningless.

We are aware that TPWD is funding outside research efforts to develop a valid means of estimating numbers of Rio Grande turkeys in Texas. We applaud that effort and urge that it continue to receive support.

Brood Card Survey: Eastern Turkey

Background: The brood card survey is used to obtain an index to eastern turkey reproductive success and to provide information on flock expansion. A list of 4,000 cooperating landowners in northeast Texas was mailed a brood card survey form during the second week of July in 2001 to survey a period from September 2001 through August 2002. The survey consists of 2 observation periods: May 1 to August 31 and September 1 to April 30. For each period, cooperators are asked to record the number of males and females that they or others have seen in their area and the largest number of turkeys that they or others observed in 1 group in their area. They also are asked to record the number of poults that they or others observed in their area from May 1 to August 31. A standardized, postage-paid data form (brood card) is provided to cooperators, along with a letter, which apparently serves as a written protocol for the survey. There is no training of observers.

Selection of cooperators in the survey is based on their identification by TPWD staff members and the willingness of the cooperator to participate. No sampling of landowners is involved.

The results of the method are said to apply to ecological regions and the State. Mean values are used to describe the data, but no other statistical parameters are employed. Data are kept in electronic form but storage is not centralized. Reporting of data takes place in Federal Aid reports, at professional meetings and to the general public.

Analysis: Because there is no estimate of effort in this survey, the total numbers reported of gobblers, hens, hens with poults, poults, unidentified adults, and all turkeys only provide information when used in ratios. Reportedly, the ratio of total number of poults to total number of hens has provided the most reliable index to production. For this ratio to perform as a useful index to production, probabilities of detection must be relatively constant across ecological regions and across years. Probability of detection is known to be affected by weather, changing land use patterns and habitat conditions, level of vehicle traffic, reproductive status, season of the year, time of day, observer performance, biological and behavioral aspects of detectability, and a number of other variables.

As far as we are able to determine, few measures have been taken to address these sources of variation in detection probability through standardization of data collection procedures. Survey protocol requires that data be recorded on standardized forms. However, in any given year or ecological region, counts may be made in different months of the year and at different times of the day, along roads of varying traffic level, in varying weather and habitat conditions, and with no training of observers. In addition, it appears that guidance given cooperators by the survey protocol letter allows much room to interpret what constitutes their "area," and how and whether to record what others have seen. As a result, it is quite likely that detection probabilities differ from year-to-year or from ecological region to ecological region, which can result in seriously erroneous interpretations of data and provides little confidence that observed trends are real.

There is no sampling effort designed to obtain a representative sample of eastern turkey habitats within ecological regions or for the state as a whole. Because landowners were not selected randomly to achieve an adequate sample of habitats within ecological regions and the state, no valid inferences can be made from the index to eastern turkey production in any region or at the state level, and the ability to assess the precision of production index estimates is limited.

Recommendations: To be a useful index to trends in production of eastern turkeys, the current eastern turkey brood card survey would require substantial revision. We do not agree with conclusions in recent Federal Aid reports that the survey is a useful or acceptable method for evaluating annual production and sex ratios of eastern turkeys (DeMaso et al. 2001, Burk 2003). We, therefore, do not recommend continuation of the Rio Grande hen-poult counts in their present form. We understand that TPWD staff members are conducting a gobbler count on 15-mile transects, combined with cursory habitat evaluation. We also are aware of a proposal, which was not funded, that would use motion detection cameras to develop an index correlated with gobbling counts. We encourage TPWD to continue its efforts to develop a valid means of estimating eastern turkey abundance and production.

Lek Surveys

Lek Count Survey: **Lesser Prairie Chicken**

Background: Lesser prairie chickens (LPC) in the Texas Panhandle are sampled using lek count surveys conducted on delineated study areas on private lands in Gaines, Yoakum, Bailey, Hemphill, Gray, and Wheeler counties. In 1997, TPWD adopted a methodology it developed with other states in the LPC Working Group in which annual and comprehensive surveys are conducted on 6 study areas (e.g., leks per unit area, males per lek, total number of birds per lek). Three of the study areas are in the northeast Panhandle, with 1 in each of Hemphill (67,298 acres), Wheeler (6,720 acres), and Gray (6,540 acres) counties. The other 3 study areas are in the Permian Basin, with 1 in each of Gaines (13,440 acres), Bailey (9,221 acres) and Yoakum (12,378 acres) counties. Demographic data are collected intensively in an area as a sub-sample of the larger regional area. Effort is consistent each year. Time required to completely survey 1 study area varies from 1 to several days, depending on weather, number of observers and size of the study area.

All active leks on each study area are counted for males, females, and unknown-sex birds; in addition, lek location coordinates are taken with a GPS unit. Survey instructions call for the survey to be conducted during the first 2 weeks of April and for counts to be completed in approximately 10 days. Counts are to begin as soon after daybreak as birds can be seen and continue for about 2 hours. Counts in the afternoon are to be avoided. Observers are instructed to get a count of males using binoculars prior to moving in and flushing birds. After the count is concluded, the protocol directs observers to listen for new grounds. Counts are to be conducted only when the wind is less than 15 mph and when the sky is clear and/or partly cloudy. Counting is to be avoided when the sky is overcast. Data are collected and recorded on a standardized survey form.

In addition to surveying all known leks on each study area, efforts are made to search for new leks within the study area. Local biologists may commit up to 25% of their time during the survey period to the search of new leks. If time and resources allow each year and study area surveys are completed, staff members attempt to visit historical and/or known lek locations outside the 6 study areas and collect comparable data to those collected at study areas.

Staff members are trained in survey methodology, although we are uncertain of the method of that training. Means and regressions are used to describe the data, which are stored centrally in electronic format. Data are used to monitor LPC trends and implement regulatory changes if necessary. In addition, data are presented in Federal Aid reports and at annual LPC interstate working group meetings. They also are used in research projects.

The scale for this method is reported as the study areas, ecological region, state, and multi-state.

Analysis: Leks counts are the product of the number of birds observed on leks and the probability of detecting birds on leks. Consequently, fluctuations in lek counts may be the result of changes in this detection probability rather than true variations in size of the biological population. A basic assumption for the LPC lek count survey is that probabilities of detection are constant across study areas and across years. Probability of detection is known to be affected by weather, changing land use patterns and habitat conditions, level of vehicle traffic, reproductive status, season of the year, time of day, observer performance, biological and behavioral aspects of detectability, and a number of other variables. Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in biological population size.

TPWD has addressed sources of variation associated with the LPC lek survey through use of a standardized protocol that seeks to control some of those due to environmental conditions (cloud cover and wind velocity), LPC biology and behavior (time of day and season), and observers (method of counting and training). These standardization efforts to minimize sources of variation improve lek counts and provide more accurate comparisons across study areas and years. Standardization, however, cannot address all variables that affect detection probabilities, and it often is not possible or practical in any case to address or even identify sources of variation in detection probability. Walsh et al. (2004) therefore conclude, "Until lek counts are calibrated to actual population parameters by estimating detection probability, managers must realize the limitations of lek-count data and should be cautious when reporting trend data based on them."

Sampling of leks on which to conduct counts is not conducted in a probabilistic manner. Consequently, it is not possible to make valid inferences from the statistical samples to the biological population from which the samples were drawn and to make assessments of the precision or accuracy of estimated parameters. Absence of a sampling basis for the LPC lek survey results in the inability to determine relative "goodness" of the data generated. As with most sampling procedures, precision and accuracy are the only 2 ways to measure validity. In absence of known biological populations, it is impossible to measure accuracy, so precision remains as the only valid measure of methodology performance. Measures of precision for study area and region (Permian Basin and Panhandle) would be most helpful in judging adequacy of the sampling methodology.

Important issues identified by staff members regarding these surveys are 1) the inability of study area data to be applied to LPC range in the state because of habitat fragmentation and land-use patterns, and 2) the inability of the study area design to provide data on LPC distribution in the state.

Recommendations: We recommend that TPWD conduct or sponsor research to identify additional means of minimizing sources of variation in the LPC lek survey detection probabilities, such as more precisely identifying dates and times of peak attendance and developing a means of estimating the number of leks in an area. For example Walsh et al. (2004) found that peak attendance of sage grouse at leks occurred during a narrow 1-hour window around sunrise, and recommended against counting multiple leks for that species unless they can be completed within 0.5 hour after sunrise. Efforts also need to be made to estimate probability of detection in order to allow the LPC lek survey index value to have meaning.

We recommend that TPWD consider some means of probabilistic sampling of leks on which to conduct counts or to estimate the number of active leks within an area so that it becomes possible to make valid inferences from the samples to the biological population from which the samples were drawn and to make assessments of the precision or accuracy of estimated parameters. For instance, consideration should be given to replacing the current LPC lek survey with one that estimates the total number of active leks through repeated line transect sampling of leks in spring or by other means.

Finally, we strongly recommend that any report of the results of the LPC lek survey indicate the scale to which the data apply, the potential sources of bias that could affect the accuracy of the data, the imprecision of the data, and the importance of interpreting it cautiously.

Lek Distribution Survey: Lesser Prairie Chicken

Background: According to staff, this survey, which is not based on a published methodology, is in place as a cursory investigation of LPC distribution. TPWD has contracted with Texas A&M University to conduct a more detailed investigation of methodologies (including use of FLIR and aerial line transects) to determine LPC distribution in the state. Driving routes are surveyed from April 1 to April 30. Routes are started approximately 20 minutes before sunrise and completed around 9:00-9:30 AM; they are not surveyed after 9:30 AM. Survey routes are located on roads and are arranged in an east to west fashion as much as possible and driven from east to west. Surveys are not conducted when winds exceed 20 mph or if it is raining (light drizzle is acceptable). The survey protocol calls for observers to drive 1 mile, stop and shut off the vehicle, get out of the vehicle and listen for 3 minutes. If LPC booming is detected (or booming LPCs are observed on a lek), their presence is noted on a field survey form and the location recorded. Other data collected include direction the booming was coming from, time, number and sex of birds (if observed), and location (UTM) using GPS information. If the observer marks the positive locations with waypoints (preferred), then the observer also records the waypoint number on the form. After 3 minutes, the observer drives another mile, stops, turns off the vehicle, and listens for 3 minutes. This methodology is continued until the survey route is completed. If the observers hear or see LPCs between stops, they record the observation in the "comments" section of the survey form. In addition, if there is any other information such as heavy background noise (e.g., traffic, oil field activity, irrigation motors, tractors), the observer records that information. The data collected are used to create general distribution maps.

Scale of the method is described as county management (i.e., survey) area, ecoregion, state, and multi-state. Training of observers reportedly occurs, but we were provided no information concerning methods employed. Means and regressions are used to describe the data. No probability values are calculated. Data are stored electronically and centrally.

Analysis: This cursory method makes possible identification of active leks that might otherwise not be identified. However, this methodology is not useful in estimating the number of active leks in an area or changes in the number of leks over time because sampling of areas to find active leks is not conducted in a probabilistic manner. Consequently, it is not possible to make valid inferences from the statistical samples to the biological population from which the samples were drawn and to make assessments of the precision or accuracy of estimated parameters. Absence of a sampling basis for the LPC lek distribution survey results in the inability to determine relative "goodness" of the data generated.

Estimates of lek presence and distribution are the product of the number of leks observed or instances of booming detected and the probability of detecting leks or booming. Consequently, fluctuations in the number and distribution of leks counted may be the result of changes in this detection probability rather than true variations in the number of leks. A basic assumption for the LPC lek count survey is that probabilities of detection are constant across study areas and across years. Probability of detection is known to be affected by weather, changing land use patterns and habitat conditions, level of vehicle traffic, reproductive status, season of the year, time of day, observer performance, biological and behavioral aspects of detectability, and a number of other variables. Slight differences in detection probabilities (due to differences in vegetation, observers, etc.) can lead to completely opposite conclusions about differences in biological population size. Staff members note that bias likely occurs because of limited access to potentially occupied LPC habitats (i.e., searching only on public roads), variation in sightability, and differences in inherent observer traits and observer performance.

Recommendations: We recommend that TPWD consider some means of probabilistic sampling of leks on which to conduct counts or to estimate the number of active leks within an area so that it becomes possible to make valid inferences from the statistical samples to the biological population from which the samples were drawn and to make assessments of the precision or accuracy of estimated parameters. For instance, consideration should be given to replacing the current LPC lek survey with one that estimates the total number of active leks through repeated line transect sampling of leks in spring or by other means.

Dove Production Survey

Background: The purposes of the white-winged dove production survey have evolved over time and include 1) understanding changes that take place in the biological population and evaluating its status and vigor; 2) providing long-term recruitment information to corroborate the white-winged dove call-count survey index and hunting statistics; and 3) providing information on reproductive activity that can be used in formulating and evaluating hunting regulations. In the future we understand that staff members hope to use this information to corroborate or correct for bias in wing age ratios of harvested white-winged doves and to corroborate recruitment rates for an adaptive harvest management model.

To determine nesting success and density, counts of number of nests and number of young fledged are made weekly from the last week in April through the third week in August each year on selected brush tracts in the LRGV. No more than 10 tracts have been selected in which no more than 15 permanent transects are located. Transects located in brush are each 0.25 acre in size (121 yards long by 10 yards wide). Each transect located in citrus is 0.5 acre in size. All nests found on transects are marked individually, mapped on a plat of the transect, and recorded on prepared data sheets. A production index is calculated for each transect as the ratio of total number fledged on each transect during the breeding season to total number of active nests counted at the peak of nesting activity. The technique has not been modified since its establishment.

As best we can determine, the tracts sampled were systematically selected based upon historic white-winged dove nesting densities. Within those tracts, transect starting points were randomly selected. Inference from the survey is made only to the citrus and brush tracts surveyed in the LRGV.

There are written protocols and verbal instruction provided to observers by the area manager of the Las Palomas Wildlife Management Area (WMA) who is in charge of conducting these nesting surveys. This individual also provides the necessary training to cross check compliance by his staff of observers.

The raw data currently are stored only in written format while an electronic (Excel spreadsheet) summary is developed and stored. We understand that the intention is to enter these data into an ACCESS database so queries can be run relating nest substrate and nest height to nest success and various other demographic parameters. There is no centralized data storage. Data have been stored on the Las Palomas WMA manager's and white-winged dove project leader's computers. Now that the project leader position has been eliminated, staff members report that the data will be stored on Mike Frisbie's computer in San Marcos.

Analysis: Because tracts were not randomly selected, inference cannot and is not made to the current range of white-winged doves in Texas or even to all citrus and brush in the LRGV. To make those broader inferences would require randomly selecting an adequate sample of all brush and citrus tracts in the LRGV or of all habitats statewide. In addition, the survey assumes all nests are located 5 yards on either side of the transect. Staff members note previous study in Mexico has found that average nest detection on transects was 75%. Other sources of bias include observer disturbance during nest checks, avoidance by white-winged doves, and nest abandonment (Roberson et al. (2001).

Efforts have been made to reduce the effects of known sources of bias. Frequency of nest searches is limited to once per week to minimize sources of known bias caused by disturbance, white-winged dove avoidance and nest abandonment or predator cuing. Staff members report that representative sampling of all brush and citrus tracts in the LRGV has not been addressed because it is anticipated there will be a switch to using wing age ratios to determine recruitment. Nest transect results are expected to provide 1 form of evaluation of age ratios derived from wings, which may provide an estimate of bias due to differential juvenile vulnerability and early migration.

We agree with Roberson et al. (2001) that on multiple successful nesting species with small clutch sizes and high egg loss, such as doves, the percent of initiated nests that fledge at least 1 young might be a better estimate of recruitment rate and warrants further investigation.

Although it is reported that most basic descriptive statistics are computed for the survey, we did not find any such statistics in the Federal Aid reports examined. No probability values are calculated. No power analysis has been completed to verify that the sample size of tracts and transects are adequate to verify breeding density estimates from the call-count survey.

Because survey results are not extrapolated to all brush and citrus tracts in the LRGV, the data appears to be used at the appropriate scale.

Data are reported occasionally in peer-reviewed journals as justification for habitat studies and to hunters and media as part of a hunt forecast. Otherwise reporting of data is limited to Federal Aid reports.

Recommendations: If use of transects to count nests and related information continues, we recommend probabilistic sampling with stratification of transects to reduce variance of estimates and use of distance sampling to develop a probability of detection function by observer.

Common statistical parameters (mean, coefficient of variation, variation, regression) should be used to a greater extent to describe data in Federal Aid reports and in delivery of information to the media and hunters.

Efforts to centralize data storage and facilitate access to data should be expedited. Efforts to ensure standardized training through instructional CDs or other means should be explored to provide greater continuity in the event of personnel changes at the Las Palomas WMA.

As we understand it, however, the TPWD may wish to adopt an adaptive harvest management strategy for white-winged doves that is similar to one for mourning doves, which will require an annual estimate of recruitment rate. It reportedly is proposed to obtain this estimate using age ratios from wings (hunter collected parts) adjusted for bias due to differential vulnerability of juveniles to the gun and migration of early-hatched juveniles before the hunting season begins. If nest transects are then used as 1 means of evaluating the bias of such a hunter collected parts survey, our recommendations above are still applicable.

Colonial Waterbird Nest Survey

Background: The colonial waterbird nest survey is used to track trends of a highly visible public resource that is dependent on wetlands and is viewed as an indicator of wetland health. From 1974 until 1992, TPWD conducted aerial surveys of nesting colonial waterbirds near the coast in areas not accessible to volunteers on the ground. From the mid-1980's until 1992, TPWD also surveyed inland sites on the ground. In 1992, TPWD discontinued these ground surveys and only conducted aerial surveys near the coast on even-numbered years. In 2002-2003, aerial surveys were expanded to historical nest sites inland in Region 3 to fill data gaps needed to address national colonial waterbird conservation planning efforts.

The survey follows the methods described by Portnoy (1977) with some modification. The original aerial survey method averaged the values of 2 observers. The current survey utilizes 1 observer to estimate number of pairs of white birds and a second observer to estimate number of pairs of dark birds. Dark birds are totally counted with smaller colonies and are given as a percentage in very large colonies; except that in great blue heron and neotropic cormorant colonies they are totally counted regardless of size. Each observer also breaks down the tally into a ratio of different species in their respective color regime. In addition, species composition of flight lines going to and from colonies is estimated for consistency with estimated ratios of species. If they differ "drastically," another flyover is made to re-estimate numbers.

For sites at which nests are scattered across reservoirs on snags, each observer counts the occasional nest from their side of the aircraft. While the original survey technique employed flushing nesting birds from dense vegetation to view all nesters, efforts are made currently to avoid flushing birds. Species mixtures in flight lines are used as an indicator of relative species diversity for use with observed birds nesting on top of vegetation.

With 1 observer conducting the TPWD portion of the survey, there are no longer written protocols. Co-observers are trained on the job. According to staff, to simplify data recording in aircraft, a standardized data sheet is not used. Instead, observations are written by colony on a tablet and transcribed to electronic data sets. Data are compiled by county, river drainage and regulatory district and used at those scales. Means, but no probability values, are calculated to describe the data. Data are stored by the biologist conducting the survey. Results are reported in Federal Aid reports and unspecified other places.

Analysis: Although ground surveys may provide the most accurate counts of nesting adults, aerial surveys usually are the most cost-effective means of surveying colonial waterbird colonies. Nevertheless, dark birds and those that nest within or under vegetation typically are poorly detected by aerial surveys. For these reasons, aerial surveys provide biased estimates of numbers for many species.

Variability in observer performance also is another key source of bias in aerial surveys. Staff members confirm that in a test of the survey there was a high degree of variation between observers.

Recommendations: The measures described below should be adopted, if they are not already in place, to provide a reliable means of estimating changes in colonial waterbird numbers.

First, aerial surveys should be supplemented periodically by counts conducted on the ground. These ground counts should be made very close to the date of the aerial surveys, and should use an appropriate ground survey method (Steinkamp et al. 2003). Totals obtained from the ground surveys can then be used to develop appropriate visibility correction factors for species that are under-sampled by the aerial surveys, so that appropriate adjustments can be made during years when only aerial surveys can be conducted at a colony.

Second, because of the issues associated with observer variability, the use of methods to estimate detection probabilities for each observer is essential. Even slight differences in probabilities of detection by observers can lead to completely opposite conclusions about differences in numbers of pairs and biological population trends. Therefore, probability of detection needs to be estimated empirically to ensure the survey results are reliable.

Third, the survey should be based on a sound sampling design with sampling allocated on the basis of optimum allocation procedures for various expected waterbird nest and colony densities and distribution in the landscape. This process would reduce expected variances and improve estimates generated, and also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test.

Finally, before conducting aerial surveys, observers should receive training in estimating large numbers of birds and in detecting and identifying species from the air (Steinkamp et al. 2003).

Eagle Wintering and Nesting Surveys

Background: The mid-winter eagle survey is a cooperative national survey that follows the protocol established by the U.S. Fish and Wildlife Service, which coordinates the survey. TPWD participates by coordinating volunteers and managing its data. Staff members report, "the winter survey reportedly originated with the National Wildlife Federation and basically surveyed lakes that wintered eagles that volunteers had interest and access." We understand that the efforts have been to repeat surveys as they have been conducted in the past for trend data. However, because this survey follows a nationally-established protocol, it is outside the scope of this review.

The nest survey is a Texas survey that was developed independently of other state surveys. Staff members were not aware of any publication describing the nesting survey. The method consists of landowners and land managers contacting TPWD staff members with information on the location of nests and aerial surveys to locate new nests and replacement nests.

There are no written protocols or written guidelines provided to those participating in the nest survey. However, nest survey staff members (2) apprenticed under the surveyor for their region before taking over. There is a standardized data sheet. Data are stored in electronic format by 1 person. Survey staff members retain their own records.

Nest survey data are used at the state scale to identify and track bald eagle nest locations for regulatory purposes to avoid damage to eagles, and are used to track status of biological populations. Means, but no probability values, are calculated to describe the data. Results are reported in Federal Aid reports and unspecified other places.

Analysis: The nest survey depends on obtaining information from landowners and land managers about nest location and on the ability to locate nests from the air. Many nests are positioned in the trees that are difficult to view. Staff members note that they obviously do not locate every nest, but believe they are tracking an increase in number of nesting eagles of about 10% per year.

From the little information we were able to obtain on the nesting survey, it appears as though it is a reasonable means of locating and tracking bald eagle nests for purposes of informing regulatory decisions and avoiding adverse effects to nesting eagles.

We saw no evidence of any methodology that would lead us to believe that the nesting survey provides reliable information on the status of nesting eagle numbers or trends. Efforts to minimize sources of known bias consist of regional coordinators for the nest survey frequently discussing what is observed and how to ensure that each observation is handled consistently.

Recommendations: If TPWD wishes to utilize the bald eagle survey as a means of estimating trends in the status of nesting bald eagles in Texas, then a number of measures need to be taken.

First, the survey routes should be based on a sound sampling design with sampling allocated on the basis of optimum allocation procedures for various expected bald eagle nest densities. This process would reduce expected variances and improve estimates generated. This design would also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test.

Second, consideration should be given to conducting aerial line transect surveys to estimate abundance or density of bald eagle nests (Burnham et al. 1980).

River Otter Survey

Background: Data are collected to demonstrate presence/absence of river otter sign at a county and district level in the Pineywoods ecological region of the State. The stated needs are to demonstrate a sustainable resource for the issuance of CITES tags for river otter and to provide a baseline for ecosystem health in the Pineywoods.

Otter sign, along with other furbearer sign, is observed under designated bridges in District 6. Generally, there are 10 bridges per county. In 2003, 253 bridge locations were surveyed in 27 counties. Bridges are visited during January or February every third year. Survey areas must be undisturbed (wash-out, etc.) for at least 1 week prior to the survey. All surveyed areas are within state or county ownership. All suitable substrate under the bridge and within the right-of-way is surveyed. Bridges surveyed are limited to those for which there is sufficient space under the bridge for human access and a suitable, exposed substrate for tracking. Presence or absence of otter or other furbearer tracks are recorded. No attempt is made to determine number of unique individuals. If a survey point is no longer suitable, observers may survey an alternate point as close as possible along the same waterway.

Written protocols are supplied to staff members each time the surveys are conducted. Training was held for the entire staff the first 2 years the surveys were implemented. Reportedly, each time a new observer is hired 1 of the established employees will accompany the new employee on all of the bridges in areas of responsibility and provide training on identification of otter sign. A standardized data sheet is used, which is in digital form for ease of dissemination to staff. No statistical parameters are calculated to describe the data. Data are stored in electronic format in an Excel spreadsheet on the District Leaders computer for District 6. Reporting of data is limited to Federal Aid reports.

Analysis: Recorded data are used to calculate the percentage of bridges with otter sign and provide trend information. Evidence of otter presence at a survey location provides information on otter distribution. The percentage of bridges with otter sign is used as an index to otter abundance.

Searches for sign are a common method of monitoring and estimating abundance of furbearers. Standardized otter survey techniques in Europe and elsewhere have involved searches for otter sign in set lengths of riverbank in good habitat and utilizing bridges as access points. These standardized techniques do not appear to have been utilized in the TPWD survey. Efforts also have been made by others to estimate probability of detection through use of radio telemetry data. No such estimates have been made or utilized by TPWD in this survey. For the percentage of bridges with otter sign to perform as a reliable index to relative otter abundance, probabilities of detecting otter tracks must be relatively constant across counties and across years. Probability of detection is known to be affected by observer performance (e.g., ability to accurately identify otter tracks), quality of substrate for reading tracks, level of other animal and human activity under the bridge eradicating tracks, flood or drought events, biological and behavioral aspects of detectability, and a number of other variables.

Efforts are made to minimize variability in detection probabilities through use of a standard protocol, limiting observations to a 3-month period, on-site training, relocation of bridges to obtain satisfactory substrate, and standardized waiting periods after environmental events that may hamper reading of otter tracks. These efforts to minimize sources of variation improve the river otter survey and provide more accurate comparisons across study areas and years. There appear to be additional opportunities to reduce variation by requiring more formal training in identification of otter tracks and other aspects of the method and shortening the duration of the survey period. Standardization, however, cannot address all variables that affect detection probabilities, and it often is not possible or practical in any case to address or even identify sources of variation in detection probability. As a result, it is quite likely that detection probabilities differ from year to year or from county to county, which can result in seriously erroneous interpretations of data and provides little confidence that observed trends are real. Slight differences in detection probabilities (due to differences in substrate, observers, etc.) can lead to completely opposite conclusions about changes in numbers of river otters.

Sampling of substrates on which to look for river otter tracks is not conducted in a probabilistic manner, and survey locations involve convenience sampling under bridges. Because of these survey attributes, no valid inferences can be made from the percentage of bridges with otter sign to relative abundance of river otter, and the ability to assess the precision of the river otter index estimates is limited.

Recommendations: The percentage of bridges with otter sign needs to be calibrated to otter abundance by empirically estimating probability of detection. Because observers are a likely source of variability, use of methods to estimate detection probabilities for each observer is essential. Absent such effort, great caution should be used when reporting trend data that is based on the river otter survey. We do not agree, for example, that there is sufficiently reliable information available to support the statement in the most recent Federal Aid report (McGinty and Young 2003), "When compared with previous survey results, river otter populations appear stable."

The survey of substrates under bridges should be based on a sound sampling design with sampling allocated on the basis of optimum allocation procedures. This process would reduce expected variances and improve estimates generated, and also allow calculation of confidence intervals, needed sample sizes to reach some level of precision, and power of the test.

Finally, before conducting river otter surveys, observers should receive formal training in identifying otter tracks in the presence of other animal tracks.

Harvest Surveys

Background: Estimation of hunter harvest is 1 of the primary functions of a state fish and wildlife agency. Hunter harvest can be estimated in a variety of ways including mail questionnaires, mandatory registration stations, check stations that sample hunter harvest, telephone surveys, hunter diaries and hunter/landowner report cards. Each method has tradeoffs between precision and cost, accuracy and bias. TPWD is 1 of 26 state fish and wildlife agencies that use mail questionnaire surveys to estimate some types of hunter harvest (Rupp et al. 2000). The Wildlife Division conducts 5 different harvest mail questionnaire surveys: Small Game, Big Game, White-winged Dove, Lesser Prairie Chicken and Public Hunt Harvest. TPWD Wildlife Division also operates mandatory registration stations to monitor eastern wild turkey harvest and hunter/landowner report cards for enumerating alligator harvest. TPWD also cooperates within the flyway system with other states and the U.S. Fish and Wildlife Service on surveys intended to estimate sandhill crane, waterfowl, dove and other migratory bird harvests.

Harvest Survey: Small Game

Background: The small game harvest survey was first completed after the 1981-82 hunting season. Various iterations since the inception have included other species with the most recent survey amendment adding prairie dog. As of 2003, the list of species surveyed through the small game harvest survey included mourning dove, scaled quail, rabbit, fall turkey, combined turkey, woodcock, rail, sport bobcat, sale bobcat, bobwhite quail, combined quail, squirrel, spring turkey, pheasant, snipe and gallinule. The purpose of the survey is to track hunter and harvest trends at the statewide level. Analysis is also done at the eco-region, county, administrative region, resident status and month level. For dove and turkey, analysis is also completed at the zone level. A random sample of 15,000 license buyers is drawn from all valid licenses in February. With the incorporation of point-of-sale licensing, the sample is drawn from current license holders. A standardized questionnaire is provided to each hunter sampled. Non-respondents are sent 2 repeat mailings, at 1 month and 2 months post survey respectively.

Analysis: TPWD recognizes that the small game harvest survey was designed to provide estimates at the statewide level. Precision at smaller levels is not optimal and the results for some species may be unusable, especially at the county level and for all levels for those species with a small number of hunters. Return rate is currently around 40%, but historically ranged 55-60%. For each species and geographical unit combination, means and 95% confidence intervals are calculated for number of hunters, successful hunters, success rate, hunter days, successful hunter days, days per hunter, days per successful hunter, kill, kill per hunter, kill per successful hunters, kill per day per hunter and kill per day per successful hunter. The data form a negative binomial distribution because of the large number of zero values. All estimates except for turkey and bobcat have the kill transformed using an arc hyperbole sine transformation to normalize the data and reduce the effect of a few large harvest or day values.

Non-response bias is addressed via 3 mailings. Previous analysis has shown that participation and harvest rates decrease with subsequent mailings. A regression equation has been developed to predict the cumulative estimate if all hunters returned the small game survey. TPWD recognizes the statistical vulnerability of basing the regression on 3 data points with an assumption of linearity.

Data and results of analysis are stored at TPWD headquarters. Data are published in Federal Aid reports.

Recommendations: While WMI applauds the logical approach to estimation of non-response bias in the small game harvest survey, we cannot overlook that the "cure" is the same method as the "disease". While it may seem logical that subsequent mailings result in lower estimates of participation and harvest, extrapolation to the larger sampling universe based on a straight line defined by 3 data points is not sound science. An alternate form of survey is necessary to independently establish trends of non-respondents.

Both the small game and the big game harvest survey estimate fall turkey season harvest. TPWD believes that the big game harvest survey is more accurate. Because the 2 surveys are correlated, a correction factor was added to the small game harvest survey in 1999 so that the estimates in the small game survey are close to the estimates of the big game survey. TPWD warns the public to only use 1 source for turkey harvest data and to be sure to state the source of the estimate. WMI recommends that this potential source of confusion be eliminated by removing the species from 1 of the 2 harvest surveys.

TPWD recognizes the problems of estimating from small sample sizes, but appears from the documentation received by WMI to include such estimates nonetheless: "if there is even one hunter the estimates are made and printed" (Small Game Harvest Survey Results 1986-87 thru 2002-03. TPWD 10 July 2003). WMI recommends that no estimate be made and printed without a corresponding confidence interval. If the confidence intervals are larger than the agency can accept, the estimate should not be made.

TPWD also recognizes the inherent problems with samples generated by hunters who hunt more than 1 county or month and by the aggregation of counties into ecological regions based upon deer distribution. Both procedural problems can be corrected by amending the survey or analysis. WMI recommends that TPWD initiate solutions to the problems identified by staff.

Harvest Survey: Big Game

Background: TPWD uses the Big Game Harvest Survey to track big game harvest and hunter trends. Prior to 1972-73, big game harvest estimates were derived from landowner surveys, game warden estimates, shooting preserve record books and antlerless permit utilization rates. Only the landowner surveys used a statistical approach and the survey was based on interviews of randomly selected landowners who provided harvest estimates for their property. Beginning in 1973-74, big game harvest estimates for white-tailed deer, mule deer and fall turkey were derived from a mail questionnaire to a random sample of approximately 2.5% of all licensed hunters. Non-respondents were mailed a second questionnaire. In 1978, javelina was added to the survey. The purpose of the survey is to track hunter and harvest trends at the statewide and eco-regional level. A power analysis determined 25,000 samples were adequate for estimates at the eco-region level and above. Analysis is also done at lower levels (e.g., county and reporting unit), but TPWD recognizes that the precision is lower and the results are only provided as "references".

Analysis: Implementation of the point-of-sale licensing system allows the 25,000 random samples to be drawn from current license holders. Each license holder is provided a standardized questionnaire that asks for estimates of harvest and time spent hunting. Return rate is currently about 37% but traditionally ranged between 50-60%. To correct for non-response bias, telephone surveys were conducted in 4 years during the mid-1970's. Correction factors were determined from analysis of the phone interviews. Statistical parameters used to describe the data include means, standard deviations and 95% confidence intervals. Data are stored in Austin and reported in annual Federal Aid reports.

Recommendations: The 25,000 sample size was chosen based upon higher return rates than currently achieved. Precision and power are believed by TPWD to be dropping. WMI recommends that TPWD increase sample sizes to levels that allow acceptable limits of precision and power. As with the small game survey, WMI recommends that no estimate be made and printed without a corresponding confidence interval. If the confidence intervals are larger than the agency can accept, the estimate should not be made.

Estimates should not be produced as "references" without corresponding confidence intervals. Sampling designed for statewide or eco-regional levels should not be extrapolated to lower levels.

The correction factors for non-response bias are now 30 years old. Prudence would suggest a repetition of phone interviews, or other methods, to assess current non-response bias.

Harvest Survey: White-winged Dove

Background: The purpose of the white-winged dove harvest survey is to provide estimates of white-winged dove harvest, hunters, hunter days and success by county, hunting zone, ecological area and statewide. Texas white-winged dove hunters are required to purchase a Texas white-winged dove stamp. Stamps may be purchased separately, or are included automatically within combination hunting/fishing licenses. The survey is broken into 2 components to assess the September white-winged dove special season and the regular mourning dove season which ends in early January. A 2-stratum sampling scheme is used to partition the sample between stamp holders and combination license holders. A random sample of 1,000 stamp and 2,000 combination license holders (4.3% and 1.6% of the sampling populations, respectively) is drawn for the survey of the special 4-day white-winged dove season. Another random sample of 1,000 stamp and 2,000 combination license holders (2.2% and 0.6% of the sampling populations, respectively) is drawn to survey the 5-month regular dove season.

Analysis: Statistical parameters used to describe the data include mean and standard deviation. Hunting activity and harvest parameters are expanded by stamp and combo license sales to produce estimates of hunter numbers, days hunted and harvest on an area and statewide basis. The sample size of 3,000 for each part of the survey was chosen when return rate was much higher. Because return rate is dropping steadily, precision and power of the estimate are dropping. Bias related to memory and prestige normally associated with post-harvest sampling is recognized by TPWD. Data are stored in Austin and reported within Federal Aid reports.

Recommendations: As response rate declines, the corresponding declines in precision and power become problematic. WMI recommends that the white-winged dove stamp be removed as an automatic component of combination licenses. Other forms of sampling that are not based on mail questionnaires should be investigated.

Harvest Survey: Lesser Prairie Chicken

Background: The LPC Harvest Survey is used to determine a statewide estimate of LPC hunters, harvest, cripples lost and hunter days. The survey is mailed to all holders of the free prairie chicken permit after the end of the season. No follow-up mailing is conducted, so no corrections are made to address non-response bias. Data are stored in Austin and provided to the regional and district offices in LPC range. Data are reported within Federal Aid reports.

Analysis: Besides the statewide harvest and effort parameters, the survey also provides means and 95% confidence intervals on birds seen, group size, years hunting and hunter age. Hunter numbers is calculated from the binomial distribution formula, while all other statistics are normally distributed.

Starting in 1998, LPC harvest permits were made available through the electronic point-of-sale system. License clerks, apparently because the permit was free, encouraged hunters to take the permit, even though they had no intention of hunting LPC. Because the survey is mailed to all hunters, sample size increased dramatically, but response rate decreased. TPWD recognizes that giving the permit to hunters that do not request it has caused great problems. Sample size for the survey has grown from 1,795 in 1997 to 14,677 in 2001. Return rate has subsequently fallen from >60% to <30%.

Recommendations: As noted in the write-up on the white-winged dove survey, any artificial expansion of the sampling frame lowers precision and decreases power. In the case of the LPC harvest survey, the fact that the permit is free and available to those with no intention of hunting LPC artificially increases the sampling universe. The resulting statistics are less precise, a condition not conducive to management of a species in the conservation status of LPC. WMI recommends that permit availability be constrained to only those hunters intending to hunt for LPC.

Harvest Survey: Public Hunt

Background: Texas hunters who purchase the Annual Public Hunting Permit are entitled to hunt for a variety of species on the 1.2 million acres of lands owned or leased by TPWD. The Public Hunt Survey is designed to collect data on usage and harvest from those hunters participating in the Public Hunt Program. The primary purpose of the survey is to quantify lease payments made to the private landowner whose lands are leased as public hunting lands by TPWD. The survey also generates estimates of hunting interest and harvest for 10 different species or species groupings within each public hunting unit and generates estimates of days hunted and the number of trips. These estimates of the hunting unit are used as indices to evaluate its hunting conditions. The survey is conducted by using a mail questionnaire administered to a random sample of 20,000 of the approximately 40,000 Annual Public Hunt Permit purchasers. A second mailing is made to non-respondents 1 month following the survey mailing. Survey response is approximately 32-35%. Statistics are generated at the statewide, hunting unit and landowner level and include the mean and a measure of variation. Data are stored in Austin.

Analysis: Total hunting days are summed from the respondents to the survey. An individual private landowner receives a percentage of the total revenue from the annual permit sales equal to the percentage of hunting use occurring on his land(s). The percentage of hunting use for the land owned by a landowner within the Public Hunt Program is equal to the proportion of the total hunter days that occurs on his land. TPWD recognizes that a 60% non-response rate may introduce non-response bias. Because the Public Hunt Survey is not used to estimate game harvest, however, TPWD believes the bias is negligible.

Recommendations: For several reasons, the public hunt survey is collecting information that does not meet a scientific standard. First, the recognized non-response bias inherent in the public hunt survey invalidates it use as a harvest estimator. Unless the non-response bias is corrected, harvest information should not be queried within the survey. Second, the design of the survey does not allow hunters who pursue multiple game species to distribute their time spent in pursuit of each. Statistics on the number of days of hunting and the number of trips cannot be broken out for those hunters who pursue multiple game species, which therefore invalidates the summation over all participants. Finally, the process of monetizing lease opportunities based on the percentage use indicated through the survey may itself be subject to response biases. A 15% response (6,000 out of 40,000) appears on the surface to be too imprecise to allocate lease revenue. Unless these biases are corrected, the distribution of lease payments to private landowners may be invalid.

Harvest Survey: Eastern Wild Turkey

Background: TPWD used harvest registration of eastern wild turkey to track trends in harvest and hunter effort. Registration stations are established in counties with an eastern wild turkey season. Registration station agents record data on harvested turkey brought to the registration station. Agents are provided standardized data forms and instructions. WMI was made aware of no other training of agents. Data collected by registration agents describe harvest and hunter effort by county. Data are used by TPWD to refine seasons. Data have been stored by the project leader, but are now being transferred to Austin. Data are reported in Federal Aid reports.

Analysis: Annual harvest is the summation of registration forms returned by station operators to TPWD.

Recommendations: None

Harvest Survey: American Alligator

Background: TPWD collects harvest data on alligator to track trends in harvest, commercial demand and alligator distribution. Texas' most recent seasons on alligator began in 1984, after protection was afforded the species following major declines in the 1900s. Harvest has stabilized, but is somewhat affected by market prices for alligator hides. Alligator hunts are available on selected TPWD wildlife management areas, several U.S. Fish and Wildlife Service National Wildlife Refuges, and on private lands. To take alligators, hunters are required to have a wild harvest CITES alligator tag as well as a Texas alligator hunting license. License allotments are established through a formula that establishes quotas for important alligator habitat types.

Analysis: Managers and/or landowners of properties with alligator hunters report alligator harvest. Reports provide an estimate of harvest by property. Annual harvest is the summation of report cards received by TPWD. No other statistical parameters are generated. Data are stored at a WMA and reported in Federal Aid reports.

Recommendations: None

Harvest Survey: Sandhill Crane

Background: Texas is one of the cooperating states in the mid-continent sandhill crane harvest survey. The survey is conducted by the Harvest Survey Section of the U. S. Fish and Wildlife Service, but the Service relies upon the states to provide hunter sampling data. The Office of Management and Budget has notified the Service that it will recommend eliminating the survey unless hunter response rates improve significantly.

Analysis: TPWD assessed non-response bias in the sandhill crane harvest mail survey through a special telephone survey conducted by the University of Texas. The assessment found that 80% of non-respondents did not hunt sandhill crane and that 44% of non-respondents did not remember requesting a sandhill crane hunting permit.

Apparently vendors under the new point of sale system are encouraging hunters to take all available permits. While there are likely other sources of non-response, the dilution to the sampling pool caused by non-sandhill crane hunters accepting sandhill crane permits is a contributing factor to the non-response, and probably significantly affects the precision of the estimate. The Office of Management and Budget has recommended that the Service improve response by including a cover letter with the survey and by increasing the number of follow-up letters to 3. If these methods do not increase the response rate to >75%, the Service has been instructed to conduct follow-up phone surveys to analyze whether non-response bias exists.

Recommendations: The dilution of the sampling pool caused by hunters taking sandhill crane harvest permits even though they have no intention of hunting sandhill cranes lowers the utility of the survey substantially. WMI recommends that TPWD constrain the availability of sandhill crane hunting permits only to those hunters who intend to hunt sandhill crane. Further steps, including follow-up phone surveys, may be necessary if response rates to the mail questionnaire continue to decline.

Harvest Survey: Waterfowl, Doves and Other Webless Migratory Game Birds

Background: Texas cooperates with other states and the U.S. Fish and Wildlife Service in the national Harvest Information Program (HIP). To hunt migratory birds in Texas, hunters must be HIP certified. TPWD certifies hunters for HIP through the point-of-sale license system. License venders are required to ask hunters if they intend to hunt for migratory birds. If they respond in the affirmative, hunters are asked about harvest levels and species hunted. The Texas HIP data is combined with other states HIP data to form a national database on harvest of migratory birds.

Analysis: For several reasons, the numbers of HIP certified hunters are artificially high in Texas. When hunters are HIP certified, but do not intend to hunt migratory birds, the sampling frame for evaluation of migratory bird harvest is diluted. TPWD estimates there are approximately 500,000 migratory bird hunters in Texas, yet there are 800,000

HIP certifications. One reason for overcertification is the automatic issuance of waterfowl and white-winged dove stamps within the Super Combination license. There are approximately 320,000 Super Combination licenses sold in Texas annually. While a percentage of Super Combination license buyers likely hunt migratory birds, TPWD cannot segregate those that do not hunt from receiving migratory bird stamps. Thus the sampling frame is diluted and estimates of harvest made less precise. A second problem likely lies with the license vender's understanding of and compliance with HIP procedures.

Recommendations: The agency needs to increase the validity of HIP harvest estimates by constraining migratory bird permits only to those hunters who intend to hunt mourning dove, waterfowl or other migratory birds. WMI understands that the agency benefits from an attractive, cost-effective combination license package, but licensing packages should not add additional levels of uncertainty to the management of migratory birds and their harvest.

WMI also recommends that TPWD improve the reliability of HIP estimates by improving awareness and understanding among license venders. Other states are dealing with this issue and TPWD would benefit from dialogue with those states.

Age/Condition Of Hunter-Harvested Game Animals

Background: Age and condition of game animals taken by hunters provides insight into age structure, health and condition and hunter harvest rate. Age data are also frequently required for estimation procedures. TPWD Wildlife Division staff members collect age and condition data from hunter harvested eastern wild turkey, white-tailed deer, mule deer and alligator.

Data are collected to monitor trends in eastern wild turkey. For mule deer, data are meant to monitor animal condition and antler development, create harvest age structure comparisons (local, compartment and county levels) and support harvest recommendations and decisions regarding regulation changes. For white-tailed deer, TPWD regulatory staff members use age and antler information to determine regional and county differences in deer condition, antler development, and the age and sex ratios of deer harvested. The data are believed to be useful in helping demonstrate the effects of various regulations on white-tailed deer age structure and sex ratios in the harvest. Age and sex ratios are also believed to help determine progress or lack thereof in managing white-tailed deer.

The techniques are also designed to measure the effect of biotic and abiotic variation on animal condition. Eastern wild turkey data, for example, are believed to reflect weather conditions, annual turkey breeding chronology, hunting conditions and mast crop. White-tailed deer and mule deer data are believed to represent the interaction between hunter density and selection, habitat quality, herbivore density and environmental (especially rainfall) conditions. Depending upon the sampling, the interaction sampled may be at the ranch, county, reporting unit and/or the ecoregional level.

All surveys collect data on age and sex. White-tailed deer surveys also collect information on dressed weight, antler beam circumference, antler spread and the number of antler points. Mule deer surveys are similar to white-tailed deer surveys. Eastern wild turkey check station data includes spur length, weight and beard length.

TPWD staff members are responsible for data collection in the white-tailed deer, mule deer and alligator surveys. Hunters make the measurements and report data in the eastern wild turkey survey.

<u>Analysis</u>: All surveys are bounded by the assumption that samples of hunter-harvested animals represent biological population age or condition values. Although bias is expected in some surveys, TPWD staff members assume that bias does not contort the results.

The white-tailed deer survey assumes that sample distribution is randomized within subpopulations of deer exposed to "average" management for the county or reporting unit. This is a difficult sampling threshold. Biological age and condition sampling must be predicated on a cause-and-effect basis (Steidl et al. 2000). Harvest regulations intended for the county as a whole must be assessed by deer harvested under those specific regulatory constraints, so that the adequacy of regulations can be influenced by the data collected on age and condition. Deer herds managed under a different set of harvest regulations on intensively managed properties do not represent the "average". TPWD programs accentuate the ability for private landowners, who desire, to manage the deer herds on their property and create regulatory flexibility to allow landowners the ability to achieve their management goals. County-specific regulations are not intended for these intensively managed properties, and should not be affected by the deer sampling therein. TPWD is correct in asking biologists to segregate data collection, but the process used is open to misinterpretation and/or misapplication by well-intentioned field staff.

All surveys assume that sample size is adequate. Sampling adequacy may be assessed by analyzing variation in measurements at different sampling intensities. As Steidl et al. (2000) state: "Virtually no 2 biological entities are identical, and even small, meaningless differences can be detected with large sample sizes and high precision of measurement." "The genuine question is whether 2 populations differ by a biologically meaningful quantity" (Steidl et al. 2000). In other words, TPWD must interpret the interface between statistical significance and biological significance.

All surveys are built around the assumption that they are representative of some predetermined geographical area. For the assumption that certain measurements are reliable at a specific geographical sampling frame, a stepwise analysis of variances obtainable at different sampling intensities would be required to frame the power of sampling at one frame versus another. No such analysis has been accomplished for eastern wild turkey, white-tailed deer, alligator or mule deer age and condition surveys.

All surveys assume that the aging technique is valid. For deer, TPWD relies upon tooth eruption and wear. The tooth eruption and wear technique, however, was documented to be an accurate age estimator for only 42.9% of samples of known-aged white-tailed deer when compared to cementum annuli (Hamlin et al. 2000). The tooth eruption and wear technique tended to overestimate young animals and underestimate ages of older animals, a measurement error likely to skew interpretations of age structure important to management of harvest. For eastern wild turkey, station operators judge a harvested turkey as juvenile (jake) or adult. Biologists also interpret beard and spur measurements to classify the sample as juvenile, second year or adult. No study has confirmed the reliability of turkey ages obtained through this procedure.

Deer surveys assume that condition variables (antler measurements and dressed carcass weights) are reflective of either deer density or a specific known environmental variable. No assessment has determined the degree to which condition measurements vary on a county- or reporting unit-wide basis. Some regions report conflicting relationships where both density and condition are positively correlated.

Eastern wild turkey surveys assume that information collected by citizen check station operators is valid and accurate and that biologists are consistently able to translate weight, beard length and spur length into an accurate age category.

Data analysis is rudimentary. No probability values are calculated for any dataset. Depending upon the species, data are reported as mean values, frequencies or counts. Confidence intervals on mean values are in some instances not calculated, or if calculated, are not reported.

The geographical area represented as a significant unit in sampling scale varies from species to species, ranging from the ecoregion to a subsection of a county. Eastern wild turkey data are believed to be representative of the ecoregion. White-tailed deer data are representative of the reporting unit (aggregation of counties) or county. Mule deer data are representative of the county or the management compartment (subsection of county). Even when the representative scale may be larger than the county, data in all instances are still reported by county.

Age and condition data are collected from hunter-harvested game at locations where there is a high probability of TPWD Wildlife Division staff members encountering a high number of animals to sample. The single exception is for eastern wild turkey, where unmanned biological check stations are located at gas stations and stores that serve as a turkey harvest registration stations in counties with an eastern turkey spring hunting season. White-tailed deer are sampled at cold storage facilities and hunting camps within counties where there is a predetermined need for intensive harvest information and the perceived ability to obtain data. Mule deer condition and age data are also collected from cold storage facilities and hunting camps, but sampling is conducted throughout the hunted mule deer range. Alligators are sampled at some coastal WMAs.

Sampling intensity varies. For white-tailed deer, the sampling goal is to measure 100 bucks and 100 does from within each of approximately 60 counties per year. In some locales where it is difficult to obtain samples, data from groups of counties are lumped. White-tailed deer weight samples are only collected every 5 years. For eastern wild turkey and mule deer, the desired sampling intensity has not been estimated. Mule deer are collected “whenever available”.

No sampling scheme for any species has been designed to yield random samples, nor has the power of any sampling scheme been determined. Staff members collecting data on white-tailed deer are instructed to only collect data representative of biological populations affected by county harvest regulations. For example, data from “Managed Lands Deer Permit” properties may contribute towards a county-wide mean value as long as the data are not significantly different from the county-wide mean value, in the opinion of the biologist.

All schemes are susceptible to observer bias, observer training and inaccuracies in the application of standard methodology. TPWD recognizes that white-tailed deer data are limited by the accuracy of the aging technique. Mule deer age data may also be limited to the same extent, since the tooth replacement and wear techniques used to age both species are similar. Locker plant checks may also be susceptible to skewed age ratios because of selective use of locker plants by hunters. Age ratios, especially of males, may be skewed by hunter selectivity.

Written protocols are available for the white-tailed deer survey but have not been distributed frequently on an annual basis since the 1970's. Project staff members indicate that regular annual distribution of protocols will begin in 2004. Written instructions are provided to citizens manning eastern turkey check stations.

Training is variable. Observers collecting white-tailed and mule deer data receive their training during their first surveys with another (experienced) employee. "A Guide to Age Determination of White-tailed Deer" has been developed to help new employees (learn the technique) and perhaps serve as a reference for experienced employees. Other than the instruction sheet, reviewers were not made aware of any training provided to eastern wild turkey check station operators.

Data collection for all species appears to be standardized but access is variable. There is a standardized data sheet for all species. Both mule and white-tailed deer data are stored in an electronic format available to both program and field staff in TPWD headquarters. Eastern wild turkey and alligator data are stored by field staff and are not maintained in a centralized location available to all.

<u>Recommendations</u>: The issue of randomness is problematic in age/condition surveys. First, hunters do not kill randomly, and hunter selectivity will vary tremendously on several different scales. Second, if TPWD sampling of hunter harvest was randomized, it likely would make representative sample sizes much more difficult to obtain. So, like spotlight surveys, the lack of randomness in sampling must be accepted as reality. To somewhat offset the lack of randomness, much more attention needs to be paid to the inherent biases that affect the sampling frame.

To quantify the assumption that harvest samples of age represent biological population values, an independent sample of age structure must be obtained. For white-tailed deer, the strategy of comparing antlerless age structure to buck age structure may yield important insight into the biases of buck age sampling. Selectivity of hunters for certain ages of antlerless deer is assumed to be less than selectivity for hunters for certain ages of bucks. Selectivity by hunters for adult does when accompanied by fawns or yearlings, however, is an unquantified bias in antlerless age structure. For mule deer, because antlerless harvest is low, no independent harvest-based samples are available. If age structure is deemed to be valuable to management, then the biases of harvest age structure need to be determined. Other jurisdictions have used age structure of road kills and hunter surveys to provide additional insight into age structure.

To quantify the assumption that harvest samples precisely represent the true age structure of the harvest, statistical confidence intervals must be calculated and reported. WMI recommends that all mean values that are reported be accompanied by a confidence interval. In addition, statistical power must be calculated for all tests. What percentage change in age structure or condition does TPWD recognize that it needs to detect in order to trigger a regulatory change?

To quantify the assumption that harvest samples are representative of the geographical area they are intended to represent, WMI recommends that sampling be aggregated at different geographic scales, and coefficients of variation used to determine when sampling is representative. Mean values and confidence intervals should only be reported for the geographical unit for which TPWD believes to be representative. Reporting of values at smaller scales should cease.

Inaccuracies and biases in aging techniques must be known. WMI recommends that TPWD increase training of both new and experienced observers in aging. Annual testing of observers should be initiated. WMI also recommends that alternative aging techniques be used to compare with current techniques used to estimate age.

Using check stations to assess harvest sex ratio is less efficient than the standard harvest survey. WMI recommends that harvest sex ratio not be reported from age/condition surveys.

Cause-and-effect needs to be determined before measures of weight and antler dimensions are utilized in regulation setting. Changes in condition that are believed to represent density effects will mislead decision-making if the changes in condition are artifacts of inadequate sampling or reflect an environmental condition. There are several correlated recommendations to address this issue. Standardized measures of density-independent factors that influence weight and antler dimensions (rainfall, winter severity, summer severity, mast availability) must be developed and used to assess cause-and-effect relationships. Second, the responsiveness of weight and antler dimensions to both biotic and abiotic factors must be shown at the scale at which the data are collected. Extrapolation of studies conducted on WMAs and/or single ownerships to county-, reporting unit, or ecoregion scale is not adequate. Regulatory units must be used as experimental units to assess the true cause-and-effect of regulations on condition and age structure. WMI recommends that condition data not be collected unless accurate cause-and-effect relationships are shown at the regulatory unit level.

Hunting pressure (hunter density) and harvest rate (harvest per hunter) may not be correlated and both measures may affect harvest age structure. If TPWD values accurate assessments of annual variation within a unit, then some measure of hunting pressure and harvest rate must accompany age structure. If TPWD is more interested in long-term trends, 3- or 5-year moving averages may screen out annual variation in hunting pressure or harvest rate. WMI recommends that TPWD sample hunting pressure and harvest rate if annual fluctuations in age structure are deemed important, or if comparisons are made between regulatory units.

Disease Monitoring

Background: Various wildlife diseases may pose a threat to wildlife and/or human health. Historically, the Wildlife Division had a "Disease Project" (Fed. Aid Proj. W-93-R) that coordinated disease activities. Upon termination of that project in 1967, Wildlife Division program staff members were given responsibility for handling wildlife disease issues. During the 1980s, the "kills and spills" team of the Resource Protection Division (later Inland Fisheries) assisted the Wildlife Division with investigating major wildlife die offs. Wildlife Division staff members are provided operational protocols on collection of dead animals when a large-scale die-off is occurring. Recent examples include collection of dead waterfowl, sandhill cranes and doves. Jurisdictional authority varies, and TPWD cooperates with Texas Animal Health Commission (TAHC) and Texas Department of Health (TDH) in sampling of wildlife for diseases. TAHC has authority for reporting and tracking for diseases in alternative livestock (including elk) and white-tailed deer and mule deer held under authority of Scientific Breeder Permits.

TDH has authority to report and track diseases that pose a risk to human health and safety. TPWD has authority over free-ranging wildlife and deer held under authority of Scientific Breeder Permits. TPWD has authority to report and track diseases that pose a risk to human health and safety. The only currently active pre-mortality monitoring program assigned to the Wildlife Division is implementation of the Texas Chronic Wasting Disease (CWD) Management Plan.

The CWD Management Plan established collection procedures for clinical, free-ranging cervids beginning in late summer 2002. The collection of clinical deer has been reported by researchers in other states to be particularly useful in detecting the presence/absence of CWD in local areas statewide. TPWD will continue testing clinical free-ranging deer for CWD as they are encountered.

A geographically-focused free-ranging cervid monitoring program was implemented during the fall 2002 deer-hunting season. Brain stem samples from hunter-killed deer were obtained from TPWD WMAs, state parks, and private land. Employees were trained in sampling procedures and provided standardized data sheets. Sampling was predicated on USDA recommendations that 148 samples would be sufficient to detect disease at 2% prevalence, regardless of the biological population size. TPWD's goals were to obtain representative samples from each of the State's 10 ecoregions. The 5-year 2002 -2006, goal is to cumulatively collect 459 samples from each of the 10 ecoregions. The cumulative sample would be used statistically to detect CWD at 1% prevalence level with 99% confidence. Since CWD could potentially occur anywhere in Texas, monitoring efforts would be focused to achieve a stratified sampling scheme across each ecoregion of the State.

The grand total of all samples collected and known April 1, 2003 is 2043 of which 2020 deer and 23 exotics were found CWD negative. Samples were collected from 143 of 254 counties in Texas, and 7 counties had 50 or more samples collected. Five ecoregions had 160 or more samples collected (150 samples from each ecoregion was the goal). The geographic distribution of sampling is currently not considered adequate for determining whether or not CWD exists in Texas. The goal is to improve upon distribution of samples collected within ecoregions and within counties. The goal of 2003-2004 and the next 3 to 5 years is to collect 5000 samples (500 from each ecoregion) each sample year. The increased sampling is to have a 99% confidence level in detecting CWD if only 1% of the biological population is infected. Long-term surveillance sampling for CWD is required, as little is known about the incubation and infectious periods of the disease.

<u>Analysis</u>: Sampling results provide a presence/absence measure of CWD in Texas. The statistical foundation of the CWD sampling should give decision-makers confidence in reporting that no CWD has been found to date in Texas. Sampling data are stored in Austin and reported in Federal Aid reports.

<u>Recommendations</u>: WMI applauds TPWD for the scientific approach to CWD monitoring. Increased sampling to achieve 99% confidence in detecting CWD if 1% of the biological population is infected is recommended.

Browse Survey: MLDP Properties

Background: The basis for browse surveys in Texas originated with the publication by Lay (1967). Original intent of the method was to provide a method to appraise deer range and was designed primarily for deer ranges in eastern Texas.

Since publication of the original method, various modifications and applications of the methodology have been tried. A key premise of the methodology is that trained observers through various sampling protocols can ascertain the foraging use on key deer browse species. It is further surmised that degree of use over a variety of species reveals information on balance of the deer herd with regard to the forage base and thus information on overall range condition.

Application of the method in habitats outside of eastern Texas has been problematic primarily because of limited number of stems available to deer and the resulting difficulty in achieving necessary stem counts. These problems have led biologists to modify the technique in a variety of ways to accommodate various range sites, browse availabilities, rainfall, etc. As a result, there is no one standard protocol statewide and efforts are continuing today to modify the methodology further to meet specific conditions. Applications in south Texas seem to be feasible. Some biologists have concluded that simple cursory surveys of deer range are preferable to the more formal browse stem count method.

Individual ranches are the most common scale for the data. Varying habitat conditions have resulted in very little standard sampling design for the method. In addition, because of this variability standardized data forms and or databases are not used. Training on use of the method is done primarily by experienced observers but lacks continuity with other users of the method elsewhere in the state. Data storage and data reporting for this method appear to be highly variable.

For purposes of this review, we will concentrate on application of browse surveys on deer ranges on cooperator lands within the Managed Lands Deer Permit Program (MLDP). A measure of deer range condition is needed for these lands prior to initiating management and at intervals afterward to see if prescribed management is improving overall land conditions. For these lands, a stated objective for the technique is to be able to detect a 10% change in use in 2 years. Use of the methodology seems to help landowners understand impact of browsing animals, and more cooperators are including habitat-based goals in their wildlife management plans.

Analysis: Assumptions of this methodology are many: 1) a measure of browse use is a telling indicator of overall range condition; 2) a change in browse use relates to a change in deer numbers; 3) multiple observers are consistent in their use of the methodology; 4) sampling strategies are based on a sound statistical design; and 5) sample sizes for key species of browse are adequate to detect desired changes in use.

Lack of a standard protocol for the method makes evaluation difficult. This technique is a prime example of how a basic methodology developed for certain ecological conditions is modified and applied elsewhere without sufficient testing to verify its validity. It will be difficult to successfully apply the method on small ranches because of needed sample sizes.

During our review, we heard a wide variety of opinions and histories regarding this method and had a hard time securing documentation of how the method is applied. Unfortunately, very little testing and formal evaluation of the method has been done since it was first applied. An analysis by Jim Yantis in 2000 is most notable. In addition, a recent evaluation by Mike Janis concerning a power analysis of the stem count index to achieve measures of stated change is helpful, long overdue, and justifies recognition. Janis was able to present needed sample sizes for managers to detect changes in 1st, 2nd, and 3rd choice plants. Because of the importance of these results to resulting management strategies and the high cost of human and fiscal resources to secure these data, further tests are called for.

In the arena of wildlife habitat analyses there is a universal desire (hope) that a fast, accurate, cheap, and easy to apply method will be found. In our opinion, this is comparable to the potential of discovering gold at the end of the rainbow.

Recommendations: Basic research studies applying the technique in pastures with known and varying densities of browsing animals should be done to verify validity of the assumption that degree of browsing use indeed is related to densities of browsers. Sampling protocols must be designed that incorporate sound statistical design and clearly specify sample sizes required for stated degrees of precision. Differences by ecoregion will make development of these protocols difficult.

Standard written protocols (by ecoregion) are needed and should be developed. The on-going tolerance of unstructured modification and application of the technique must be stopped. Once protocols are adopted, formal training in application of the methodology should be implemented for all users. Finally, for this method to be scientifically valid in making management recommendations, analyses of resulting data as performed by Janis are needed. Importance of these studies is such that additional expertise from statisticians in Austin should be sought and used.

Baseline Inventory and Monitoring

Baseline Inventory and Monitoring: Wildlife Division Lands

Background: The objectives of the Baseline Inventory and Monitoring Project are to obtain complete floral and faunal surveys, collect essential ecological data on selected species, and investigate effects of habitat-altering occurrences on plant and animal species found on lands managed by TPWD's Wildlife Division. Surveys to determine species absence or presence, as well as responses to habitat changes are conducted annually utilizing TPWD personnel, volunteers, and cooperative agreements with university personnel. Baseline inventory and monitoring activities on Wildlife Division lands are coordinated and performed by staff members assigned to those lands. Methods used to conduct these activities follow the procedures outlined in Simpson et al. (1996).

Of the 53 WMAs managed by the Wildlife Division, 7 areas reported active baseline inventory and monitoring programs, 39 reported no such activities, and 7 submitted no report (Ruthven 2003). Findings are intended to result in development of management recommendations for specific species or habitats and species lists for individual properties. Results of baseline inventory and monitoring are documented in Federal Aid reports. New species accounts and results of species ecology and habitat management studies reportedly are published in professional journals and disseminated to the general public.

Analysis: Our review of Simpson et al. (1996) is that it provides a sound basis from which baseline inventory and monitoring can proceed. It presents a variety of accepted techniques that could be used to inventory and monitor floral and faunal species based on site objectives. Importantly, the manual recommends that site managers first review pertinent literature about the techniques to improve understanding of their use and limitations. There are a number of important attributes of the manual that contribute to rigorous, scientific surveys. It stresses the importance of first determining objectives of any survey prior to selecting techniques or conducting surveys by making it clear that the objectives and purpose of an inventory will determine the required level of detail needed and the methods that should be implemented. It recommends that a statistician be consulted in developing monitoring projects that have as an objective using abundance data to compare different management practices, and emphasizes that objectives must be pre-determined and proper sampling methods must be used to achieve those objectives.

We are concerned that at least 73% of the WMAs managed by the Division have no active baseline inventory and monitory program, and that there appears to be no clear policy on conducting such efforts. Instead, our understanding is that inventory and monitoring is conducted on a catch-as-catch can basis and often depends on interest by university researchers.

A further concern is that use of baseline inventories to determine effects of habitat treatments on wildlife management areas apparently tends to utilize ad hoc experimental designs.

Recommendations: We recommend the following measures to improve the scientific basis of Wildlife Division baseline inventory and monitoring:

First, baseline inventory and monitoring activities are long-term endeavors that should be planned for and funded accordingly.

Second, the manual describing procedures for baseline inventory and monitoring (Simpson et al. 1996) needs to be updated on a regular basis. Efforts should be made to incorporate changes based on experience in using the manual and its described procedures. It is approaching 10 years since it was last compiled, and it likely would benefit from such revision at this time.

Third, greater effort is needed to put in place active baseline inventory and monitory programs on WMAs managed by the Division. Policy and priorities should be established and carried out to achieve this goal.

Fourth, use of baseline inventories on WMAs to determine effects of habitat treatments should, as Simpson et al. (1996) recommend, be contingent upon receipt of guidance on experimental design and sampling considerations by TPWD statisticians. Consideration also should be given to putting such baseline inventory efforts through the research project review committee process.

Baseline Inventory and Monitoring: State Parks

Background: Qualitative and quantitative studies pertaining to flora and fauna within state parks are conducted to record baseline data, establish a basis for long-term monitoring, change detection, restoration, and provide guidance for natural resource planning and management.

Baseline data collection for characterization of vegetation or habitat type on state parks consists of Ecosystem Surveys, 2 levels of Department Lands Inventory (DLI), and Fire Monitoring Handbook (FMH) permanent vegetation monitoring. Ecosystem survey is a broad, Series-level characterization of plant community acreage on conservation lands that shows and rates condition by acres. DLI Level 1 is a standardized characterization of representative plant communities at the Series level. DLI Level 2 includes mapping and ground-truthing to provide the baseline for long-term ecological research and monitoring. FMH permanent vegetation monitoring is used to accumulate a statewide database for developing baseline information and for monitoring vegetation response to management practices.

TPWD has prepared a written document to prescribe the scope, guidelines and protocols that govern baseline vegetation studies on state parks. The document sets forth the responsibilities of project managers and investigators with respect to vegetation inventory of all vascular plants, collection of voucher specimens, noting and locating rare species, vegetation characterization, vegetation mapping, sampling locations, GIS data collection and use, and reporting of results and recommendations for additional inventory/survey work. The document also describes required actions to be undertaken in conducting FMH permanent vegetation monitoring, including specification of sampling protocol, establishment of plots or transects to characterize vegetation at a minimum significant sampling level, digital photograph documentation, and coordination with other surveys. Required procedures are laid out for archiving inventories and databases from state parks.

To the extent possible and depending on the standards called for in the resources management plan for the site or that may be required by the U.S. Fish and Wildlife Service for listed taxa (plants, vertebrates, cave/karst invertebrates, etc.), priority is given to nesting plots into existing FMH vegetation monitoring/fire effects permanent plots.

Floral inventories are conducted to maximize sampling for state and/or federal species of concern. Ecological data/collection labels/literature/specimens/WWW databases are reviewed and then search images are generated based upon rapid assessments of the subject tracts. Vegetation polygons are developed a priori based upon geology, soils, landform, and aspect as well as historical or aerial images. Rare or unusual/noteworthy communities are field mapped and then sampled during the appropriate season(s). Follow-up assessments are fine-tuned in the field and the polygons are sampled as repeatedly as practicable during different seasons and wet-dry cycles. DLI are developed accordingly.

Fauna and flora are inventoried by habitat and association by competent observers and documented according to established collection and curation, and in some cases federal permit protocols. Avifauna are observed and, if appropriate, point counts are installed following Ralph et al. (1993). Documentation of observations of unusual/rare birds reported is requested and follows the standards of the Texas Bird Records Committee (TBRC).

Baseline inventory and monitoring on TPWD lands, at a minimum, follows procedures set forth in a Departmental manual (see discussion in review of Wildlife Division methods). Baseline inventories of mammals follow Wilson et al. (1996). Specific project needs and PhD or MS thesis research require specific methodology, which are reviewed, permitted and tracked by TPWD Natural Resources Program (NRP) staff. Sampling for taxa listed under the Endangered Species Act, such as cave and karst faunal investigation in the Balcones escarpment zone, follows protocols established by the Service. Geology mapping follows the standards of the University of Texas Bureau of Economic Geology and the STATEMAP geological mapping agency. Soil sampling relies on the NRCS Soil Survey Geographic database.

Sampling of biota generally is weighted by habitat. Within habitats, quantitative sampling is governed by standard methodologies. Where habitat is more extensive or where habitats are characterized by patchiness (e.g. grasslands, bogs), random samples are taken. In some limited habitats, such as xeroriparian corridors, a sampling interval of a set length suitable to the size of the habitat patch (e.g., 50m) is utilized. Insects are sampled by habitat and then within habitats by means of standard sampling protocols depending on taxa, such as malaise, blacklight, CO2, sweep nets, pitfalls, etc.

Analysis: From the information made available to us, TPWD's NRP appears to have adopted a rigorous approach to inventory and monitoring of flora and fauna of state parks. In part this approach is demonstrated by the document prescribing the scope of work, guidelines and protocols to be used for NRP baseline vegetation projects undertaken. In addition, protocols for permanent vegetation monitoring adhere to the National Park Service's well-established, standardized data collection procedures (USDI 2003). A similar approach is taken with respect to requiring use of established, accepted protocols for monitoring of faunal species, such as those of the Service for ESA-listed cave and karst species. Uniformly-gathered data facilitates information exchange among parks and training and movement of staff, and provides databases useful to evaluate management practices and inform park management programs.

We reviewed several baseline assessments of fauna and flora at state parks and found that they provided explicit methodologies and used statistical parameters to describe the data where appropriate. We understand that many baseline assessments are graduate student research projects, which likely assures a rigorous approach to data collection, reporting and analysis and helps cultivate and foster good relationships with universities to the benefit of the NRP and state park management.

We are concerned about the practice of year-to-year NRP contracts for mammalogists, herpetologists, geologists, hydrologists, and other specialists needed to carry out monitoring plans. The funding uncertainty created by this practice appears to make it difficult to plan and carry out monitoring efforts over a sufficiently long period of time (at least 5 years) to provide useful information.

At present, it appears that the NRP is not able to access information electronically in TPWD's Biological Conservation Database and input that information in the State Park Resources Information System (SPRIS) or the Resources Information System (RIS). Most elemental occurrences on state parks in the BCD come from the parks. Use of the same scaling among databases is essential to allow import of overlays.

Finally, we were informed of a number of shortfalls that present challenges to TPWD's park programs. We understand, for instance, that only about 45% of sites have good, solid information. The absence of dedicated research or project funds and lack of success in competing in the research project review process are likely significant contributors to this situation.

Recommendations: First, monitoring plans should be developed and funded for a 5-year period. Second, efforts need to be made to ensure that the NRP and state parks are able to access information in TPWD's Biological Conservation Database and input that information in SPRIS or RIS. Use of the same scaling among databases is essential to allow import of overlays. Third, greater effort is needed to ensure that solid baseline information is obtained on all state parks. Although some sites may not be appropriate for baseline or natural history surveys, changes should be considered to make accessible research or project funds for state park efforts.

Human Dimension Surveys

Background: The agency acquires information on opinions and desires of interested publics through several methodologies. The review team found human dimension information was obtained through 2 basic approaches: 1) formal contracts with other agencies, organizations, or universities where specific human dimension studies (surveys) are designed and implemented and 2) various inquiries designed and implemented by the agency. For the most part, human dimension studies carried out through formal contracts are designed, analyzed, and reported on by entities beyond the agency. A good example of this process is the cooperative agreement with the Western Association and

Colorado State University investigating "Wildlife Values in the West." For purposes of this review we will concentrate on those surveys designed and implemented by the agency.

Surveys to determine opinions, desires, and success rates of hunters were the most common example of agency designed and implemented human dimension investigations. Harvest surveys to measure success of hunters and hunting seasons are discussed elsewhere in this review. One example of TPWD human dimension investigations are surveys used by the waterfowl program to help guide management decisions regarding waterfowl hunting seasons. Other examples include the use of regulatory hearings to receive input on proposed regulatory changes and the on-going Deer Advisory Committee to reach out to interested publics.

Analysis: Basic assumptions of human dimension investigations are 1) the survey is based upon a scientifically designed protocol; 2) the human population to be sampled is properly identified and a random sample is obtained for query; 3) adequate sample sizes to achieve stated confidence considering non-respondents are taken; and 4) properly designed questionnaires with unambiguous questions are developed. We found the surveys conducted by the waterfowl program to be good examples of appropriate use of human dimension surveys. These surveys are based on random samples of hunters and designed and analyzed with help from the statistical lab in Austin. As discussed elsewhere, a declining response rate is hindering results of all surveys (especially mailed surveys) and special efforts must be taken to achieve necessary sample sizes.

Information received on regulatory hearings is primarily obtained from those that attend the forums. Typically, those attending do not represent the broader interests of the public. The review team appreciates the long time-honored approach to regulatory hearings (i.e., public input for the Commission prior to decision-making) but cautions the agency on relying too heavily on this input with regard to obtaining sound and unbiased input.

Finally, the review team learned about the Deer Advisory Committee that has been established to provide recommendations to the agency and Commission on topics related to deer management. Even though the membership of this Committee may be broad-based, it does not reflect opinions of all interested publics and their recommendations should be considered with this limitation.

Recommendations: Human dimension investigations are becoming important tools for agencies to secure valid and scientific public input (Decker et al. 2001). We recommend the agency strengthen its internal ability to design, conduct, and analyze human dimension surveys. Statistical expertise in the Austin office should be used for all surveys. Analytical procedures and hypotheses to test with the resulting data should be identified prior to obtaining data. Outside expertise should be sought in designing survey instruments.

We further recommend the agency increase use of human dimension inquiries to supplement other information gathering forums like regulatory hearings and the Deer Advisory Committee to ensure a broader-based input for important decision-making processes.

OBJECTIVE 2: EMPLOYEE KNOWLEDGE AND USE OF SCIENCE

Wildlife Division Questionnaire

Background: Objective 2 of the WMI Science Review was to ascertain opinions and insights of selected TPWD staff members on use of, and gaps in, science available for monitoring and managing wildlife resources to determine how well science is integrated into management decision processes. This objective was investigated through a mail questionnaire that contained 30 statements. Each statement described a different science-based condition, attitude or process. If employees strongly agreed with the statement, WMI inferred that there was strong agreement that sound science was being practiced. If employees strongly disagreed with the statement, WMI inferred that sound science was absent. The percentage of employees in disagreement with a survey statement was deemed the most informative method to organize results. Agency leaders should be most aware of statements with which employees most strongly disagree that sound science is a foundation of agency actions.

The 163 mail questionnaires returned to WMI were tabulated and summary statistics calculated. For the Wildlife Division, differences in response between duty station, position type and position grade were tested through analysis of variance. Probability thresholds were set at < 0.01.

Questionnaire responses were distributed on the Likert scale which ranged from 1 for strongly agree to 4 for strongly disagree. Values greater than 2.5 indicated some level of disagreement with the questionnaire statement. Values less than 2.5 indicated a general level of agreement with the questionnaire statement. In the section that follows questionnaire statements are aggregated by the percentage of employees in disagreement. Statements receiving the highest percentage of disagreement are discussed first.

A. <u>> 60% of Wildlife Division Employees With an Opinion Disagree with the Following Statements:</u>

1. **Statement: Science training is a priority of the agency for continuing education of employees (Mean Score = 2.76).**

   a. The response of employees differed by position type with Program Specialists most strongly disagreeing with the level of science training**.**

Position Type	Mean	N	Std Dev
Manager	2.74	25	0.523
NRS	2.64	70	0.762
Program Spec.	3.00	35	0.676

Degrees of Freedom	F Value from AOV	P Value
2	3.11	0.0480

   b. The response of employees also differed by position grade among employees with grade 5 employees disagreeing most strongly with the statement**.**

Position Grade	Mean	N	Std Dev
2	2.76	19	0.54
3	2.74	31	0.63
4	2.51	43	0.80
5	3.08	36	0.65
6	2.50	2	0.71

Degrees of Freedom	F Value from AOV	P Value
4	3.50	0.0096

   c. The response of employees suggests that they perceive agency leaders place a low priority on science training. There was a relatively high number of "strongly disagree" responses indicating that opinions are strongly held.

   d. Agency leaders should note that the degree of disagreement is strongest in the senior levels of the Division.

2. **Statement: There is a well-defined and effective process for integrating science information into decision-making (Mean Score = 2.71).**

a. There were no differences in response detected among employee's duty station, position or position grade.

b. The general level of disagreement with the statement implies that employees assigned to both headquarters and field, and at all grades, believe that science information could be better integrated into decision-making.

B. <u>50-60% of Wildlife Division Employees With an Opinion Disagree with the Following Statements</u>:

1. Statement: Science recommendations are considered adequately by decision-makers in the agency (Mean Score = 2.62).

a. The response of employees to this statement differed at the $p<0.1$ level by position type. Managers had the highest level of disagreement with the statement that science recommendations are considered adequately by decision-makers.

Position Type	Mean	N	Std Dev
Manager	2.88	26	0.77
NRS	2.52	60	0.65
Program Spec.	2.56	31	0.76

Degrees of Freedom	F Value from AOV	P Value
2	2.47	0.0894

b. The general level of response to this question suggests that there is widespread belief that science decisions are not considered adequately.

c. A relatively high number of responses (19%) were "no opinion".

2. Statement: Data from survey efforts are frequently compromised at the district or regional level for considerations beyond biology (Mean Score = 2.58).

a. No differences were detected in the response of employees to this statement among duty stations, position or position grade.

b. The mean score indicates that the majority of employees believe that survey data are not being compromised at the district or regional level.

c. This statement had the highest number of responses coded strongly disagree.

d. This is the only statement in the questionnaire where a disagree response indicates a better adherence to science than an agree response.

e. This statement also had a high (22.4%) response of "no opinion".

C. <u>40-50% of Wildlife Division Employees With an Opinion Disagree with the Following Statements</u>:

1. **Statement: A competent biostatistician is consulted routinely before data are analyzed (Mean Score = 2.52).**

   a. There were no differences detected in response to this statement between duty station, position or position grade.

   b. Responses suggest that many employees either do not themselves consult with a competent biostatistician, or do not believe that others do, before data are analyzed.

   c. A high percentage of responses (31%) were "no opinion".

2. **Statement: Scientifically sound evaluations of land management practices are conducted to determine the outcomes of management (Mean Score = 2.53).**

   a. Responses to the statement differed by duty station among employees with headquarters personnel in stronger disagreement than field personnel.

Degrees of Freedom	F Value from AOV	P Value
1	5.31	0.0228

DUTY STATION	Mean	N	Std Dev
Field	2.47	109	0.739
Headquarters	2.94	16	0.854

b. The response of all employees is slightly on the disagree side of neutral. Slightly less than the majority of employees do not believe that scientifically sound evaluations of land management practices are regularly conducted.

3. **Statement: Training is adequate for employees to accomplish the science-based studies their jobs require (Mean Score = 2.52).**

a. The response to this statement differed at $p<0.1$ by duty station among employees with headquarters personnel more strongly disagreeing with the statement than field personnel.

DUTY STATION	Mean	N	Std Dev
Field	2.48	116	0.595
Headquarters	2.78	18	0.647

Degrees of Freedom	F Value from AOV	P Value
1	3.85	0.0517

b. The response of all employees to this question is slightly on the disagree side of neutral.

4. **Statement: Employees routinely seek peer review and consultation before a land management treatment is prescribed (Mean Score = 2.46).**

a. The response of employees to this statement differed by duty station with headquarters staff disagreeing with the statement more than field staff.

DUTY STATION	Mean	N	Std Dev
Field	2.40	115	0.735
Headquarters	2.94	16	0.680

Degrees of Freedom	F Value from AOV	P Value
1	7.64	0.0066

b. Most employees believe that peer review and consultation is sought before a land management treatment is prescribed.

5. **Statement: Data from survey efforts are easily accessible by all appropriate personnel (Mean Score = 2.50).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. The numerical mean score to this question is exactly midway between disagree and agree.
   c. That at least 40% of employees disagree that survey efforts are easily accessible implies that different employees have either different levels of access or different levels of understanding of how to access survey data. The response may also suggest that different surveys have different levels of accessibility.
6. **Statement: Survey methods are designed, tested, and applied adequately (Mean Score = 2.48).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. The mean numerical score suggests that on the average, most employees agree with the statement.

7. **Statement: Access to library materials, internet resources, and abstract services is facilitated (Mean Score = 2.47).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. This statement generated the second highest level (14%) of responses coded to strongly disagree.
   c. Given that there are no differences in grade or position, the numerical mean score is on the agree side of neutral, but a large percentage of employees strongly disagree, implies that there is a differentiation among employees that cannot be characterized by the coding employed to

segregate employees. Speculation would suggest that perhaps there is 1 district, program or region with substantially less access than its counterparts.

8. **Statement: Survey methods are applied in the same manner across districts and regions (Mean Score = 2.38).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. The numerical mean score suggests that most employees agree with the statement and believe that survey methods are consistently applied across districts or region.
   c. Of note to agency leaders, however, is the relatively large percentage (40%) of employees with an opinion who disagree with the statement.

D. <u>30-40% of Wildlife Division Employees With an Opinion Disagree with the Following Statements:</u>

1. **Statement: Data from routine survey activities are pertinent and directly applicable for decision-making (Mean Score = 2.40).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. The majority of employees agree that survey activities are relevant to decision-making.

2. **Statement: Inherent biases in survey methods are well understood (Mean Score = 2.38).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. The majority of employees believe that biases are well understood, but the split is approximately 60:40 between agree and disagree.

3. **Statement: Data are adequately reported, stored, and retrievable (Mean Score = 2.30).**
   a. The response to this question differed by duty station among employees with headquarters personnel having a higher level of disagreement that data are adequately reported, stored and retrievable.

DUTY STATION	Mean	N	Std Dev
Field	2.239	117	0.7358
Headquarters	2.650	20	0.9333

Degrees of Freedom	F Value from AOV	P Value
1	4.90	0.0285

4. **Statement: Advice of a competent biostatistician is sought on the design of new methods or studies before data are gathered (Mean Score = 2.37).**
   a. The response to this statement differed at $p<0.1$ by duty station with headquarters personnel having a stronger level of disagreement with this statement.

DUTY STATION	Mean	N	Std Dev
Field	2.3172	93	0.6907
Headquarters	2.6429	14	0.4972

Degrees of Freedom	F Value from AOV	P Value
1	2.88	0.0929

   b. Nearly 25% of responses from employees were coded “no opinion”.

5. **Statement: Differences between precision and accuracy are clearly understood (Mean Score = 2.33).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. Nearly 16% of responses from employees were coded “no opinion”.

6. **Statement: Routinely collected data are used at the correct scale (Mean Score = 2.39).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. Nearly 20% of responses from employees were coded “no opinion”.

7. **Statement: Strengths and weaknesses of data are communicated effectively to decision-makers by those individuals responsible for presenting science information (Mean Score = 2.40).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. Nearly 16% of responses from employees were coded “no opinion”.

8. **Statement: Survey methods are based on a sound sampling design (Mean Score = 2.32).**
   a. There were no differences detected in response to this statement between duty station, position or position grade.
   b. The split between agree and disagree is approximately 65:35% for this statement.

9. **Statement: Adequate opportunities are provided to advance science training through attendance at workshops and symposia (Mean Score = 2.32).**
   a. The response to this statement differed by duty station with headquarters employees having a strong level of disagreement with the statement.

DUTY STATION	Mean	N	Std Dev
Field	2.23	117	0.75
Headquarters	2.75	24	0.91

Degrees of Freedom	F Value from AOV	P Value
1	9.50	0.0025

b. Several interpretations of the response are possible. First, headquarters staff may believe that attendance at workshops and symposia are more important to their job responsibilities than field staff, and they therefore are more aware of attendance issues. Second, field staff may believe they have adequate opportunities to attend workshops and symposia given their job responsibilities, or conversely, they may not be aware of missed opportunities.

10. Statement: Appropriate data analysis techniques are used routinely (Mean Score = 2.30).

a. There were no differences detected in response to this statement between duty station, position or position grade.

b. The split between agree and disagree is approximately 70:30% for this statement for employees with an opinion.

E. <u>20-30% of Wildlife Division Employees With an Opinion Disagree with the Following Statements</u>:

1. **Statement: The wildlife research project selection process selects research studies applicable to agency needs (Mean Score = 2.18).**

   a. There were no differences detected in response to this statement between duty station, position or position grade.

   b. A relatively high percentage of employees coded their response as "no opinion" (17.4%).

2. **Statement: Written protocols are followed as data are gathered (Mean Score = 2.15).**

   a. There were no differences detected in response to this statement between duty station, position or position grade.

3. **Statement: Good science is appreciated and valued among <u>supervisors</u> (Mean Score = 2.08).**
    a. There were no differences detected in response to this statement between duty station, position or position grade.

4. **Statement: Membership in professional societies and attendance at professional meetings is encouraged (Mean Score = 2.05).**
    a. Responses to this statement differed at the p<0.1 level by duty station with headquarters personnel less in agreement with the statement than field personnel.

DUTY STATION	Mean	N	Std Dev
Field	2.00	119	0.75
Headquarters	2.30	24	0.91

Degrees of Freedom	F Value from AOV	P Value
1	3.28	0.0723

    b. While there were differences between duty stations, both headquarters and field personnel were in agreement with the statement.

5. **Statement: Expertise in science is properly identified for entry-level positions where data gathering will be a large part of the job (Mean Score = 2.13).**
    a. Employees differed in their response to this statement between position types with Program Specialists disagreeing with the statement and NRS and Managers agreeing with the statement.

Position Type	Mean	N	Std Dev
Manager	1.89	27	0.577
NRS	2.16	74	0.620
Program Spec.	2.56	35	0.741

Degrees of Freedom	F Value from AOV	P Value
2	2.65	0.0741

F. <u>10-20% of Wildlife Division Employees With an Opinion Disagree with the Following Statements</u>:

1. **Statement: Good science is appreciated and valued among <u>employees</u> (Mean Score = 1.98).**
    a. Employee responses to this statement were different among position grades with grade 5 employees being less in agreement than other grades.

Position Grade	Mean	N	Std Dev
2	1.75	20	0.55
3	1.86	37	0.86
4	1.95	44	0.78
5	2.28	36	0.66
6	1.67	3	0.58

Degrees of Freedom	F Value from AOV	P Value
4	2.31	0.0607

    b. Even with differences among grades, all grades were in general agreement with the statement.

2. **Statement: Standard data forms are used routinely (Mean Score = 1.91).**
    a. There were no differences detected in response to this statement between duty station, position or position grade.
    b. This statement generated the highest percentage of strongly agree responses (25%).

3. **Statement: Routinely prescribed land management practices are scientifically founded (Mean Score = 1.90).**
    a. Responses to this statement differed by duty station with headquarters personnel less likely to agree than field personnel with the statement.

DUTY STATION	Mean	N	Std Dev
Field	1.8087	115	0.5603
Headquarters	2.4000	20	0.7539

Degrees of Freedom	F Value from AOV	P Value
1		0.0001

b. Responses to this statement also differed by position type with Program Specialists and Managers in less agreement with the statement than NRS employees.

Position Type	Mean	N	Std Dev
Manager	1.96	28	0.637
NRS	1.77	71	0.512
Program Spec.	2.08	37	0.759

Degrees of Freedom	F Value from AOV	P Value
2	3.24	0.0422

c. This statement generated the highest mean agreement score of all questions.

Parks Division Questionnaire

The State Parks Division employee questionnaire was sent to 24 employees, including state park managers with a completed natural resource management plan, regional resource coordinators and regional directors. Because of small sample sizes, no attempt was made to break down responses by duty station, position or position grade. Eighteen completed surveys were returned to WMI. Summary statistics were run and response was ranked by the degree of disagreement with the science-based statements.

A. > 75% of State Parks Division Employees With an Opinion Disagree with the Following Statements:

a. Statement: A competent biostatistician is consulted routinely before data are analyzed. (Mean Score = 3.10).

b. Statement: Advice of a competent biostatistician is sought on the design of new methods or studies before data are gathered. (Mean Score = 3.0).

B.60-75% of State Parks Division Employees With an Opinion Disagree with the Following Statements:

- **a. Statement: Data from flora and fauna inventory efforts are easily accessible by all appropriate personnel. (Mean Score = 2.90).**
- **b. Statement: Appropriate data analysis techniques are used routinely (Mean Score = 2.70).**
- **c. Data are adequately reported, stored, and retrievable (Mean Score = 2.60).**
- **d. Science training is a priority of the agency for continuing education of employees (Mean Score = 2.60).**

C. 50-60% of State Parks Division Employees With an Opinion Disagree with the Following Statements:

- **a. Statement: Training is adequate for employees to accomplish the science-based studies their jobs require (Mean Score = 2.70).**

D. 40-50% of State Parks Division Employees With an Opinion Disagree with the Following Statements:

- **a. Statement: Standard data forms are used routinely (Mean Score = 2.50).**
- **b. Statement: Adequate opportunities are provided to advance science training through attendance at workshops and symposia (Mean Score = 2.50).**

c. **Statement: There is a well-defined and effective process for integrating science information into decision-making (Mean Score = 2.40).**

d. **Statement: Written protocols are followed as data are gathered (Mean Score = 2.50).**

e. **Statement: Membership in professional societies and attendance at professional meetings is encouraged (Mean Score = 2.50).**

E. <u>30-40% of State Parks Division Employees With an Opinion Disagree with the Following Statements</u>:

a. **Statement: Flora and fauna inventory methods are applied in the same manner across Parks regions. (Mean Score = 2.50).**

b. **Statement: There is an adequate process within the Parks Division to select research projects applicable to agency needs (Mean Score = 2.50).**

c. **Statement: Science recommendations are considered adequately by decision-makers in the agency (Mean Score = 2.40).**

d. **Statement: Strengths and weaknesses of data are communicated effectively to decision-makers by those individuals responsible for presenting science information (Mean Score = 2.40).**

e. **Statement: Inherent biases in flora and fauna inventory methods are well understood (Mean Score = 2.30).**

f. **Statement: Access to library materials, internet resources, and abstract services is facilitated. (Mean Score = 2.20).**

g. **Statement: Scientifically sound evaluations of land management practices are conducted to determine the outcomes of management. (Mean Score = 2.20).**

F. 20-30% of State Parks Division Employees With an Opinion Disagree with the Following Statements:

   a. **Statement: Flora and fauna inventory methods are designed, tested, and applied adequately (Mean Score = 2.30).**
   b. **Statement: Expertise in science is properly identified for entry-level positions where data gathering will be a large part of the job. (Mean Score = 2.20).**
   c. **Statement: Differences between precision and accuracy are clearly understood. (Mean Score = 2.10).**

G. 10-20% of State Parks Division Employees With an Opinion Disagree with the Following Statements:

   a. **Statement: Routinely prescribed land management practices within state parks natural resource management plans are scientifically founded (Mean Score = 2.00).**
   b. **Statement: Good science is appreciated and valued among employees. (Mean Score = 2.00).**
   c. **Statement: Flora and fauna inventory methods are based on a sound sampling design (Mean Score = 2.00).**
   d. **Statement: Good science is appreciated and valued among supervisors (Mean Score = 2.00).**
   e. **Statement: Employees routinely seek peer review and consultation before implementing a land management treatment ~~is~~ prescribed within the state park natural resource management plan (Mean Score = 1.80).**

State park employees indicated strongest disagreement with statements that referred to the design and analysis of science-based activities, access to results of science-based activities, and training of park employees in the use and interpretation of science. Employees were largely in agreement with statements that referred to the appreciation of science, the design of flora and faunal inventories, and the degree to which land management decisions were influenced by peer review and consultation.

OBJECTIVE 3: EVALUATION OF EXISTING SCIENCE PROCESSES

Existing Processes

The third objective of the WMI review was to evaluate existing TPWD processes for on-going evaluation of their science-based activities and propose modifications as needed to improve this evaluation and allow for the most effective use of data in management decision-making. The review team used information from all aspects of the review to fulfill this objective, including interviews, questionnaires, and written documents. Individual employee interviews were most helpful in familiarizing the team with existing processes. For this review we considered TPWD processes to be "sets of actions, changes, or operations occurring or performed in a special order toward some result." We then identified those existing elements or institutional operations that were aimed at carrying out, improving, or evaluating science-based activities.

The review team found a limited number of science processes in place that met our definition. TPWD is a large and complex organization spread across many ecological zones. As a result, standard agency-wide operating procedures and processes are hard to develop and maintain. Following are the existing processes we identified.

Strategic Planning: The TPWD Strategic Plan for fiscal years 2003-2007 and Land and Water Resources Conservation and Recreation Plan reflect processes that established strategies, and objectives, and goals for science-based activities. The Strategic Plan uses number of endangered resource research studies completed, number of fish and wildlife management research studies underway, and number of biological population and harvest surveys conducted as some of the measures to evaluate efforts to conserve and manage Texas' fish, wildlife and plant resources. The Land and Water Plan establishes as a goal improvement of science and data collection by undertaking a complete review of all scientific and conservation programs and developing an integrated GIS database of fish, wildlife and water data. This review is one of the measures taken to achieve that goal. In general, the broad priorities set by these documents should be evident in the additional processes described below.

Operational Planning: The most basic process in place appears to be the annual operational planning discussions. It is during this process that limited agency fiscal and human resources are allocated to priority tasks. With regard to science-based activities, it is this process that determines those activities that are to be funded and accomplished in the budget year. During the review, the team consistently heard about logistical difficulties for employees to accomplish all that is identified in the annual Operations Plan. We learned that typically employees have greater than 100% of their time allocated. We further learned that often science-based activities are activities likely to not be prioritized in these planning deliberations. As a result, many employees make sure their "special" activities are identified as they consider them important to their jobs. A result of this process is many employees feel overworked and pressed to get their annual work completed. This results in many science-based activities being done as "add on" work. When this happens a common result is poorer quality outcomes with less attention given to such things as written protocols and standard operating procedures. The leadership of the agency understands this conundrum and has attempted to address it. The review team considers this process critical and very much related to ability of the agency to accomplish and evaluate science.

Research Selection Process: Another on-going science related process is the annual research selection process. This process is in place to identify and select the most effective research studies that are needed to improve management decision-making. The process identifies research to be done internally by the agency as well as research to be contracted to outside groups like universities. Other key objectives for agency research are to train staff members and inform the public. The process is well known by employees and appears to be supported and recognized as a valuable process. During the review we heard some consider the process to be too "inner agency" limited and could be benefited by more outside review. Concerns also were expressed that Parks Division projects did not compete successfully for limited research funds. A publication entitled

"Wildlife Research Highlights" is published biennially that provides an excellent summary of ongoing and completed research work This publication is part of the science process in the agency and does serve to communicate information about science activities.

Program Staff: Organizationally, the most obvious process in place is role of the program staff in Austin in carrying out science activities. During the review we learned that a key responsibility of the program staff is to identify key management needs, develop programs to address those needs, and in general demonstrate leadership to make sure those programs are successful. Program leaders must be well versed in the science behind their programs and dedicated to making sure the science developed and used is as good as it can be. They must continually monitor inventory processes and provide necessary guidelines and direction to field staff regarding science processes. They also must demonstrate leadership in evaluating accuracy and precision of existing methods and identifying means of gathering more reliable information in an efficient and effective manner. Consequently, program leaders play a large role in science activities in the agency.

Field Supervisory Leaders: TPWD is organized to facilitate development of science standards by program staff. For that function to be productive, district leaders and regional directors in the Wildlife Division are tasked with implementing science studies through the actions of field staff. Actions by field supervisory leaders to maintain consistent adherence to science-based protocols are critical to the science mission of the Division.

Management, Research and Inventory on WMAs and State Parks: Key stated purposes and objectives of WMAs and, to a lesser extent, state parks are to provide a place for 1) demonstration and evaluation of management techniques and approaches in various ecoregions and 2) establishment of long-term monitoring to make possible detection of ecoregional changes, restoration, and guidance for natural resource planning and management. However, we did not note an effective, integrated, and consistent approach to using WMAs as the Wildlife Division's science demonstration area. Most of the WMAs managed by the Wildlife Division have no active baseline inventory and monitoring program, and use of baseline inventories to determine effects of habitat treatments on WMAs relies too much on ad hoc experimental design. Less than 50% of state parks have sufficient monitoring information to make possible achievement of management, research and inventory and protection/conservation goals on these lands. Many parks and historic sites do not have sufficient lands or natural resources to warrant baseline ecological monitoring. The Parks Division reports that it has initiated baseline monitoring efforts for most state parks with significant natural resources.

Statistical Services: One organizational unit in place that could play an important role in evaluating science in the Wildlife Division is the statistical services unit housed in the Austin headquarters. Quality of data is basic to any science program. It is important that all data gathering processes within the agency be based upon sound statistical principles and designed to be most efficient in selecting the most effective methodologies.

Hunting Regulation Changes: The review team identified procedures that the agency uses for making proposed hunting regulation changes as an important on-going science process. Before a change in regulations can be made the agency requires documentation of the existing regulation and justification for the proposed change. The proposed change must be signed by the pertinent regulatory biologists, district leader, regional director, program leader, public hunt director, director of wildlife, and chief operating officer. Justification in regulatory proposals is highly dependent upon biological data. As a consequence it is important that the information be reliable and in support of the proposal.

Electronic Databases: An emerging and important process is the role and use of the TWIS or RIS electronic databases. Efficient data storage and retrieval is a key component of any modern science activity. The review team found that awareness and use of this system is inconsistent among employees in the agency. We also heard numerous questions asking how and where this process should be housed and supervised. Written standard operating procedures describing how and what data should be entered into the system are lacking and needed.

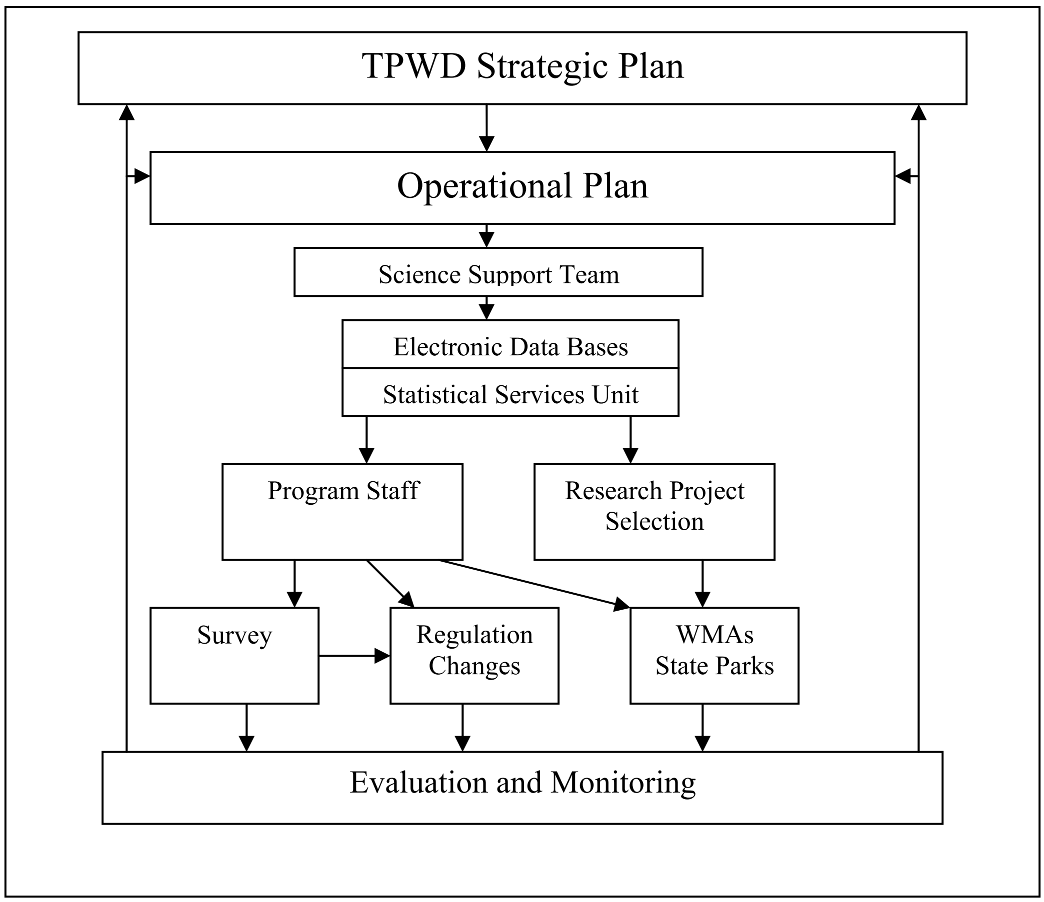
Ad Hoc Research and Science: During the review the team noted a number of "research" studies that have been initiated and conducted by individual employees working to solve a problem or gain information. Examples include cow bird trapping, black bear and mountain lion databases, eastern turkey investigations, and browse measurement analyses. These efforts all demonstrated significant creativity, dedication, and most have lead to better management by the agency. As far as we could tell most of these ad hoc investigations seem to develop without much guidance, interaction, or control by agency leadership or other science processes.

Recommendations

Strategic Planning: WMI recommends that TPWD utilize changes in the processes described below to inform future revisions of the Strategic Plan and Land and Water Resources Conservation and Recreation Plan. Based on our review, for example, we suggest that the number of biological population and harvest surveys conducted is not an appropriate metric to measure the outcome of TPWD conservation and management efforts. A reduction in the number of those surveys may be necessary to improve the scientific basis of others.

Operational Planning: WMI recommends that the Wildlife Division better integrate science into operational planning. Quality science cannot be done as "add on" to a full plate of other duties. Those employees most responsible for gathering inventory data and conducting other science investigations must be provided work time necessary to do the work. In addition, we have identified elsewhere in this review opportunities to terminate some surveys that are not providing reliable information. Division leadership should adjust the annual operations plans so that priority science work is properly budgeted and planned. The Division should consider establishment of specific goals and objectives for science within the agency.

Science Standards Process: WMI recommends that TPWD institute a well-defined process that coordinates and integrates science into agency actions. There are numerous ways to define the process, and WMI holds no method higher than another. We recommend that agency personnel may be the most knowledgeable at how to structure the process. The following schematic represents 1 potential organizational approach that may have merit.



Science Support Team: The function of the Science Support Team is to interpret which agency goals and objectives require science-based activities and then how best to conduct science-based activities. The research team recognized a prevalent lack of coordination, integration, awareness, and rigor of agency science efforts. There is need in the agency to highlight the role of science in all its programs and take steps to help all employees recognize this importance.

Statistical Services: The review team found this is potentially the most important aspect of the entire agency science program but at the same time found it to be unlinked to most science activities in the agency. Professional statistical expertise is basic to any quality science program. As our review points out, absence of sound sampling designs is a major weakness for most inventories conducted by the agency. Statistical services must be accessible to all employees and divisions. Existing staffing of this unit is insufficient to properly address statistical needs in the agency. There is a trade-off in where statistical expertise is housed in the agency. On one hand, it is good to have this service housed in a central and coordinated office such as the Austin headquarters. On the other hand, the team found that when statistical expertise was directly available to field employees, quality of the investigations was improved. It is recommended the agency immediately assess this need and take steps to increase effectiveness of the statistical services. Availability of statistical expertise is basic to any effective science program.

Research Selection Process: To broaden the perspective on agency research it is recommended that the research selection process include at least 2 qualified external reviewers who have weight equal to internal reviewers in selection decisions. These reviewers could come from universities in the state or from other state and federal agencies. The research process should clearly be linked to and support research efforts that are occurring on state wildlife and park areas.

Program Staff: It is recommended that leadership of the agency once again affirm that a key role of the program leaders is to chart the course for all key program initiatives within the agency, including and especially science-based initiatives. Program leaders must take a larger role in monitoring, oversight and evaluation of all inventory methods. They must be sure that written and consistent methodologies are provided to all employees conducting science work. They must also take a leadership role in designing and carrying out appropriate training sessions and in developing training videos and CDs. They must play a major role in getting all inventory databases into electronic format (i.e., RIS), so they can be easily retrieved and used. Finally, they must demonstrate leadership in evaluating accuracy and precision of existing methods and identifying modifications or alternatives to those methods that will improve the reliability and efficiency of data gathered. Our review identifies many inventory methods that have not been evaluated or revised in decades.

Management, Research and Inventory on WMAs and State Parks: Science ought to be included on department lands including state parks. WMAs and state parks could be a key part of the science process in the agency but management, research and inventory on these lands must be linked and coordinated to a broader science vision for the agency. It is recommended agency leadership immediately address this issue and clearly articulate the role that management, research and inventory on WMAs and state parks will play with regard to the agency science programs. These efforts on the WMAs and state parks must be integrated into all science programs in the agency.

Hunting Regulation Changes: The review team recommends the regulation change process be recognized by the agency as a key science process and steps be taken to develop a more formal approach to the science used in the justifications for regulation change. Once a regulation is changed, it should be the responsibility for 1 or more people to follow through with a sufficiently detailed evaluation so that results of the regulation change can be documented. It is through this evaluation that science used for regulations would improve.

Electronic Databases: The review team recommends the agency determine priority data sets that should be entered into these electronic systems and then make sure that data quality review systems are in place to "filter" the data before they are entered. Once they are up and running, the agency should strongly promote and use the databases.

Ad Hoc Research and Science: The ad hoc examples mentioned previously point out an overriding observation by the review team related to the overall problem of lack of coordination, integration, and information exchange about science programs in the agency. In most of these situations the work being done was significant and important but seemingly not connected to other more "mainstream" science processes or programs. It is recommended the agency develop a more coordinated and integrated research study approach and make sure all science "investigations" are integrated into the agency science process and leading directly to achievement of agency goals and objectives.

Communication: From our interviews and questionnaires it was also apparent that Wildlife Division field and program staff members have different opinions on existing agency science programs. Given the different perspectives of the 2 responsibilities this is not surprising. It does suggest, however, that there is a need for better communication and dialog between the 2 groups. If program staff does have lead responsibility for conduct of science programs, then they have a larger responsibility in this dialog. The review team recommends TPWD reaffirm the role of program staff in science efforts and make sure this responsibility is clearly communicated to the entire agency. It is also recommended that a Science Standards Committee made up by program leaders formally conduct ongoing evaluation of agency science standards and processes and work to make sure science training for employees is a priority.

CONCLUSIONS

TPWD clearly understands that agency actions must be grounded in science. The agency has made it a priority to obtain an independent science review of the agency's programs and has allocated the funding and staff resources to make the review possible. TPWD has a long tradition of employing numerous surveys, techniques and methods of collecting data to improve the quality and reliability of agency decision-making. Some of these data collection methods have been in place for decades.

Among TPWD employees, WMI found broad interest and participation in efforts to improve the science foundation of agency operations. Employees generally demonstrated a solid understanding of the scientific process and a commitment to practice sound science. Staff members are engaged in a number of ongoing reviews that seek to improve the reliability of survey methodologies, including those for deer, turkeys, and doves. Employees commonly are seeking opportunities to learn more, to receive better training, and/or to gain additional access to science materials. Employees clearly appreciate agency programs to provide training, access and outside consultation on science, and they requested agency leaders increase availability of these efforts wherever possible.

Many employees used the questionnaires and interviews to express concerns about agency programs and priorities. Some common themes emerged. WMI found a level of concern among employees about science results being disregarded in decision-making and recommends that this topic be a special focus of agency leaders. While the solution may involve improvements to both communications and the decision-making process, we also sense that employees are looking for strong leadership to maintain what they believe to be the agency's historic science-based mission. Many employees also expressed concern about the design of studies or the reliability of interpretations that they were asked to make regarding data collected. The review team concluded that employees were indirectly echoing one of WMI's major findings – much time is spent on data collection, but if the data are not worthy of interpretation, employees could better serve the resource by rededicating those hours in the operational plans towards better stewardship activities. Unique to the Parks Division, we noted concerns about the absence of natural resource stewardship plans, and where plans were in place, the slow implementation of plan recommendations. There is a need for all science applications in the agency to be better coordinated and elevated in key decision-making processes.

As the agency's mission has evolved to include additional issues, constituents, responsibilities, expectations and initiatives, the tried-and-true methods for data collection and science support for decision-making have had to compete with other agency demands. At the same time, the bar establishing the threshold for good science has been raised. Challenges to agency action are now more prevalent, a trend that will likely continue, and those challenges will, more often than not, be on the science the agency is using to justify decisions. Credibility of the agency largely depends upon quality of its science programs.

It is time for the agency to stop doing more with less. In the review, WMI recommends that TPWD determine whether there is a need for the type and scale of data currently being collected, and whether that need is sufficiently important to require reliable information. Collection of reliable information will require the agency to do a better job of designing sampling strategies prior to data collection and making greater use of other science-based methods to improve accuracy and precision of estimates. Many survey methodologies the review team examined will need to be revised substantially to meet established scientific standards and provide reliable information. Other methodologies may be able to be replaced by less expensive modeling techniques or use of existing correlative information on habitat or meteorological conditions. Still other surveys may not be needed sufficiently to warrant the cost. These efforts will do much to improve reliability and confidence in the agency science inventories. The ability to retrieve, use and understand information gathered in these inventories depends heavily on a well-supported home for RIS electronic data storage.

While we believe all of our recommendations are feasible, we conclude our review with 2 expectations: first, that the agency will be conducting far fewer survey activities and second, that any science-based activity that the agency retains in the future will be more expensive, better founded in the scientific method, and defendable in a court of law or the arena of public opinion.

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APPENDIX A: METHODOLOGY SURVEY

METHODS TO BE EVALUATED

A. Mitch Lockwood
    a. White-tailed Deer Spotlight counts
    b. White-tailed Deer Mobile counts
    c. White-tailed Deer Aerial counts
    d. White-tailed Deer Age/wt/antler
    e. CWD sampling
    f. Browse survey on MLDP properties
B. Clay Brewer
    a. Mule deer spotlight counts
    b. Mule deer aerial counts
    c. Mule age/wt/antler
    d. Pronghorn aerial counts
C. Monique Slaughter
    a. Alligator spotlight counts
    b. Alligator nest counts
D. Robert Perez
    a. Roadside quail observation survey
E. Steve DeMaso
    a. Eastern hen/poult survey
    b. Eastern turkey check station
    c. Rio hen/poult survey
    d. Roadside pheasant observation survey
    e. Lesser Prairie Chicken Lek Survey
    f. Lesser Prairie Chicken Lek Distribution Survey
F. Jay Roberson
    a. Dove Call Counts
    b. White Wing Production Surveys
G. Dave Morrison
    a. Aerial Goose Regulatory Survey
H. Brent Ortego
    a. Eagle Survey
    b. Colonial Wading Bird
I. Gary Calkins
    a. River Otter Surveys

STANDARDIZED QUESTIONS REGARDING EACH METHOD

Please provide a set of responses to the following questions for each method for which you are assigned. When the questionnaire(s) are completed, return to Ron George. Please respond by July 16.

A. Establish the Basis of the Method –
    - Provide full citations for the key literature references that support the use of this technique?
    - Has the technique been modified since the original reference was published? If so, how.
B. Statistical Design:
    - Describe the sampling frame including information on original design and sample size calculation.
    - Are samples randomly distributed?
    - What is the statistical power of the technique?
    - What percentage change is the technique designed to detect?
    - Note any obvious sources of bias?
    - What is the scale for this method (management unit, county, eco region, state, multi-state, multi-national).
C. Implementation of method
    - Are there written protocols?
    - Are observers provided with the written protocols?
    - Is there training in the use of the method?
    - Are there efforts made to minimize sources of known bias?
D. Data Acquisition
    - Is there a standardized data sheet?
    - Are the data stored in electronic format?
    - Is there centralized data storage?
E. Data Analysis
    - Which of the following statistical parameters are used to describe the data (Mean, Coefficient of Variation, Variation, Regression)
    - Are probability values calculated?
F. Interpretation and Use of Data
    - Why are these data collected and how are they used?
    - Is the data used at the appropriate scale?
G. Documentation and Reporting
    - Are these data reported outside of the PR report?

APPENDIX B: WILDLIFE DIVISION QUESTIONNAIRE

WILDLIFE MANAGEMENT INSTITUTE
TPWD SCIENCE REVIEW

EMPLOYEE SURVEY

Date Questionnaire Completed: ________________________

Circle Your Duty Assignment:

Field   Headquarters

Circle Your Position Classification:

Manager	II	III	IV	V
Program Specialist	III	IV	V	VI
Program Administrator II	III	IV	V	
NRS	III	IV	V	

I. Please circle your response to the following statements about the scientific basis of data gathering, summary, and analysis procedures for surveys conducted by the Texas Parks and Wildlife Department:

1. Survey methods are applied in the same manner across districts and regions.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

2. Survey methods are based on a sound sampling design.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

3. Survey methods are designed, tested, and applied adequately.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

4. Inherent biases in survey methods are well understood.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

5. Appropriate data analysis techniques are used routinely.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

6. Data are adequately reported, stored, and retrievable.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

7. Advice of a competent biostatistician is sought on the design of new methods or studies before data are gathered.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

8. A competent biostatistician is consulted routinely before data are analyzed.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

9. Differences between precision and accuracy are clearly understood.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

10. Standard data forms are used routinely.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

11. Written protocols are followed as data are gathered.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

12. The wildlife research project selection process selects research studies applicable to agency needs.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

II. Please **circle** your response to the following statements about the scientific basis of public and private land management decisions or recommendations of the Texas Parks and Wildlife Department:

13. Routinely prescribed land management practices are scientifically founded.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

14. Employees routinely seek peer review and consultation before a land management treatment is prescribed.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

15. Scientifically sound evaluations of land management practices are conducted to determine the outcomes of management.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

III. Please **circle** your response to the following statements about employment, training, culturing, and rewarding of good scientists in the Texas Parks and Wildlife Department:

16. Expertise in science is properly identified for entry-level positions where data gathering will be a large part of the job.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

17. Training is adequate for employees to accomplish the science-based studies their jobs require.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

18. Science training is a priority of the agency for continuing education of employees.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

19. Access to library materials, internet resources, and abstract services is facilitated.

    Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

20. Membership in professional societies and attendance at professional meetings is encouraged.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

21. Adequate opportunities are provided to advance science training through attendance at workshops and symposia.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

22. Good science is appreciated and valued among employees.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

23. Good science is appreciated and valued among supervisors.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

IV. Please **circle** your response to the following statements about the integration of science into the management decision process of the Texas Parks and Wildlife Department:

24. Routinely collected data are used at the correct scale.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

25. There is a well-defined and effective process for integrating science information into decision making.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

26. Data from survey efforts are easily accessible by all appropriate personnel.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

27. Data from routine survey activities are pertinent and directly applicable for decision making.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

28. Science recommendations are considered adequately by decision makers in the agency.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

29. Data from survey efforts are frequently compromised at the district or regional level for considerations beyond biology.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

30. Strengths and weaknesses of data are communicated effectively to decision makers by those individuals responsible for presenting science information.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

V. In this section please provide any additional comments you feel important in helping WMI evaluate Texas Parks and Wildlife science programs. If possible, please reference your comments by providing the number(s) of the question(s) most related to your comments. Attach another page if necessary.

Upon completion of the questionnaire place it into the addressed and stamped envelope provided and mail it by: AUGUST 13, 2004.

Thanks for your participation in this review.

Wildlife Management Institute

APPENDIX C: PARKS DIVISION QUESTIONNAIRE

WILDLIFE MANAGEMENT INSTITUTE
TPWD SCIENCE REVIEW

EMPLOYEE SURVEY

Circle Your Position Classification:

Natural Resource Specialist

State Park Manager

I. Please circle your response to the following statements about the scientific basis of data gathering, summary, and analysis procedures for flora and fauna inventories conducted by the Texas Parks and Wildlife Department:

1. Flora and fauna inventory methods are applied in the same manner across Parks regions.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

2. Flora and fauna inventory methods are based on a sound sampling design.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

3. Flora and fauna inventory methods are designed, tested, and applied adequately.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

4. Inherent biases in flora and fauna inventory methods are well understood.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

5. Appropriate data analysis techniques are used routinely.

   Strongly Agree   Agree   Disagree   Strongly Disagree   No Opinion

6. Data are adequately reported, stored, and retrievable.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

7. Advice of a competent biostatistician is sought on the design of new methods or studies before data are gathered.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

8. A competent biostatistician is consulted routinely before data are analyzed.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

9. Differences between precision and accuracy are clearly understood.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

10. Standard data forms are used routinely.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

11. Written protocols are followed as data are gathered.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

12. There is an adequate process within the Parks Division to select research projects applicable to agency needs.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

II. Please **circle** your response to the following statements about the scientific basis of land management decisions for Texas State Parks:

13. Routinely prescribed land management practices within state parks natural resource management plans are scientifically founded.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

14. Employees routinely seek peer review and consultation before implementing a land management treatment ~~is~~ prescribed within the state park natural resource management plan.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

15. Scientifically sound evaluations of land management practices are conducted to determine the outcomes of management.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

III. Please **circle** your response to the following statements about employment, training, culturing, and rewarding of good scientists in the Texas Parks and Wildlife Department:

16. Expertise in science is properly identified for entry-level positions where data gathering will be a large part of the job.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

17. Training is adequate for employees to accomplish the science-based studies their jobs require.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

18. Science training is a priority of the agency for continuing education of employees.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

19. Access to library materials, internet resources, and abstract services is facilitated.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

20. Membership in professional societies and attendance at professional meetings is encouraged.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

21. Adequate opportunities are provided to advance science training through attendance at workshops and symposia.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

22. Good science is appreciated and valued among employees.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

23. Good science is appreciated and valued among supervisors.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

IV. Please **circle** your response to the following statements about the integration of science into the management decision process of the Texas Parks and Wildlife Department:

24. There is a well-defined and effective process for integrating science information into decision-making.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

25. Data from flora and fauna inventory efforts are easily accessible by all appropriate personnel.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

26. Science recommendations are considered adequately by decision makers in the agency.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

27. Strengths and weaknesses of data are communicated effectively to decision makers by those individuals responsible for presenting science information.

Strongly Agree Agree Disagree Strongly Disagree No Opinion

V. In this section please provide any additional comments you feel important in helping WMI evaluate Texas Parks and Wildlife science programs. If possible, please reference your comments by providing the number(s) of the question(s) most related to your comments. Attach another page if necessary.

Upon completion of the questionnaire place it into the addressed and stamped envelope provided and mail it by: November 5, 2004.

Thanks for your participation in this review.
Wildlife Management Institute

APPENDIX D: DISTANCE SAMPLING REFERENCES

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman & Hall, London. 446 pp.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. J. Thomas. 2001. An introduction to distance sampling: Estimating abundance of biological populations. Oxford University Press, Oxford, UK. 432 pp.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, L. J. Thomas (Editors). 2004. Advanced Distance Sampling. Oxford University Press, Oxford, UK.

Laake, J. L., S. T. Buckland, D. R. Anderson, and K. P. Burnham. 1994. Distance User's Guide V2.1. Colorado Cooperative Fish & Wildlife Research Unit, Colorado State University, Fort Collins, CO. 84 pp.

Thomas, L., S. T. Buckland, K. P. Burnham, D. R. Anderson, J. L. Laake, D. L. Borchers, and S. Strindberg. 2002. Distance sampling. Pp.544-552, Volume 1, *in* Encyclopedia of Environmetrics, El-Shaarawi, A. H. and W. W. Piegorsh (Eds). John Wiley and Sons Ltd. Chichester.