Chapter 12

SAGE-GROUSE (*Centrocercus urophasianus*)

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I. INTRODUCTION – Characteristics of greater sage-grouse (*Centrocercus urophasianus*) populations and habitats have been described in numerous studies throughout the species' range (Gregg et al. 1994, Fischer et al. 1996a, Schroeder 1997, Apa 1998, Sveum et al. 1998, Commons et al. 1999, Lyon 2000, Nelle et al. 2000, Smith 2003, and others). Connelly et al. (2000b) developed guidelines for managing sage-grouse populations and habitats, and stressed monitoring is a critical element of any effective management program.

Most studies of sage-grouse ecology have relied on previously published techniques for assessing rangeland vegetation, and for monitoring and trapping sage-grouse (Canfield 1941, Daubenmire 1959, Floyd and Anderson 1982, Giesen et al. 1982, Emmons and Braun 1984, Wakkinen et al. 1992, Burkepile et al. 2002, Connelly et al. 2000a, and others). However, those vegetation assessment methods were not developed specifically for sage-grouse habitats. In addition, some techniques for monitoring populations were not described in detail while others were based on work done in a limited geographic area, or done over a relatively short time.

In recent decades, sage-grouse populations have declined (Connelly and Braun 1997, Braun 1998, Connelly et al. 2004) and numerous factors continue to threaten the species and its habitats (Connelly and Braun 1997, Wambolt et al. 2002, Connelly et al. 2004, U. S. Department of Interior 2010, Knick and Connelly 2011). Standard techniques for monitoring populations and habitats will provide consistent data sets that permit comparisons among areas and years. Connelly et al. (2003) compiled and attempted to standardize all the major techniques useful for monitoring sage-grouse habitats and populations. The following information is largely taken from their report. Some important additions (e.g., lek definitions) and edits have been made to adapt the information for use in Wyoming. Recently, Stiver et al. (2010) developed a more detailed framework for monitoring sage-grouse habitats at multiple scales. However, their document is too large to append to this chapter.

II. POPULATION MONITORING AND ASSESSMENT – The foundation of an effective conservation strategy for sage-grouse is a standardized monitoring program that assures meaningful population status and trend information is collected. The monitoring program must generate regular reports that can be used to analyze factors affecting sage-grouse populations on a local scale, in order to implement local conservation plans. As well, the data should be suitable for statewide analyses and comparisons with similar data sets from other states. The WGFD sage-grouse database

fulfills these needs. The database houses results of lek surveys and counts, and harvest data including age and sex composition derived from wing barrel collections. The database provides a basis for local, regional and statewide analyses of sage-grouse status and trends.

A. Breeding Populations – Sage-grouse gather on traditional display areas called leks each spring. This behavior enables biologists to collect data used to track breeding populations. Survey methods include lek censuses (annually counting the number of male sage-grouse attending leks in a given area), lek complex routes (annually counting the number of male sage-grouse within a group (complex) of leks that are relatively close and represent part or all of a single breeding population), and lek surveys (annually counting the number of leks that are active in a given area). All lek monitoring is done early morning (1/2 hour before to 1 hour after sunrise), under reasonably good conditions (calm to light wind, partly cloudy to clear), from early March to early May. Appropriate ranges of survey dates depend on the elevations at which leks are found and the persistence of winter conditions. In milder climates at lower elevations, sage-grouse begin displaying during late February. Grouse may also begin displaying at this time in response to mild winter weather. At higher elevations, lek attendance persists through early or mid-May.

   The following definitions have been adopted for the purposes of collecting and reporting lek data:

   - Lek. A traditional courtship display area attended by male sage-grouse in or adjacent to sagebrush dominated habitat. A lek is designated based on observation of two or more male sage-grouse engaged in courtship displays. Before a suspected lek is added to the database, it must be confirmed by a survey conducted during the appropriate time of day, during the strutting season. Sign of strutting activity (tracks, droppings, feathers) can also be used to confirm a suspected lek. Sub-dominant males may display on itinerant (temporary) strutting areas during years when populations peak. Such areas usually fail to become established leks. Therefore, a site with small numbers of strutting males (<5) should be confirmed active for two years before the site is added to the lek database.

   - Satellite Lek – A relatively small lek (usually less than 15 males) within about 500 meters of a large lek often documented during years of relatively high grouse numbers. Locations of satellite leks should be encompassed within lek perimeter boundaries. Birds counted on satellite leks should be added to those counted on the primary lek for reporting purposes.

   - Lek Perimeter – The outer perimeter of a lek and associated satellite leks (if present). Perimeters of all leks should be mapped by experienced observers using accepted protocols (Section 1.b.v below); larger leks should receive higher priority. Perimeters may vary over time as population levels or habitat and weather conditions fluctuate. However, mapped perimeters should not be adjusted unless grouse use consistently (2+ years) demonstrates the existing perimeter is inaccurate. The lek location must be identified and recorded as a specific point **within** the lek perimeter. This point may be the geographic center of the perimeter polygon calculated though a GIS exercise, or a GPS waypoint recorded in the field, which represents the center of breeding activity typically observed on the lek.

- Lek Complex. A cluster of leks within 2.5 km (1.5 mi) of each other, between which male sage-grouse may interchange from day to day.

- Lek Count. A census technique that documents the number of male sage-grouse observed attending a particular lek, lek complex, or leks along a lek route based on repeated observation.

- Lek Count Route – A lek route is a group of leks in relatively close proximity that represent part or all of a discrete breeding population/sub-population. Leks should be counted on routes to facilitate replication by other observers, increase the likelihood of recording satellite leks, and account for shifts in distribution of breeding birds. Lek routes should be set up so an observer following criteria described under "Lek Count" can count all leks within 1.5 hours.

- Lek Survey. A monitoring technique designed primarily to determine whether leks are active or inactive. Obtaining accurate counts of males attending is secondary.

- Annual status – Lek status is assessed annually based on the following definitions:

    - active – Any lek that has been attended by male sage-grouse during the strutting season. Acceptable documentation of grouse presence includes observation of birds using the site or signs of strutting activity.

    - inactive –Any lek where sufficient data indicates no strutting activity took place throughout a strutting season. Absence of strutting grouse during a single visit is not sufficient documentation to establish a lek is inactive. This designation requires documentation no birds were present on the lek during at least 2 ground surveys separated by at least 7 days. The surveys must be conducted under ideal conditions (site visits between April 1 and May 7, no precipitation, light or no wind, ½ hour before to 1 hour after sunrise) **or** a ground check of the exact lek location late in the strutting season (after 4/15) during which sign (droppings/feathers) of strutting activity is not found. Data collected by aerial surveys cannot be used to designate inactive status.

    - unknown – Leks for which active/inactive status has not been documented during the course of a strutting season. Excepting leks not scheduled to be checked in a particular year, the "unknown" status designation should be applied only in rare instances. Each lek should be checked enough times to determine whether it is active or not. It is preferable to conduct two good field checks every other year and confirm the lek is "inactive" rather than check it once every year and have it remain in "unknown" status.

Based on its annual status, a lek may be assigned to one of the following categories for management purposes:

- occupied lek – A lek that has been active during at least one strutting season within the prior ten years. Occupied leks are protected through prescribed management actions during surface disturbing activities (see Section V).

- unoccupied lek –Two classifications of unoccupied leks are "destroyed" and "abandoned" (defined below). Unoccupied leks are not protected during surface disturbing activities.

- destroyed lek – A formerly active lek site and surrounding sagebrush habitat that has been destroyed and is no longer suitable for sage grouse breeding. A lek site that has been strip-mined, paved, converted to cropland or undergone other long-term habitat type conversion is considered destroyed. Destroyed leks are not monitored unless the site has been reclaimed to suitable sage-grouse habitat.

- abandoned lek – A lek in otherwise suitable habitat that has not been active during a period of 10 consecutive years. To be designated abandoned, a lek must be "inactive" (see above criteria) in at least four non-consecutive strutting seasons spanning the ten years. The site of an "abandoned" lek should be surveyed at least once every ten years to determine whether it has been reoccupied by sage-grouse.

- undetermined lek – Any lek that has not been documented as active in the last ten years, but survey information is insufficient to designate the lek as unoccupied. Undetermined lek sites are not protected through prescribed management actions during surface disturbing activities until sufficient documentation is obtained to confirm the lek is occupied. This status should be applied only in rare instances (also see "unknown" above).

1. Locating and Mapping Leks –

   a. Rationale – Managers must locate leks and document status before designing a program to monitor sage-grouse breeding populations. Leks can be detected by searching from the ground or air in early March to early May.

   b. Application –

      i. Aerial Searches – Lek searches can be done effectively from either helicopters or fixed-wing aircraft. Strutting cocks are highly visible during early morning hours when the sun illuminates their white chests. Fly north-south transects approximately 1 km (0.6 mi) apart throughout suitable breeding habitats. Observations made during aerial searches are biased toward larger leks; small leks (<15 birds) are more difficult to detect. Conduct aerial searches only on calm, clear mornings. Cancel the flight if winds exceed 15 mph or if more than scattered cloud cover is expected. Cocks can be seen from more than 1.0 km (.6 mi) in early morning sun, but cloud cover greatly reduces illumination and contrast at this distance. In marginal light, fly narrower transects. High winds not only make traveling a straight transect difficult, but also

affect strutting behavior. Under such conditions, fewer cocks strut continuously, and they tend to flush at greater distances.

Fly transects about 100-150 meters (300-450 ft) above ground level. Whenever possible, transport 2 observers in addition to the pilot so 1 observer always looks away from the sun regardless of the flight direction. Begin north/south search patterns at the east edge of the survey area and progress westward to avoid flying over leks before they are seen. Pay particular attention to old lakebeds, stock-watering areas, and other relatively open sites largely surrounded by sagebrush with 15 to 25% canopy cover. Conduct aerial searches from ½ hour before sunrise to 1 hour after. Searches can be extended to 1½ hours after sunrise during the portion of the breeding season when male attendance peaks.

Cocks respond to approaching aircraft in various ways that can affect search results. In some cases, they may continue to strut as the plane approaches and flies past or overhead. In other cases, grouse will "squat" as they do when an avian predator approaches. Sage-grouse virtually disappear when they squat, therefore observers should scan well ahead and laterally to the next transect line to detect cocks before the aircraft approaches closely or flies overhead. Based on past research, up to a third fewer birds are detected by aerial counts compared to ground counts. Therefore aerial counts are not generally considered adequate to monitor trends in lek attendance. Researchers in Nevada have attempted to develop a dependable method for counting grouse from helicopters.

Search intervals can be increased to 1.5 km (about 1.0 mile) in poor habitat and areas with no recent history of use by sage-grouse. On the other hand, narrower search intervals are advised in areas where habitat alteration or human development is anticipated, to assure the area is thoroughly searched.

ii. Ground Searches – In areas with relatively good access, observers can locate leks by driving along roads in suitable breeding habitat and stopping every half mile to listen for sounds of displaying grouse. During calm mornings, displaying sage-grouse may be heard from a distance of 1.5 km (about 1 mi). Ground searches can begin an hour before sunrise. In less accessible areas, searches can be done from a mountain bike, trail motorcycle, 4-wheel all-terrain vehicle, on horseback or afoot. Use binoculars or a spotting scope to look for displaying birds within openings and areas of less dense sagebrush.

Leks can also be located by looking for evidence after fresh snowfall the prior night or early morning. Lek activity is minimal during stormy weather and the birds may flush at the first sign of an intruder. However some male sage-grouse will attend leks virtually every morning throughout the spring period, regardless of weather. Search locations of suspected leks immediately following a snowfall. If grouse use the area, they will leave tracks in the snow. The number of tracks may give some indication of the relative size of the lek. In addition, leks are occasionally discovered when

concentrated tracks, droppings, and feathers are encountered during other field activities (e.g., big game winter mortality transects).

Leks characteristically have concentrations of scattered fecal pellets, feathers, tracks and trampled vegetation (Fig. 1). In contrast, fecal deposits on winter ranges and roost sites are typically discrete piles next to sagebrush (Fig. 2). In addition, strutting sites are usually marked by large numbers of caecal droppings (miniature black "cow pies") (Fig. 1). Caecal droppings are initially green, but cure to black quickly in the sun. Presence of green caecal droppings and fresh tracks indicate lek was active earlier in the morning. Fecal droppings can last for years, though they fade with time. On the other hand, caecal droppings usually decay within days or weeks depending on precipitation. Always have field personnel record locations where this sign of a lek is observed. To confirm the site is a lek, it must be visited during early morning strutting hours to document attendance by male sage-grouse.

Fig. 1. Lek sign: scattered fresh fecal pellets (olive green and white), fresh caecal droppings (black/green "tar") and scattered feathers.

Fig. 2. Roost sign: pile of fecal pellets with decaying caecal dropping in lower right portion of photo.

iv. Lek Identification – Not every site where sage-grouse are seen strutting is a lek. Grouse that have been flushed from a lek often resume strutting at a different location for the remainder of the morning, and then return to the actual lek the following night. Juvenile cocks sometimes pursue hens as they leave a lek. Groups of strutting juvenile males have been observed up to 0.8 km (½ mi) from the lek as they follow the females. Therefore, additional confirmation is necessary to verify a site where males are seen strutting is actually a lek. Strutting activity should be documented at a site on at least two mornings before it is designated as a lek. A ground survey to search for sign of prolonged activity at the site can also separate true leks from temporary strutting sites.

v. Lek Perimeters - The Wyoming Greater Sage-Grouse Conservation Plan (2003), the eight local sage-grouse conservation plans, the Governor's Sage-Grouse Executive Order 2011-5 and various federal agency planning documents recommend or stipulate protective measures based on occupied lek perimeters (see also Section V). Distance-based stipulations such as "No Surface Occupancy (NSO)" and "Controlled Surface

Use" (CSU), and other management practices are more effective when the action is based on lek perimeters rather than lek centers.

Mapping Lek Perimeters with a Handheld GPS Unit (Preferred)

1. Only observers familiar with the recent history (≥1 year, ≥3 observations) of each individual lek should map its perimeter given day-to-day variation of grouse use. Any perimeter mapping exercise is an approximation of grouse use and requires some judgment. However, observers should strive for accuracy and refrain from subjectively buffering perimeters.
2. Record waypoints in UTMs using NAD 83 datum.
3. Do not disturb grouse on the lek. Map perimeters after the birds leave for the day.
4. Locate the perimeter based on cumulative observations and grouse sign. While walking the perimeter, record waypoints at approximately 10 meter intervals.
5. Also record a single waypoint representing the lek center. This should be located in the center of strutting activity. The center point MUST be within the current perimeter.
6. Download the waypoints to a computer. Use a file extension that allows the ability to directly transfer data between Garmin GPS handheld receivers and various GIS software packages. This and other useful extensions are available at: http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html .
7. Save the data in .txt, .csv, .dbf, or .shp format.
8. Email your data to the sage-grouse GIS analyst who will convert the data into polygon format. Store and distribute the data as required.

Alternate Method: Pen and Paper Map

1. Follow steps 1 and 2 above.
2. Observe the lek and note where the birds are strutting.
3. Use a fine point pen or pencil to carefully hand draw the lek perimeter on a 1:24,000 scale orthophoto map.
4. Add the following information: name, affiliation, date and time of data collection.
5. Complete step 8 above.

c. Analysis of Data – Numbers and distribution of occupied and abandoned leks are monitored through time to assess population trends, changing habitat conditions and impacts of disturbance. Lek locations are also incorporated into GIS layers for future reference by persons planning or commenting on development activities, and by persons who are preparing habitat management plans or mitigation projects.

d. Disposition of Data – Record the center point and perimeter of all leks in UTM demarcations using NAD83 datum and enter the information in the Wyoming Sage-grouse Database.

2. Breeding Surveys –

a. Rationale – Various types of breeding surveys are applied in research and management to monitor lek status, population trends, and responses to disturbances, habitat treatments, and land management practices. The data also provide documentation for commenting on land use plans and proposed developments.

b. Application –

i. Lek Counts –

- Rationale – Lek counts are a common means of collecting data used to monitor sage-grouse populations. Methods accepted by researchers and managers are used to document the actual number of male sage-grouse observed on a particular lek or lek complex (Jenni and Hartzler 1978, Emmons and Braun 1984). A lek complex is a group of leks in close proximity between which male sage-grouse are expected to interchange.

  Although lek counts are widely employed to monitor sage-grouse populations, some researchers have questioned their usefulness (Beck and Braun 1980). However, problems tend to arise more because the survey protocols are not rigorously followed than from any inherent flaw in the techniques themselves. For example, some leks have been counted at the wrong time of the year or during periods of wind or precipitation. All observers should receive adequate training before conducting lek counts. Proper methods for conducting lek surveys are described in this chapter. Video training guides (Power Point format) are also available from the WGFD sage-grouse program coordinator.

- Application – Adhere to the following criteria to assure counts are done consistently and accurately, enabling valid comparisons among data sets.

  - Conduct lek counts at 7-10 day intervals over a 3-4 week period after the peak of mating activity. Although mating typically peaks in early April in Wyoming, the number of males counted on a lek is usually greatest in late April or early May when attendance by yearling males increases.
  - Conduct lek counts only from the ground. Aerial counts are not accurate and are not comparable to ground counts.
  - Conduct counts between ½ hour before sunrise and 1 hour after.
  - Count attendance at each lek a minimum of three times annually during the breeding season.
  - Conduct counts only when wind speeds are less than 16 kph (10 mph) and no precipitation is falling.

Subdominant males are often less active and visible than are dominant males occupying the center of the lek. Consequently, subdominant birds are easily overlooked during a single count. A lek can be counted effectively in the following manner:

- Count from a location that affords good visibility of the entire lek. If the lek is very large (100 or more birds) it may be necessary to select two or more vantage points. Be careful not to get so close that your presence disturbs the grouse.
- Record the time the count begins.
- Count the birds from left to right (or vice versa), tallying males and females separately.
- Wait one to two minutes and then count from right to left.
- Wait one to two minutes and count from left to right again.
- Record the highest individual counts of male grouse and female grouse, and then move to the next lek.

Some sage-grouse will move among several leks throughout a breeding season (Dalke et al. 1960, 1963). Therefore, changes in attendance at a particular lek may actually reflect birds shifting to nearby leks. Moreover, birds may cease using a lek because of disturbance or changes in vegetation. The disappearance of a lek may or may not mean the population is declining. To assess actual changes in a grouse population, all leks within a complex or along an established lek route must be counted annually.

ii Lek Count Routes –

- Rationale – A lek count route is a survey method designed to census a group of leks that are relatively close and represent all or part of a single breeding population. Leks should be counted along routes to facilitate replication by other observers, increase the likelihood of recording satellite leks, and account for any movement of breeding birds among leks.

- Application – Select routes that enable all leks on the route to be counted within 1.5 hours. If weather conditions deteriorate after you begin a lek route, the route should be run again. If no birds are observed on a lek that was occupied in prior weeks or years, the observer should exit the vehicle and, with the engine off, listen for sounds of displaying grouse. Birds will sometimes relocate to a new lek site when they are subjected to continuing disturbance. If a predator flushes grouse from a lek, and it is still reasonably early in the morning, the grouse may also resume displaying nearby once the predator leaves the area.

  Before establishing lek routes in a given area, give some thought to the number of personnel available to conduct the counts. It is much better to plan fewer counts yielding high quality data than to compromise data by scheduling more counts

than personnel can reasonably handle. A responsible Department biologist or wildlife management coordinator should assign personnel to conduct lek counts and count routes. It is acceptable for persons from outside the agency to conduct counts if they are properly trained. Leks with the longest history of consistent data collection should be included in count routes, as these provide a basis for long-term trend assessment. Leks most vulnerable to impacts from a management activity or disturbance should be counted if possible. Pre-, during-, and post-treatment counts provide important information for determining project impacts and appropriate mitigation. At least one lek count route should be conducted in each biologist district, preferably more as personnel resources allow.

iii. Lek Status Surveys –

- Rationale – Ideally, all sage-grouse leks would be counted annually. However, some breeding habitat is inaccessible during spring due to mud and snow conditions, or because the lek is so remote it cannot be routinely counted. In other situations, topography or vegetation may preclude an accurate count from any vantage point. In addition, time and budget constraints often limit the number of leks that can be visited. Where lek counts are not feasible for any of these reasons, status surveys are the only other reliable means to monitor population trends. Lek status surveys are often designed principally to determine whether leks are active or inactive, requiring just a single visit to each lek. Obtaining accurate counts of the numbers of males attending is not essential during these surveys. Status surveys involve substantially less time and effort than lek counts. They can also be done from a fixed-wing aircraft or helicopter. Because multiple visits are not required to determine peak attendance, leks that are not on count routes can be surveyed over an extended period from the initiation of strutting in early March until early-mid May depending on the site and spring weather.

  This technique has a drawback in that it is not very sensitive to population changes unless the sample of leks is large ($\geq$50) (Fedy and Aldridge 2011). For example, 50 males may be observed within a group of 5 leks during one spring survey and 75 males two years later. What appears to be a 50% increase may not be the case for a variety of reasons. The only legitimate interpretation is that all 5 leks were active each year they were surveyed. However, on a large scale, lek survey data have been consistent with lek count data and population trends within Wyoming (Fedy and Aldridge 2011). Therefore, whenever possible, lek status surveys should be conducted with the same rigor, using the same criteria as lek counts other than the number of visits per year.

- Application – To support the most useful inferences regarding population trends, lek status surveys need to be conducted the same manner, during the same time frame each year. In other words, surveys should not be conducted from a fixed-wing aircraft one year and a helicopter the next year, or in early March one year and May the next. Record the date and time each survey is conducted. Also record UTM coordinates of each lek encountered, and note any other information

that might later be considered important. Although it is difficult to accurately count birds from an aircraft, it is usually possible to estimate the number present.

If the exact location of a lek is known, its activity status can be checked any time of day and for a short period following the strutting season based on presence of sign (refer to previous discussion of sign in "locating leks – ground searches"). Site visits also give observers an ideal opportunity to precisely map the lek by walking its perimeter and recording the coordinates with either GPS technology or orthophoto quad maps (refer to "lek perimeters").

The ideal time of day to conduct lek status surveys is the same as specified for lek counts – about 1/2 hour before until 1 hour after sunrise. Under some conditions, sage-grouse will strut up to two hours or more after sunrise. Prolonged attendance usually coincides with: 1) presence of hens on the lek; 2) dim light conditions (overcast skies, fog, or light snowfall); or 3) the dark or "new" phase of the moon, when little strutting activity occurs at night. Males generally stop strutting early on mornings when hens are absent (late in the strutting season) or near the full moon, when much of the strutting and breeding take place at night. During the full and nearly full moon, sage-grouse may strut all night and males will occasionally initiate strutting at sunset or shortly after. At these times, leks can occasionally be checked in the evening. Lek status surveys can be conducted at night during the full moon, provided leks can be approached closely enough to either hear or spotlight displaying grouse. However, nighttime surveys are not suitable for counts of lek attendance.

The frequency of surveys conducted at known leks may depend on personnel availability and budget. Leks in remote locations should be surveyed at least once every other year. Other leks should be surveyed more frequently, annually if feasible, based on the findings of Fedy and Aldridge (2011). Public interest in sage grouse management has increased in recent years, and has afforded the opportunity to utilize volunteers to survey or count leks, thus increasing data collection capacity. Volunteers should be properly trained to ensure they collect quality data and do not disrupt breeding activity.

c. Analysis of Data – Before compiling and analyzing data from lek counts or status surveys, proof all raw data to assure the information was collected properly. Lek counts conducted during stormy weather, high winds or late in the morning (i.e., routes completed more than 1.5 hours after sunrise) should not be included in the analysis. In addition, status surveys done under any of the above conditions should not be considered conclusive if birds were not observed.

To assess breeding population trends, the minimum information required is a record of the number of active leks in a given area over a period of years. This information can be obtained from lek status surveys and lek routes, but these data only represent gross changes in the population and can produce misleading results.

When collected properly, lek count data are more useful to assess population trends. The following types of data are derived from lek counts: number of active leks per route; average number of males per route or complex; maximum number of males per route or complex; average number males per lek; maximum number of males per lek; and possibly, males per area (all males counted on a group of lek routes). Sometimes the number of leks along a route changes because the route was altered, the habitat has changed or satellite leks have become established. If such circumstances arise, the most effective means of tracking populations and analyzing changes is to examine the number of males per lek. If the number of leks does not change over a period of years, then the number of males per route should constitute the basis for assessing the breeding population.

Although females are generally encountered along lek routes, they are difficult to accurately count because of their secretive nature and cryptic appearance. The number of females observed may provide some indication when breeding peaks; however these data should not be used to assess population changes.

The Wyoming sage-grouse database and Job Completion Report have improved data storage, retrieval, analysis and reporting both at regional and statewide scales. All current and historical data should be entered into the database.

Estimates of breeding populations have been developed from lek attendance data in the Wyoming Sage-grouse database and Job Completion Report. However, the procedure is not widely accepted by other wildlife agencies. All leks representing a population are identified and the maximum attendance counts recorded during a specific year are summed. The total is divided by 0.75 (to adjust for unseen males) and multiplying by 2 to estimate the number of females in the population (assuming a 2:1 sex ratio of females to males). The estimated numbers of males and females are then added together. In effect, the breeding population estimate is 3 times the estimated number of males. This method has never been validated through experimental trials nor have researchers recommended it as an independent population estimator. Because of uncertainties associated with lek attendance patterns (Beck and Braun 1980, Emmons and Braun 1984, Walsh 2002), possible differences in sex ratios among years and areas (Swenson 1986), and some lack of uniformity in counting procedures, population estimates derived from lek counts are considered very crude, minimum estimates and are not generally useful for making comparisons among areas or years. However, Walsh (2002) identified another procedure based on Bowden's estimator (Bowden and Kufeld 1995) that may be useful for estimating sage-grouse populations in relatively small, discrete areas.

d. Disposition of Data – Enter all data from lek counts and status surveys into the Wyoming Sage-grouse Database. These data are annually summarized and analyzed in the Sage-grouse Job Completion Report.

B. Brood Production – Brood production is monitored for several purposes: 1) low production can indicate problems with habitat or effects of drought and other stressful weather patterns; 2) production is useful to forecast the availability of birds during the upcoming hunting season; 3)

production can be an indicator of the success of habitat treatments; and 4) increasing or decreasing brood production can foretell the beginning of a population recovery or downward trend, respectively. Production is expressed as the proportion of hens with broods or the ratio of juveniles to adult hens, and can be assessed using one or more of the following techniques: brood observations, brood routes and wing surveys (Autenrieth et al. 1982).

1. Brood Observations –

    a. Application – Brood observations, sometimes called random brood routes, are simply records of all sage-grouse broods observed incidentally by any field personnel working in an area. Once they are tallied, brood observations provide some indication of the juvenile to adult ratio and proportion of hens with broods.

    b. Analysis of Data – Brood observations are somewhat better than anecdotal information, but not easily replicated. It can also be difficult to interpret comparisons of brood data among years.

2. Brood Routes –

    a. Application – Brood route surveys are usually scheduled during late June, July, and early August. Routes are generally established in areas of known sage-grouse concentrations, often in or adjacent to wet meadows, riparian zones, and agricultural areas. Routes are followed on foot or horseback, or in a vehicle driven at speeds <32 kph (20 mph) and are completed in the morning (sunrise to about 0900) and evening (1800 to sunset). Record each brood separately, indicating the size of the brood, its location, and whether a hen is present. Also tally groups of unsuccessful females and males as they are encountered. Chicks are quite secretive therefore it is usually necessary to flush the brood to obtain an accurate count. A trained bird dog can help the observer locate more broods. If a sufficient sample of grouse broods is observed, this technique can provide a reliable indication of production trends.

    b. Analysis of Data. The following information is derived from brood route data: birds/km, broods/km, average brood size, and ratio of chicks to adult hens. Brood routes are the only economical means to assess production within non-hunted or lightly-hunted populations from which relatively few wings are collected. Productivity can also be assessed using hens marked with telemetry transmitters, however this is a much more intensive and costly method.

3. Wing Collections –

    a. Rationale – Sage-grouse wings collected during hunting seasons are used to estimate the age and sex composition of harvested birds. Within hunted populations of sage-grouse, wing surveys are the most useful technique available to estimate production (chicks/hen) provided an adequate sample can be obtained. The minimum sample size should exceed 150 wings, and could be considerably greater depending on how large an area is sampled and the size of the population.

b. Application – Wings are normally collected in "wing barrels" (Fig. 3) strategically placed along egress routes or by Department personnel at hunter check stations. Wing barrels should be painted a conspicuous color and placed at road intersections where vehicles are required to slow or stop. Signs should be attached to the barrels, instructing the hunter to remove one (1) wing from each harvested bird and place it in the barrel. Plastic signs have been made for this purpose and are available from the Sage-grouse Program Coordinator. Wings should be collected at least twice during the season – the Monday following opening weekend and at the end of the season. Wings should not be stored in plastic. Rather, place wings in paper grocery sacks that are clearly labeled with the wing barrel name/location and the collection date. Sacks of wings should be frozen and stored until the wings can be examined to determine age and sex. Wings are usually "read" at an annual "wing-bee" held in November each year. The wing-bee format allows participants to share their experience and expertise, which greatly enhances the learning process for those with less experience. The Wyoming Game & Fish Department's Sage-grouse Working Group published a "Sage-grouse Sex and Age Guide" (Attachment 1) based on Braun's "A Key for Age/Sex Identification from Wings of Hunter-Harvested Sage-grouse." Use this guide to determine age and gender from wing plumage characteristics of harvested grouse.

Fig. 3. Sage-grouse wing barrel with instruction sign.

c. Analysis of Data – Data from wing collections are compiled to assess trends in production and to compare production among geographic areas. However, these data may not accurately represent population trends. For example, a range type conversion could impact or eliminate a portion of the winter habitat used by a population while breeding habitat remains intact. Afterward, the overall population may decline because mortality has increased on winter range, yet this decline might not be evident from production statistics (the ratio of juveniles to adult hens), which could remain stable. Thus, it is best to view production information in conjunction with other data (e.g., lek counts) to make inferences about population trends.

d. Disposition of Data – Production data should be entered into the Wyoming Sage-grouse Database and summarized in the applicable Job Completion Reports.

C. Winter Habitat Selection

1. Documentation of Winter Use Areas –

a. Rationale – Knowledge about winter use areas can be helpful as biologists review proposed development actions or land use plans, and is also an important consideration for planning habitat treatments. In addition, the information can help biologists identify seasonal movement patterns within migratory populations of grouse. However, no widely accepted method is recognized for censusing grouse populations during winter. In part, this is because grouse distribution can vary markedly from winter to winter. Birds may be spread out over large areas during mild winters but concentrate in relatively small portions of their range in severe winters (Beck 1977). Sage-grouse feed almost exclusively on sagebrush leaves and buds during winter. They tend to select wintering sites where sagebrush is 10-14 inches above the snow and canopy cover may range from 10 to 30 percent. Foraging areas tend to be on flat to generally southwest facing slopes or on ridges where sagebrush height may be less than 10 inches but the snow is routinely blown clear by wind. When these conditions are met, sage-grouse typically gain weight over winter. In most cases winter is not considered limiting to sage-grouse. Under severe winter conditions grouse will often congregate in tall stands of sagebrush located on deeper soils in or near drainage basins. Under these conditions winter habitat may be limiting. On a landscape scale, suitable winter habitats should be accessible under all snow conditions.

Winter Concentration Areas [specific areas persistently occupied by large numbers of sage-grouse between December 1 and March 14] should be delineated and protected (see section V). Delineation of concentration areas is based on presence of winter habitat characteristics and is confirmed by repeated observations and sign of large numbers of sage-grouse. The definition of "large" is relative to the overall population size. In most core population areas, frequent observations of groups of $\geq$50 sage-grouse meet the definition, whereas smaller group sizes of $\geq$25 may indicate winter concentration areas in marginal habitats (including core areas in northeastern Wyoming).

b. Application – Winter concentration areas can be identified by searching for grouse or sign from a 4-wheel drive vehicle, snowmobile, or on foot. Winter habitats can also be located effectively from either a fixed-wing aircraft or helicopter by looking for grouse and tracks in snow cover. Aerial searches can often be done in conjunction with surveys for other wildlife (e.g. elk trend counts/classifications). Fly north-south transects about one minute of longitude apart. This transect interval is not intended to provide complete coverage for "census" purposes. Rather, it is designed to systematically survey a large area in order to efficiently determine relative distribution and habitat use patterns. Not every group of grouse will be seen. In addition to observations of grouse, record tracks and sign. Under good conditions (bright sun and fresh, uncrusted snow) grouse tracks are

quite easy to detect from 300 feet or lower elevation above ground. Tracks are usually seen in groups. Individual tracks tend to wander in a "snakelike" pattern rather than a straight line, and the birds' abdomens plow the snow.

In Wyoming, the falconry season for sage grouse extends through March 1. Falconers often hunt grouse in winter and can be a good source of information to help locate potential wintering areas. Many have volunteered to record grouse observations.

c. Analysis of Data – At a minimum, record the approximate size and location of each flock you observe during winter. Additional descriptive information, particularly cover type (including species of sagebrush), topography, and snow depth, is also valuable. However, it may not be possible to collect this information from an aircraft. Data should be acquired over a series of years and varying snow conditions to obtain a more complete picture of grouse distribution.

d. Disposition of Data – Use the Sage-grouse Observation Form attached to this chapter (Appendix B) to record winter survey data. Observations should be entered on the Wildlife Observation System (WOS). Delineation of winter concentration areas requires consultation and coordination with the WGFD. Winter concentration areas do not account for all habitats sage-grouse use during winter, nor are they restricted to "severe winter relief" habitats. Where available, use seasonal habitat models to assist in the delineation of these habitats. Validate model output using the methods that follow. Important winter habitats should be incorporated in the statewide GIS layer of sage-grouse habitats, and described in the applicable Job Completion Report.

III. TRAPPING AND MARKING –

A. Trapping –

1. Rationale – Sage-grouse are captured and handled predominantly for two purposes: 1) to mark individual birds; and 2) to collect biological samples for analysis. If samples are collected, this is generally done in conjunction with a marking study. Marking has been employed as a method to study sage-grouse populations for well over 50 years (Patterson 1952). Techniques have been refined and the quality of radio transmitters has improved considerably. The 2 periods sage-grouse can be captured most effectively are spring and late summer. Biologists in Colorado have also successfully trapped grouse during winter (A. D. Apa, pers. Comm.). Selection of suitable techniques depends on terrain, access, weather, and population size.

2. Application –

a. Night-lighting. During March and much of April, male and female sage-grouse often roost on or near leks at night. This behavior is especially common when attendance by hens is at its peak, usually the last week of March and first week of April. (In higher elevations, hen attendance may peak in mid-April). At these times, birds are fairly easy to capture by night-lighting (Giesen et al. 1982, Wakkinen et al. 1992). One difficulty is

that males are much easier to see and hence, captured more often than females. Moreover, males tend to roost in the center of a lek while females are found near the edges, sometimes in rocky cover. The peripheral areas can be more difficult to traverse with a 4-wheel drive truck. To overcome these difficulties, researchers in Idaho have adapted the standard night-lighting technique by employing binoculars (to spot and sex birds from a distance) and by broadcasting rock and roll music (a form of "white noise") to conceal approaching footsteps.

Before each trapping session, the research leader should assign specific responsibilities and brief the crew about general trapping procedures. Ideally, the crew will consist of four people: a driver, spotter, primary netter and secondary netter. If possible, personnel should rotate jobs during the night to avoid fatigue.

Trapping begins after complete darkness. The crew drives slowly toward the lek area in a 4-wheel drive truck. As the vehicle approaches, the crew scans the ground with a 1-million candlepower spotlight and binoculars to locate roosting grouse (Wakkinen et al. 1992). (More powerful spotlights may also be available). The spotlight should be equipped with a shroud to narrow its beam. An effective shroud can be made from a coffee can or plastic plant container. As the crew moves around the lek, the driver should stop every 100-200 m (yds), or whenever the crew signals, allowing the spotter to scan the lek and nearby area. If possible, drive to higher ground near the lek to gain a better vantage for spotting birds roosting in heavier cover.

Sage-grouse eyes reflect light at night, and resemble sparkling green emeralds in the spotlight. Depending on terrain and vegetation, this eye reflection can be visible from over 200 m (yds). Normally, spotters are able to identify the white breast feathers of males when they are viewed from less than 100 m (yds). However, it may not be possible to distinguish sex at longer distances. The bird's location relative to the lek also provides an indication of the bird's probable gender. Males tend to roost alone in the comparatively open area of the lek, or sometimes on sparsely vegetated ridges adjacent to the lek. Females tend to be more secretive, roosting near sagebrush cover at the perimeter, and sometimes in small groups.

Once the crew has spotted a bird and decided to capture it, the rock and roal music is put to use. Trapping trucks are equipped with tape or compact disc (CD) players and loud, external speakers. A portable player with reasonably powerful speakers can also be used. As trappers approach the grouse, loud music is played which, together with the sound of the vehicle's idling engine, masks footsteps and tends to disorient the roosting bird. Tape recordings of snowmobiles, generators, or other sources of "white noise" can serve the same purpose.

Two netters dressed in dark clothing walk along the driver's side of the truck. All netting should be done from the driver's side for safety (assuring the driver is aware of the netters' location) and to facilitate communication between the driver and netters. As the truck and netters get closer to the grouse, the spotter will eventually see it easily without binoculars. At this point, the spotter begins to shimmy the spotlight rapidly, keeping the

light focused on the roosting grouse. This produces a strobe-like effect that further confuses the grouse. Netters on the ground are unlikely to see the bird at this point but when they see the light begin to shimmy rapidly, they move 5-10 m (yds) to the side of the truck while staying out of the spotlight. Even if the bird is not visible, the netter must concentrate on the center of the light. Eventually, the bird will come into view. As the truck's front fender is about to pass the grouse, the trapper should place the net over the bird. The net should be swung relatively low and parallel to the ground rather than down from overhead like a butterfly net – to do so increases the risk of injuring the grouse. If the netters are somewhat slow, the driver should begin to circle the bird at a distance of about 5 m (yds) until the netters are able to position themselves for a capture attempt. Throughout this activity, the spotter continues to shimmy the spotlight directly on the bird's eyes to keep it mesmerized.

Once the grouse is in the net, the netter should restrain it by holding the wings next to the bird's body and wait for help to remove it from the net. To reduce the chance of injury or escape, a grouse should not be allow to struggle loosely in the net. An experience netter can remove grouse from the net and safely handle them without additional help. As soon as the spotter sees the captured grouse is under control, he should begin searching the immediate area (out to about 100 m/yds) to locate other grouse. If another bird is found, the trapping crew can proceed after it. If the crew waits until the captured bird is processed, nearby birds will likely flush before another approach can be made. The second netter has two purposes. The first is to replace the primary netter should he stumble or fall while approaching the bird. The other is to assist with a rapid, second capture when the opportunity avails itself.

Most sage-grouse are caught within a few meters of the truck. A capture should only be attempted at longer distances (up to 20 yards) when a grouse is roosting in a rock pile or muddy area where driving is unsafe. The same procedure should be followed, but the netter must move quite rapidly and take special care to stay out of the light. The loud music is especially helpful to conceal footsteps during such attempts.

In very muddy or rough terrain, the same procedure can be deployed from a 4-wheel ATV. Birds are more difficult to spot because the observer does not have the high vantage angle afforded by a truck. When an ATV is used, the trapping crew is normally just 2-3 individuals.

Night-lighting can also be done on foot. This technique can be especially useful when roosting locations are known and minimal search time is necessary. Only two personnel are required, although three are optimum. The method is also suitable for terrain that is too rough for a vehicle. One person is equipped with a rechargeable power pack carried in a backpack, a portable spotlight, and a tape or CD player to broadcast loud rock music. The power pack is the type normally used to jump start engines, available at most auto supply and hardware stores. Binoculars are also useful to locate sage-grouse by glassing from high points. The other trapper carries a long-handled net and a backpack with marking supplies. When a grouse is located, the trappers should approach it swiftly, although running in the dark often results in falls, and the bird typically escapes when this

happens. The netter should remain a few meters/yards abreast of the person with the spotlight. If the grouse begins to walk (usually a prelude to flushing), the netter may have to sprint ahead to capture it.

Personnel may consider carrying a portable power-pack while night-lighting from a truck in case grouse are found roosting in inaccessible areas. Night-lighting on foot is generally the best method to capture birds associated with a radio-marked bird (usually a hen and her brood), or to replace a radio. In such applications, the person with the spotlight carries an antenna and telemetry receiver connected to headphones. Headphones enable the transmitter signal to be heard over the rock music.

Night-lighting is normally done in spring, summer, and early fall. The method may be less effective during winter when grouse often roost in large flocks. In addition, snow cover makes trappers visible at longer distances and deep or crusty snow can impede the netters' movements. However, researchers in Colorado have captured grouse effectively by night-lighting during winter (A. D. Apa, personal communication). During the 2001 winter, Colorado biologists captured 40 hens. The technique worked well until snow became shin deep or very crusty.

Night lighting is not very effective on bright, moon-lit nights because birds can easily see approaching trappers well before spotlights and music have any effect. Avoid night-lighting within 3 days of a full moon unless the sky is heavily overcast.

b. Walk-in Traps – Various walk-in traps (Gill 1965, Schroeder and Braun 1991) are also effective for capturing sage-grouse on leks (Schroeder 1997, Leonard et al. 2000, Aldridge and Brigham 2002) and on summer foraging habitats (Connelly 1982). Walk-in traps can be round, square, or rectangular. They are typically about 50 cm (20 in) high, and 100 to 150 cm (40-60 in) deep (round traps are 100-150 cm (40-60 in) in diameter). Each trap has a funnel opening that provides unobstructed entrance but hinders the bird's escape. Normally, wings or leads connect several traps or "pods" together and direct walking grouse into the trap entrances. Leads are generally 25 to 75 meters/yards long, about 35 cm (14 in) high, and are set to intercept hens moving onto a lek or grouse moving onto a feeding area. Traps should be constructed of nylon or cotton netting. Never use poultry netting because it can inflict deep cuts into grouse when they struggle to escape. A latching door can be installed on the side or roof of each trap to provide access for removing birds. Personnel should constantly tend traps when they are set. Otherwise, a captured bird can injure itself while struggling in the trap; a predator may detect and kill it; or it can suffer from stress and overheating.

c. Mist Nets – Mist nets can be used to capture sage-grouse on summer range (Connelly 1982, Browers and Connelly 1986). Researchers have also attempted to use mist nets on leks, but typically only 1 or 2 males are caught each morning. As soon as the grouse are become entangled, they must be removed to prevent injuries and this disrupts breeding activities for the remainder of the morning. However, mist nests can be an effective means to capture broods on summer foraging areas. They have also been used in conjunction with walk-in traps. By placing mist nets behind walk-in traps, birds that

would otherwise flush at the trap entrance may be caught. As with walk-in traps, mist nets must be tended continually to avoid injuring birds.

d. Drop Nets – Drop nets have been used to capture sage-grouse on leks (Leonard et al. 2000). However, they tend to disrupt lek activities and are not as efficient as other trapping methods.

e. Cannon and Rocket Nets – For many years, cannon and rocket nets were widely used to capture grouse on leks. More recently, some researchers have used the CODA Netlauncher™ to capture hens on leks (Hausleitner 2003, T. L. Maechtle personal communication). However, cannon and rocket nets also disrupt lek activities and may not be as efficient as other trapping techniques.

f. Pointing Dogs – Sage-grouse chicks up to about 4 weeks of age can be caught with the aid of a well-trained pointing dog. Connelly et al. (2003) used pointing dogs to capture the chicks of radio-marked hens by first locating and flushing the hen. The dog was allowed to search an area within a radius of 200 m/yd from where the hen flushed. The dog will normally point within 50 cm (20 in) of a chick's location. Once it is spotted, the chick can then be picked up by hand. A long-handled net is useful to catch older chicks (> 2 weeks old). This technique requires the use of very steady, experienced dogs.

3. Analysis of Data – Analysis of marking data is discussed in Section B.3 below. Maintain records of all grouse that are captured or recaptured, including numbers, age and sex, location, time and date, weather conditions, and method of capture. Note any capture-related mortalities and the circumstances involved, so techniques can be modified if necessary.

4. Disposition of Data – Report results of all capture projects in research reports and applicable job completion report.

B. Marking –

1. Rationale – Sage-grouse are marked to serve various research and management purposes such as movement and distribution studies, survival studies, home range delineation, nesting studies, assessment of impacts from development or other land uses, and monitoring response to habitat treatments. Marking methods and devices have included cataloging pigmentation patterns on tail feathers or clipping tail feathers (Wiley 1973), leg-bands (Patterson 1952, Dalke et al. 1963), wing markers (Connelly 1982), ponchos (Wallestad 1975), colored back-tags (Autenrieth 1981), and radio-transmitters (Wallestad 1975, Autenrieth 1981). Two researchers even resorted to shooting tips off the tail feathers of displaying males as a means to identify individual birds (Hartzler and Jenni 1988). Leg bands and radio-transmitters are the most common methods presently used to mark grouse. Patagial tags can also provide some movement and distribution data at a relatively low cost.

2. Application –

   a. Banding – Virtually all captured sage-grouse are marked with serially numbered leg bands. Very young chicks (<10 weeks of age) are the only exception. In most cases, the bands are imprinted with unique numbers and an address for providing notification when bands are recovered. Letters denoting the species and other information [e.g., sgm (sage-grouse, male), sgf (sage-grouse, female)] can also be included. The letter prefix identifies the species, which is very useful if other game birds are being banded in the state or province. In some studies, grouse (especially males) have been marked with series of color-coded leg bands that identify individual birds in the field. This system works well if birds can be observed on leks or other reasonably open areas, but grouse stay in relatively dense cover much of the time so viewing leg markers is often difficult.

   b. Wing-markers – Wing-markers or patagial tags have also been used to identify individual birds (Connelly 1982, Musil et al. 1993). These are often modified cattle ear tags inscribed with an identifying letter or number. Wallestad (1975) used numbered metal clips to mark wings of young chicks. Patagial tags are a relatively inexpensive means of obtaining information on local and seasonal movements. They tend to be more visible than colored leg bands and should therefore yield more data from re-sightings. However, birds marked in this manner may also be more vulnerable to predators. Therefore, patagial tags should only be placed on males (considered expendable to the population) and should be used when other marking methods are ineffective.

   b. Radio-telemetry – Radio transmitters are the most common and effective means of documenting seasonal habitat selection and movements by sage-grouse. Data from radio-telemetry studies can also be used to estimate daily, seasonal, and annual survival rates. Biologists have used radio-transmitters to study sage-grouse since at least 1965 (Autenrieth 1981). Unfortunately, early transmitters weighed >70 g (≥5% of an adult female's weight) and had relatively short battery lives. Because of the potential effects these larger, heavier transmitters had on grouse behavior and survival, and their brief span of operation, data and conclusions from early studies should be interpreted cautiously. By the mid- to late 1970s, transmitters weighed about 25 g (≤ 2% of an adult female's weight) and would generally last 6 months or more. Throughout the 1970s and early 1980s, researchers employed variations of a backpack harness (Brander 1968) to attach transmitters on sage-grouse. During the early 1980s, we learned backpack harnesses increase susceptibility to predation and thus switched to a poncho-mounted transmitter (Amstrup 1980).

      Poncho-mounted transmitters were placed on sage-grouse throughout much of the 1980s and early 1990s. Both battery and solar powered transmitters were used. Poncho openings were custom fit to individual birds. The poncho was attached by pulling the opening over the bird's head and arranging or "preening" feathers around the poncho material. The transmitter was fixed to the poncho so it would lie against the bird's crop. Although the method provided a quick, reliable way to place radio-transmitters on sage-grouse, solar transmitters mounted in this fashion occasionally malfunctioned. During summer, sage-grouse often feed on succulent forbs including dandelion (*Taraxacum*

officianale), salsify (*Tragopogon dubius*), lettuce (*Lactuca* spp.) and hawksbeard (*Crepis acuminata*). A milky substance contained in these plants often runs down the bird's bill, onto the breast feathers. The substance can collect and harden on transmitters and will cause solar transmitters to stop functioning as it accumulates on light panels.
By the mid 1990s, most research biologists were using a necklace-mounting system and battery-powered transmitters on sage-grouse. The necklace is generally made of plastic-coated cable. This type of radio-harness is somewhat lighter than a poncho, but attaches just as quickly to the bird's neck area. The transmitter itself can be attached more quickly to a necklace than to a poncho. The necklace cable must be loose enough to avoid constricting the crop and potentially harming the grouse. Normally, a finger's width of room is left between the bird's throat and cable. This enables the bird to forage normally, yet is sufficient to retain the transmitter.

A tremendous amount of biological information has been acquired and published from studies of radio-marked sage-grouse. However, virtually all birds fitted with radio transmitters were more than 10 weeks old. Prior to 1998, few if any attempts were made to place radios on grouse chicks younger than 10 weeks. A technique suitable for chicks had to address several practical limitations. Foremost was the physical challenge of designing a radio and attachment device suitable for chicks as young as 1 day and weighing just 30 grams. A transmitter life of at least 2 weeks was desired, but the device also needed to pose low risk to grouse chicks. A simple attachment system was developed for sage-grouse chicks. The procedure involves piercing the skin just in front and behind the transmitter with a 20-gauge hypodermic syringe. Sutures are threaded through the syringe and through holes in the transmitter, and then tied off. Cyanoacrylic glue ("Superglue") is applied to the knots to enhance security of the attachment (Burkepile et al. 2002).

Global Positioning System (GPS) technology has recently been deployed to monitor sage-grouse movements in Wyoming (Bedrosian 2010, B. L. Walker and Chad Olson personal communication). Although the technology is expensive, it provides multiple locations per day allowing more precise determination of habitat use and movement patterns. Solar rump-mounted GPS transmitters differ from traditional VHS necklaces in terms of weight, juxtaposition and visibility. A monitoring study is underway to determine whether vital rates, especially survival, differ between birds fitted with the two transmitter types. Observations to date do not suggest any immediate concern or reason to discontinue use of this technology.

1. Analysis of Data – Several types of data are obtained from marking studies. Information on harvest rates, survival, and seasonal movements can be derived from band return data (Zablan et al 2003). If a sufficient number of grouse are marked and subsequently recaptured, the population size can be estimated through a mark-recapture analysis. The sample of captures and recaptures necessary to estimate a population depends on the size of the population and the geographic area it occupies. Re-sight data from birds marked with patagial tags are used predominantly to determine local distributions and movements and to identify migration patterns. Radio-telemetry studies are typically done to document seasonal habitat use, response to disturbances, distribution and movement patterns, and

survival rates. Methods applied to analyze telemetry data depend on the specific purpose(s) for which the study was designed and conducted.

4. Disposition of Data – Numbered leg bands are attached to all adult sage-grouse that are captured and marked regardless of the marking method or device. Leg bands must be recorded in the Department's banding database. In addition, radio frequencies of telemetry transmitters must be entered in the Department's telemetry frequency database. Both databases are managed by Biological Services in Cheyenne.

   Results of studies involving marked birds are typically published in special reports prepared by the investigators. An annual report must be submitted for all studies requiring a Chapter 33 permit to capture sage-grouse. The annual report must include capture records, recorded observations of marked grouse, and all telemetry or satellite GPS data as applicable. Criteria for use and distribution of these data are currently being developed. In addition, progress and final reports should be included in the applicable Job Completion Reports.

IV. HABITAT ASSESSMENT – (also consult Stiver et al. 2010)

A. Rationale – Sagebrush (Artemisia spp.) habitats have been altered markedly over the past 25 to 50 years. In many areas of the west, fire management and agricultural activities have had major influences (Knick and Rotenberry 1997, Connelly et al. 2000a, 2004, Wambolt et al. 2002). Energy development has substantially impacted sagebrush rangelands in other locations (Braun 1998, Lyon 2000, Holloran 2005). Connelly et al. (2000b) emphasize habitat management plans must rely on the best available data regarding the quality and quantity of seasonal habitats used by sage-grouse, which must be thoroughly investigated to assure appropriate management decisions are made. Habitats are assessed for 5 general purposes: 1) identify and characterize seasonal habitats used by a sage-grouse population; 2) document current condition and trend; 3) evaluate impacts of a land treatment; 4) assess the effectiveness of habitat restoration; and 5) evaluate the suitability of a location for a reintroduction effort.

B. Application – In virtually all cases, managers should identify and characterize habitat based on the areas sage-grouse select and inhabit seasonally or yearlong (Johnson 1980). Habitat assessments should initially reflect "first-order selection" or the geographic range of a sage-grouse population. Habitats constituting "second-order selection" are based on home ranges of individual birds or subpopulations (e.g., birds associated with a lek or lek complex). The condition of various habitat components within the home ranges constitutes third order selection and further refines the habitat assessment process (e.g., breeding habitat). Finally, assessments can be done at a fourth-order selection level, if necessary, to evaluate the quality and quantity of food or cover at particular sites used by sage-grouse.

   Changes in vegetation characteristics can be monitored over time by establishing permanent transects and rereading them at regular intervals. These kinds of data are often collected to assess the impacts of land uses, or effectiveness of habitat treatments.

1. Landscapes-scale assessments – Many, if not most sage-grouse populations are migratory. They characteristically occupy large ranges on an annual basis, though they rely on differing

habitats at different times of the year (Connelly et al. 1988, 2000b, 2004). Seasonal habitats can be highly interspersed within the ranges of non-migratory populations, but separated by considerable distances (up to several km) within the ranges of migratory grouse (Schroeder et al. 1999; Connelly et al. 1988, 2000b, 2004, Leonard et al. 2000). The seasonal movements and distribution of grouse must be well documented before managers or researchers begin a meaningful assessment of habitat conditions on a landscape scale. Aerial photos, satellite imagery, and digitized maps are helpful to identify specific habitats and measure their sizes and juxtaposition (Homer et al. 1993). Remote sensing imagery is often the basis for inventorying, evaluating, and monitoring rangeland resources (Tueller 1989, Anderson and Gutzwiller 1994). Landscape assessments correspond to first-order habitat selection (Johnson 1980). Landscape characteristics that should be measured include patch size, habitat quality, connectivity (availability of corridors connecting patches), amount of edge and distance between habitat patches. Hamerstrom et al. (1957) provided an early example of a landscape assessment for managing greater prairie chickens (*Tympanuchus cupido*).

To be functional, seasonal habitats used by non-migratory populations should be well interspersed and free of major barriers to movements (e.g., reservoirs, urban areas). These areas (sagebrush uplands, mesic areas) can be identified from aerial photographs, satellite imagery, or by field inspections and mapping. Some past studies offer a general sense of the size or scale of various seasonal habitats used by grouse. Breeding complexes have been measured at 23 km^2 (Wallestad and Pyrah 1974) and specific areas used as summer habitats ranged from 0.4 to 0.9 km^2 in Montana (Wallestad 1971) to 28 km^2 in northeastern Colorado (Hausleitner 2003). Wallestad (1975) identified and mapped winter ranges that varied from 11 to 31 km^2.

Populations of migratory grouse may undertake seasonal movements ranging throughout areas as large as Rhode Island. These movements vary depending on factors such as annual precipitation (Connelly 1982, Fischer et al. 1996*a*). However, migratory grouse tend to use specific seasonal habitats on an annual basis. These habitats may be disjunct, but are typically interconnected by sagebrush dominated corridors. Seasonal ranges of migratory grouse also vary in size, but generally breeding habitats are 150 to >600 km^2 (Leonard et al. 2000, J. W. Connelly unpublished data), summer ranges are 0.5 to 7 km^2 (Connelly and Markham 1983) and winter range can exceed 400 km^2 (Leonard et al. 2000).

Leonard et al. (2000) used remote sensing technology to analyze spatial components and juxtaposition of seasonal habitats within the range of a migratory sage-grouse population. On a landscape scale, this study contrasted seasonal habitats available to sage-grouse in the 1970s and 1990s. The analysis was based on LandSat imagery obtained from the U.S. Geological Survey's Earth Resources Observation Systems Data Center. Image processing software was used to classify habitats. Land ownership was documented with Arc View software (ESRI, Inc., 380 New York St., Redlands, CA 92373-8100). The research determined agricultural lands had increased more than 70% within sage-grouse habitat over a 17-year period in eastern Idaho. A relationship between cropland expansion and declining sage-grouse populations was demonstrated (Leonard 1998, Leonard et al. 2000).

Landscape analysis is becoming a fairly common tool for assessing sage-grouse habitat. Oyler-McCance et al. (2001) used a landscape approach similar to that of Leonard et al. (2000) to document changes in sagebrush-dominated habitats occupied by Gunnison sage-grouse (*C. minimus*) between the 1950s and 1990s (Oyler-McCance et al. 2001). Smith (2003) applied a similar approach to investigate sage-grouse habitat in the Dakotas.

2. Vegetation Assessments – The methods used to sample vegetation and the amount of data needed usually depend on objectives of the habitat assessment or research project, but may also be influenced by time, budget, and manpower constraints. Irrespective, habitat assessments should be done in as unbiased a manner as possible. This usually requires a stratified, random sampling design. The selection of sample strata depends on proportions of differing vegetative and topographic features, interspersion and clustering effects. Thus, consulting a statistician early in the planning process is usually a good idea to assure results will withstand critical review.

   Long-term studies commonly exceed 3 years during which numerous personnel changes can occur. Therefore, it is essential to apply standardized techniques for all data collection. Field personnel should receive adequate training and the techniques generally should not be modified throughout the study. These considerations will help assure data are collected consistently among personnel and over time.

   Most quantitative assessments of sage-grouse habitats are based on one or more of the following vegetation measurements: cover, height, density, frequency, and visual obstruction. "Density" is the number of individual plants per unit area (e.g., plants/m^2), often used to measure the availability of plants that are important to sage-grouse. "Frequency" is the percent of a series of sample plots, in which a species or genus of plant is found (Daubenmire 1968). Sample plots must be uniform size and shape. The relative abundance or distribution of specific plants is often expressed as "frequency of occurrence." "Visual obstruction" is a method used to measure the relative density and height of vegetation. The term "cover" is generally used to describe the percent of ground covered by plant material, litter, rocks, or bare soil at ground level, or by the projection of the plant canopy onto the ground. Canopy cover is the attribute most often used to characterize sage-grouse habitat.

   Three general approaches are commonly applied to assess vegetation characteristics within shrub steppe habitats: line transects, quadrats, and ocular estimates (Table 1). Line transects are more suitable for estimating shrub cover while quadrats have advantages when estimating herbaceous cover. Several technique refinements have been developed within each of the general approaches. Different techniques can often yield comparable results. Hanley (1978) reported similar estimates of sagebrush canopy cover were obtained from line intercept and Daubenmire plot sampling in northwestern Nevada. However, line intercepts are superior to Daubenmire frames when greater precision is required (Hanley 1978). Common techniques used to estimate canopy cover in sagebrush-dominated rangelands are discussed in the paragraphs that follow.

   Visual obstruction represents the collective cover of all vegetation, alive and dead, at a sampling point. This measurement is sensitive to density and height of vegetation, but does

not measure cover according to individual species or genera of plants. Methods for measuring visual obstruction (Table 2) have a wide range of field applications, but for sage-grouse, are most often used to assess nesting cover. However, visual obstruction alone may have limited value for identifying nesting habitats because readings can be similar in areas dominated by sagebrush, and in habitats dominated by other shrubs and grasses, which are not important to nesting sage-grouse.

Sometimes it is necessary to classify proportions of habitats based on dominant vegetation (e.g., the relative amount of sagebrush-dominated habitat within a rangeland). Marcum and Loftsgaarden (1980) described a simple, non-mapping technique for this purpose. A number of points are randomly selected and then located in the field (easily accomplished from the ground or air with a GPS unit). The dominant vegetation is classified at each point (e.g., sagebrush, annual grass, bare ground, etc.). The authors also provided an appropriate method for analyzing these data.

Rotenberry et al. (2002) described a model that predicts animal use based on a minimum combination of the species' requirements. The model functioned well for predicting habitat use by sage sparrows (*Amphispiza belli*) in an altered landscape. The model may be also adaptable for sage-grouse habitats.

Sather-Blair et al. (2000) devised another approach to assess sage-grouse habitats and prescribe management actions based on the assessments. They described a qualitative method and 2 quantitative methods for gathering data. Although various methods are available to assess habitat conditions, all should be relatively objective and biologically defensible.

Table 1. Methods for estimating canopy cover in shrub-steppe habitats. "Yes" or "no" entries indicate whether a technique is suitable to measure the specified parameter.

	Technique					
	Line Transect Methods		**Quadrat Methods**			**Ocular Estimates**
Parameter: Attribute	**Line Intercept**	**Point Intercept**	**Daubenmire Plot**	**Circular Plot**	**Point Intercept**	
Shrub Cover	Yes	Yes	Yes	Yes	Yes	
Time Required[a]	2	2	1	3	2	1
Precision[b]	3	2	1	2	2	1
Ease of Replication[c]	2	1	2	2	2	1
Other Data Recorded[d]	1,3,4	1,3,4	1,3,4	1,2,3,4		--
Herbaceous Cover	Yes	Yes	Yes	No	Yes	
Time Required[a]	2	2	1	NA[e]	1	1
Precision[b]	2	2	3	NA	3	1
Ease of Replication[c]	2	2	2	NA	2	1
Other Data Recorded[d]	1,3,4	1	1,2,3,4	NA	1,2,3,4	--
References	Canfield 1941	Evans and Love 1957	Daubenmire 1959	Connelly 1982	Floyd and Anderson 1982	Daubenmire 1968

[a] Approximate time needed to sample: 1 = < 10 minutes; 2 = 11-30 minutes; 3 = 31-60 minutes (20 m transect, standard Daubenmire plot, point intercept frame, and 1-m radius circular plot).

[b] 1 = low; 2 = medium; 3 = high.

[c] An indication of the relative bias when other observers repeat the process: 1 = not easily replicated, results may vary substantially among observers; 2 = easily replicated, results are comparable among observers.

[d] Other data that can be recorded while using this technique: 1 = height; 2 = density; 3 = frequency; 4 = species composition.

[e] NA = not applicable

Table 2. Methods for estimating visual obstruction in shrub and grass dominated habitats.

Attribute	Technique			
	Robel Pole	**Cover Pole**	**Jones Cover Board**	**Profile Board**
Time Required[a]	1	1	1	1
Precision[b]	2	2	1	2
Ease of Replication[c]	2	2	1	2
Other Data Recorded[d]	1	1	1	1
References	Robel et al. 1970	Griffith and Youtie 1988	Jones 1968	Nudds 1977

[a] Approximate time needed to sample: 1 = < 10 minutes; 2 = 11-30 minutes; 3 = 31-60 minutes.
[b] Estimated for sagebrush dominated habitats only: 1 = low; 2 = medium; 3 = high.
[c] An indication of the relative bias when other observers repeat the process: 1 = not easily replicated, results may vary substantially among observers; 2 = easily replicated, results are comparable among observers.
[d] Other data that can be recorded while using this technique: 1 = height; 2 = density; 3 = frequency; 4 = species composition.

a. Shrub Characteristics – Field personnel assigned to measure shrub characteristics must be trained to identify shrub species and to differentiate among the subspecies of sagebrush. Several keys to sagebrush taxa have been published (e.g., Atwood 1970; Winward and Tisdale 1969, 1977; Shultz 1984).

i. Cover – Shrub overstory is a vital component of sage-grouse habitat. Normally, overstory is measured in terms of canopy cover, defined as the projection of the plant's crown or stems onto the ground (Higgins et al. 1994). Canopy cover is the measurement of habitat suitability most commonly reported by studies. The suitability of an area for nesting, early brood-rearing, or winter habitat is frequently based on measures of live shrub canopy along with herbaceous vegetation. In virtually all cases, data are recorded separately for each species and subspecies of shrub. Accordingly, field personnel must be proficient at identifying shrubs.

It is also important to understand the difference between canopy cover and total cover. Total cover includes the cover contribution from all plant species, regardless their relation to the canopy. This distinction becomes important when evaluating multi-layer vegetation response to treatments. For example, in a community dominated by sagebrush with a significant understory of rabbitbrush, canopy cover would accurately represent the sagebrush cover but would underestimate the rabbitbrush cover (i.e., some of the rabbitbrush lies within the canopy projection of the sagebrush). If this community were treated (fire, herbicide, rotobeating, mowing, etc.) and then inventoried several years later, canopy cover data would correctly show the expected decrease in sagebrush, but would it would also show an increase in rabbitbrush (a species that resprouts readily after fire). This apparent increase may not

be real because rabbitbrush cover was underestimated in the initial canopy cover measurements.

Specific techniques for cover measurements:

- Line Intercept – Line intercept (Canfield 1941) is one of the commonest techniques used to estimate shrub canopy cover. A tape is stretched out (usually 15 to 50 m) and the lengths of tape intersected by live shrub canopy are recorded along an imaginary vertical plane. Line-intercept measurements are usually done at specified intervals along a baseline transect (e.g., they are laid out perpendicular to the transect), but may also be done at specific points such as sage-grouse nest sites. The distances intercepted by shrubs along the line are tallied and then divided by the total length of the line (for example: 580 cm of sagebrush ÷ 2500 cm of total line = 23.2% canopy cover). Exclude large gaps (e.g., ≥5cm) between live branches or foliage so only live shrub cover is counted (Baker 1968). Often, the Daubenmire technique (Daubenmire 1959 – see below) is applied to estimate herbaceous cover at the same time line-intercepts are run.

  Line intercepts may be somewhat more time consuming than other methods, but are less subjective, generally more accurate and precise (Higgins et al. 1994), and the method is widely accepted. Data from line intercept transects can often be compared among studies because this is a very common and standardized method used to measure sagebrush canopy (Wakkinen 1990, Connelly et al. 1991, Gregg et al. 1994, Fischer 1994, Holloran 1999, Lyon 2000).

- Point Intercept – The point intercept method (Evans and Love 1957, Hanson et al. 1988, Sather-Blair et al. 2000) is based on the proportion of random sample points that intercept live shrub canopy. A pin or small-diameter rod is randomly dropped to the ground (a notch or point on the toe of a boot can also be used). A "hit" is recorded each time the pin strikes the canopy of a shrub. Canopy cover (percent) is estimated based on the following calculation: 100 times the number of hits divided by the total number of pin drops. The pin diameter and manner in which the pin is dropped or lowered can affect accuracy (Higgins et al. 1994). A very large sample of points is needed to estimate canopy in sparse shrub cover. Consequently, the method can be very inefficient within these types of environments (Heady et al. 1959, Higgins et al. 1994). Hanson et al. (1988) evaluated three specific variations of the point intercept method for estimating cover: step-point, wheel-point, and point-frame. They reported data obtained from the step-point and wheel point methods differed from that of the point-frame method. All methods were affected by operator bias as well. In most sagebrush stands, results of point intercept and line intercept methods are comparable. Point intercept sampling can often be faster (depending on the number of samples needed), but is also prone to greater observer bias.

- Quadrat Sampling – Quadrat sampling is another means of estimating shrub canopy (Connelly 1982, Alldredge 2000). A frame (usually metal) is laid on the

ground at sampling locations, usually at set intervals along a baseline transect. The percent of the frame area covered by individual species or groups of species is estimated. Quadrats can vary in size and shape, but are generally square or rectangular. The Daubenmire frame (Daubenmire 1959) and its variations (Leonard 1998) are among the commonest types of quadrat sampling frames. Although some frames can be bulky and awkward [e.g. point intercept frame (Floyd and Anderson 1982)], many are easy to construct and highly portable in the field (Neal et al. 1988).

Quadrat sampling is a relatively quick way to estimate shrub cover. Unfortunately, the definition of canopy cover used in some quadrat methods (e.g., Daubenmire frame) differs somewhat from the definition used in line intercept sampling. In quadrat sampling, canopy cover is often considered the surface area over which a plant has influence, thus root systems can be included. Plant canopies are also treated as polygons (i.e, the exterior points of the canopy shape form a polygon). Quadrat sampling based on this cover definition can over-estimate nesting cover for sage-grouse.

- Circular Plot – The circular plot (Connelly 1982) is another variation of quadrat sampling, but is seldom used. It was originally developed to estimate cover on big game winter ranges (Lyon 1968, Peek et al. 1978) and subsequently adapted to measure shrub characteristics on sage-grouse winter habitat (Connelly 1982). Circular plots (often 1-m in radius) are placed at intervals along transects laid out within the area of interest. Lengths and widths of sagebrush plants within the plots are measured to estimate the crown area of each plant, and an average crown size is determined. The percent of the plot area covered by the sagebrush crowns is an estimate of canopy cover.

- Ocular Estimates – In some circumstances, shrub cover is estimated based on a strictly visual examination in the field (Leonard 1998). These "ocular" estimates are suitable mainly for reconnaissance type inventories that don't require a high degree of precision. Although the Daubenmire frame may be considered an ocular estimate as well (Higgins et al. 1994), precision is enhanced through the use of a sampling frame and cover classes, which also enable the different observers to replicate the method (Daubenmire 1959). True ocular estimates are simply characterizations of the canopy cover, sometimes by cover class, without the aid of sampling frames or other standardized techniques. This approach may be useful for broad categorizations (Leonard 1998), but is subject to a great deal of observer bias. Cover tends to be overestimated because shrubs screen more of the ground surface when viewed from an oblique compared to a more or less vertical aspect. Thus, ocular estimates should only be used to make very rough approximations of shrub cover in a stand.

ii. Density – Studies of sage-grouse habitats often report shrub densities. However, density alone may not be sufficient to characterize nesting or winter habitats. Canopy cover is a more meaningful metric, but may not be closely tied to density. For

example, the density of new seedlings can be very high after initial establishment, but young plants are short and often provide minimal canopy. Density may be a more useful metric for evaluating reestablishment of sagebrush from a seeding project or natural regeneration after a disturbance.

Density estimates are typically done using sample plots placed systematically or randomly within an area of interest. The number of shrubs inside the plots is counted and then divided by the total area of the sample plots. Plots are often placed at intervals along transects randomly established within a study area.

iii. Frequency – Frequency sampling is not normally used to assess the shrub component of sage-grouse habitats. However, sage-grouse are known to selectively forage on some sagebrush species, subspecies, or individual plants (Remington and Braun 1985, Welch et al. 1988, Welch et al. 1991). Thus, data on the frequency of preferred shrubs may have some utility as an indicator of habitat quality, especially within winter habitats. Methods used to collect this kind of data are also less subjective, which can minimize inconsistency among different observers and help detect trends over time (R. Miller, personal communication). Frequency data can be collected using quadrat-sampling procedures. Relatively large frames or plots are used to assure the proportion of plots in which each shrub species is detected is a consistent indication of the species' relative abundance. The plots must also be of uniform size so the probability of detection is even (Daubenmire 1968). Frequency can also be measured based on the point intercept method (Higgins et al. 1994). The point of a pin or small-diameter rod is dropped to the ground repeatedly (usually along a transect). The percent of drops that hit each species provides an estimate of the species' frequency of occurrence. If frequency information is needed, observers can collect the data most efficiently during sampling procedures to assess shrub density.

iv. Height – Most sage-grouse nest where sagebrush is 40-80 cm tall (Connelly et al. 2000b). During winter, sage-grouse feed on relatively short sagebrush or sagebrush that protrudes slightly above snow (Robertson 1991, Connelly et al. 2000b). Accordingly, shrub height has some intrinsic value in characterizing these habitats. Shrub heights are normally recorded in conjunction with procedures for estimating canopy cover. The tallest live part of each shrub in the sample (along transects or within plots) is measured. Normally, the average height is reported. Height measurements can vary depending on time of year and whether seed heads were included. Therefore, observers should always record the date measurements were taken, and indicate whether seed heads were included in the measurements.

v. Age Class – Connelly et al. (2003) do not mention shrub age class among the attributes they recommend for monitoring sage-grouse habitats. However, the Department's Habitat Biologists regard age composition as a primary indication of a shrub stand's health and vigor. A stand that is comprised largely of dead and decadent shrubs that are not being replaced through recruitment of young plants may be in a declining trend.

Age data can be collected by classifying shrubs within a three foot belt transect along one side of a line transect tape. Unfortunately, investigators have used inconsistent criteria to define shrub age classes. For example, some Department reports (Cundy, 1989, Clause 1999) defined "decadent" as a mature plant having a canopy that is more than 25% dead. USFS (1993) and Nelson et al. (1994) defined decadence as >50% dead wood in the crown. To assure data are consistently collected and the surveys can be replicated, the same age class definitions should always be applied. Investigators should record the definitions used for classifying shrub ages at the time data are collected. Those definitions should be retained with the archived data (e.g., data files) and included in any report or publication in which the data are summarized or analyzed.

b. Herbaceous Vegetation Characteristics

i. Cover – Herbaceous understory is a critical component of sage-grouse breeding, early brood rearing, and summer habitats. Canopy cover measurements are widely used to assess the quality and availability of these seasonal habitats (Fischer 1994, Gregg et al. 1994, Hanf et al. 1994, Apa 1998, Lyon 2000). This approach is based on the same techniques described previously for estimating canopy cover of shrubs. However, herbaceous canopy is generally sampled faster using quadrat and point intercept methods opposed to line intercept. The Daubenmire technique is one of the commonest methods for estimating herbaceous cover (also litter and bare ground) in sagebrush steppe habitats (Daubenmire 1959). Regardless of method used to sample, canopy cover of each grass and forb species should be recorded and these measurements should normally be taken in late May and early June to coincide with hatching of sage-grouse chicks.

Ocular estimates are not generally suitable for estimating herbaceous canopy because shrub overstory can screen much of the understory from view. Moreover, shrubs and grasses can obscure the forb component. In some cases, very general observations (e.g., sparse or dense herbaceous cover) are useful.

Herbaceous canopy cover is sensitive to annual climatic changes. For example, cover can increase significantly during favorable conditions and decreases in unfavorable periods such as drought. The annual effects of climate make it difficult to detect overall trends. Basal cover is less influenced by annual climatic changes and is therefore a better indicator of long-term trends. However, the utility of this measurement is limited mainly to bunch grasses.

ii. Density – The density of important forb species can be measured to assess quality of habitats used by pre-laying hens (Barnett and Crawford 1994) and young broods. Density is estimated by counting the number of individual plants in a circular, square or rectangular quadrat. The size of the quadrat should be sufficient to ensure each forb species of interest occurs in a majority of quadrats, yet small enough that individual plants can be counted efficiently.

iii. Frequency – Frequency measurements are another method for quantitatively assessing the availability of forbs to pre-laying hens and young broods (Barnett and Crawford 1994, Drut et al. 1994). Frequency of important forbs can be assessed using any of the quadrat sampling procedures used for density or cover sampling, provided the sample plots (frames) are of uniform size (Daubenmire 1968). Hyder et al. (1963) suggested a quadrat of 230 to 645 cm^2 was adequate to estimate frequency of forb species within a sagebrush habitat in eastern Oregon. If frequency information is needed, observers can collect the data most efficiently during sampling procedures to assess herbaceous cover or density.

iv. Height –An important characteristic of sage-grouse nest sites is herbaceous cover averaging more than 18 cm tall (Wakkinen 1990, Gregg et al. 1994, Delong et al. 1995). Heights of grasses and forbs (both residual and new growth) can be easily measured along transects or within quadrats established for estimating cover. Most grasses and many forbs tend to bend or droop somewhat when mature, often because of the weight of the seed head. Normally, observers should record the natural or "droop" height above ground rather than the plant's total length. This provides a better indication of the lateral cover afforded by the herbaceous vegetation. Height measurements are normally taken in late May and early June to coincide with hatching. Windy conditions may affect accuracy of height measurements and if wind is a problem, measurements should be suspended until winds decrease.

c. Visual Obstruction – Visual obstruction is another means to assess the overall cover value provided by the combination of both shrub and herbaceous vegetation in sage-grouse habitats. The Robel pole (Robel et al. 1970), cover pole (Griffith and Youtie 1988), and Jones cover board (Jones 1968) can be used to assess visual obstruction in sagebrush-dominated rangelands (Wakkinen 1990, Fischer 1994, Gardner 1997). Nudds (1977) also described a cover board that may have similar applications. Some data that were collected using a Robel pole have been useful for analyzing nest sites. However the Jones cover board (3-sided or 4-sided) did not appear sensitive enough to detect differences among areas and may not be easily replicated by different observers (Wakkinen 1990, Fischer 1994). The Jones cover board is shorter than a Robel pole, so readings taken in some sagebrush habitats tend to be grouped near 100% (Wakkinen 1990). However, Fischer (1994) and Apa (1998) successfully used the Jones cover board to identify cover characteristics that distinguished sage-grouse nest sites from random sites.

The Robel pole was originally developed to help distinguish habitats used by greater prairie chickens in grassland ecosystems (Robel et al. 1970). The method is now in widespread use and appears suitable for assessing habitats of many other species, except where vegetation is very sparse (Higgins et al. 1994). The cover pole (Griffith and Youtie 1988) was developed to evaluate deer hiding cover in several habitats including sagebrush-dominated rangeland. It has not been widely used to assess condition of sage-grouse habitats, but should be investigated further. Given the limited experience with cover poles and comparatively poor sensitivity of the Jones cover board, we generally

recommend investigators use the Robel pole method to measure visual obstruction in sage-grouse habitat.

3. Insects – Insects are an essential food source for young sage-grouse chicks (Patterson 1952, Klebenow and Gray 1968, Johnson and Boyce 1990). To thoroughly investigate quality of early brood-rearing habitat, investigators should consider an evaluation of insect abundance. Several methods including sweep nets, beating sheets, and pitfall traps are available to estimate insect numbers (Fischer 1994). Ants and beetles are often the most important groups of insects eaten by young sage-grouse chicks (Johnson and Boyce 1990, Fischer et al. 1996*b*). Abundance of ants and beetles can be easily gauged with pitfall traps. Although pitfall traps vary in size, shape, and composition, a common method in sage-grouse habitat is to place test tubes in a grid arrangement such that the top of each tube is flush with the ground (e.g., a 4x4 grid of 16 tubes placed 50 cm apart) (Nelle 1998). Tubes are filled with a 1:1 solution of water and ethylene glycol, and then sealed with a cork or rubber stopper until the sampling period begins. Insect sampling should coincide with the early brood-rearing period (late May to mid-June). We suggest sampling be conducted over at least one 24-hour period during this timeframe.

V. ENVIRONMENTAL COMMENTS AND RECOMMENDED MANAGEMENT PRACTICES –

It is imperative that reviewers refer to Wyoming Executive Order 2015-4 and associated documents when conducting wildlife environmental reviews (WERs) of actions potentially impacting sage-grouse habitats, or when developing habitat management plans. All relevant documents can be accessed on the WGF website: http://wgfd.wyo.gov/Habitat/Sage-Grouse-Management. Also refer to Appendix X (Environmental Review Procedures). Additional resources include: Cagney et al. (2010), Connelly et al. (2000b), Paige and Ritter (1999), Wyoming Game and Fish Dept. (2003 and 2007-2008).

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ATTACHMENT 1

A KEY FOR AGE/SEX IDENTIFICATION FROM WINGS OF HUNTER-HARVESTED SAGE-GROUSE

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Key words: sage-grouse, Centrocercus urophasianus, age and sex identification

The Sage-grouse (Centrocercus urophasianus) is an important game bird in the western United States and is presently hunted in 9 states. Most states collect wings from hunter-harvested sage-grouse to ascertain sex and age composition of the harvest. These data are used to monitor trends in productivity and overall reproductive health of populations by local area, region, and state (Autenrieth et al. 1982).

Separation of sex and age classes of sage-grouse has followed descriptions of Eng (1955) and Dalke et al, (1963), and a key developed by Crunden (1963). Beck at al. (1975) summarized the general knowledge useful in identification of sage-grouse sex and age from wings. Each of these sources is useful but each has limitations such as incorrect terminology and failure to report repeatable measurements. Some require that "wing boards," be constructed and retained, examination of intact birds or intact wings, or have reduced usefulness because feathers are damaged, missing, or discolored (because of water or blood). The objective of this paper is to present a dichotomous key to distinguish sex and age classes of sage-grouse from wings collected through mail surveys, volunteer wing collection stations (Hoffman and Braun (1975) and at hunter-check stations.

METHODS

Measurements of primaries from hunter-harvested sage-grouse were initially obtained from hunters at check stations in Jackson County, Colorado in 1973-74. This effort was expanded to all hunted populations in Colorado in 1975-79. Sex of bird from which wings were collected ($n \geq 1000$ individuals) was obtained from gonadal inspection of intact birds at check stations in Jackson and Moffat counties, Colorado from 1976 continuing into the late 1980's. Wings from gonadally inspected, hunter-harvested sage-grouse were used to initially develop and refine measurement criteria for males and females in each age class. Additionally, wings ($n \geq 500$) from hunter-harvested, spring-banded sage-grouse were obtained (and individually marked or stored) at check stations in Jackson and Moffat counties, Colorado from the mid-1970's continuing until the early 1990's.

USE OF THE KEY

The key (Table 1) can be used for frozen, dried, or fresh (unfrozen) wings but is easier to use if the wings have been allowed to thaw without becoming dry. The only tool necessary is a flexible metric ruler having a minimum length of 210 mm. Primary feathers (numbered 10 through 1, distal to proximal) are examined for appearance (pointed or rounded, Fig. 1) as is the 1st secondary (numbered I through 10, distal to proximal) (Fig. 2).

Measurements of fully replaced primaries are taken from the insertion point between the bases of primary feathers (skin) to the tip of the target primary. Thus, length of primary 10 is measured from the base of the feather between primaries 10 and 9 to the top of primary 10, 9 is measured by placing the ruler between primaries 9 and 8, etc., except that both primaries 1 and 2 are measured by placing the ruler between them. Care must be taken to identify primaries that are being molted, but this is rarely a problem except for late hatching chicks (those molting/replacing juvenile primaries 5 and /or 6). Late-hatched chicks molting juvenile primaries 5 and/or 6 comprised 0% of the chicks examined in Nevada in 1986 (n = 51) and in Oregon in 1993 (n = 205), 6.3% in Utah in 1993 (n = 222) and 20.5% in Colorado in 1993 (n = 774).

Wings can be sorted (if sample sizes are large) by apparent size (females are markedly smaller than males in all age classes) and by age class based on appearance of primaries 10 and 9 (Fig. 1) as compared to primaries 7 or 6 through 1 (except for a few late-hatching chicks). Separation of yearlings (birds 15-16 months of age) and chicks should be based on examination of the 1st secondary (rounded in yearlings, pointed if still retained in juveniles) (Fig. 2) or the presence or absence of juvenal tertials and covert feathers (Figs. 3, 4). The first secondary of juvenile sage-grouse is normally replaced with an adult secondary when juvenile primary 8 has been replaced with an adult primary that is greater than 40-60 mm in length.

Once wings are sorted (for large samples) or examined, sex and age classes can be verified using the key. Sample sizes in each category should be recorded along with molt schedules, and length of the most recently molted growing adult primary for juveniles, etc. depending on data requirements. One person can easily process 500-600 wings per day. Two people can easily process in excess of 1000 wings per day including measurement of feathers in wings of chicks to aid in ascertaining hatching date and recording of molt schedules for all age classes.

DISCUSSION

Using the appearance of outer primaries 10 and 9 to separate age classes of prairie grouse was first reported by Petrides (1942), Wright and Hiatt (1943) and Amman (1944) and specifically for sage-grouse by Patterson (1952) and Eng (1955). However, these authors made no attempt to separate the yearling age class from adults in areas in Nevada, Oregon, and Utah and in low elevation areas of Colorado since few yearlings can be identified in harvest samples after mid-September. This is because replacement of primary feathers follows completion of breeding activities for males and nesting activities of females. Yearling males cease breeding activities prior to adults (Eng 1963) and initiate molt of primaries (starting with primary, 1) 7-14 days before adult males. Thus, in areas where breeding activities peak in March, few yearling males will be identifiable in the harvest after 7-10 September. Wings from these birds appear as having all primaries fully molted (replaced) and are indistinguishable from wings of adults.

Successfully nesting yearling hens have primary molt schedules similar to successfully-nesting adults. However, replacement of primary feathers is initiated by hens following termination of incubation and yearlings are markedly less successful than adult hens in nesting. Accordingly, many yearlings have advanced primary molt schedules when compared to adults harvested at the same time. Depending upon timing of nesting activities (which is related to amount of snow cover, elevation, etc.), hens retaining old primaries 9 through 6 (in combination 9 and 8; 9, 8 and 7; or 9, 8, 7 and 6) can be considered as

successfully hatching their clutch. Hens that have molted all primaries or are retaining only old primary 10 can be considered as unsuccessful in hatching their clutch (C.E. Braun, unpubl. data). Most wings with fully molted (replaced) primaries are likely from yearlings because of low nest success and early advent of molting.

Some difficulty may arise in separating yearlings from chicks (birds less than 3-4 months of age). These difficulties are minimal if the first secondary is retained (pointed in juveniles, rounded in yearlings) (Fig. 2), the tertial feathers are examined (narrow and worn in juveniles vs. rounded and usually new in appearance in adults) (Fig. 3), or the upper wing Coverts are examined (narrow with a white streak in the center for juveniles vs. broad and barred in adults and yearlings) (Fig. 4).

Identification of sex classes for chicks is only a problem for late hatching birds that have actively growing juvenile primaries 10 and 9 (sheathed at base). This problem is minor except in extremely late hatch years, which may be caused by late springs, heavy winter snowfall, etc. Measurement of primary 1 will normally result in correct classification of all chicks older than 4-5 weeks.

Substantial variation in size of sage-grouse occurs throughout the species' range with the smallest birds occurring in southwestern Colorado and southeastern Utah. (Now considered a separate species – Gunnison Sage-Grouse – ED). Separate keys have been developed for use in southwestern Colorado, Oregon, and Washington along with the "standard" key presented in this paper. These keys vary only in length of primaries 10, 9, and 1. All differences between the populations of sage-grouse tested are less than 10 mm per key feather and less than 5 mm for primary 1.

SUMMARY

The key developed in Colorado and used since the late 1970's has been tested on sage-grouse populations in Nevada, Oregon, Utah, and Wyoming. It is reliable for an estimated 97% of the wings examined (40,000 + since development), it is useful for wings under most conditions (dried, disintegrating, frozen, stained, etc.), and is easily understood and applied by relatively inexperienced personnel. It needs further testing and refinement (adjustment of the length criteria) for populations in other states. Upon testing, it is logical that a modified key (In terms of length of primaries 10, 9, and 1) will be developed for individual populations in some states (such as has been done in Colorado, Oregon, and Utah).

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KEY FOR SEPARATION OF AGE AND SEX CLASSES OF SAGE CROUSE FROM NORTHERN COLORADO

Clait E. Braun

1a. Primaries 10[a] and 9 rounded and similar in appearance to primaries 7 and 6 …..…….…….2

1b. Primaries 10 and/or 9 and/or 8 pointed when compared to primaries 7 and 6……...…….…….3

2a. All primaries rounded, primary 9 if present, longer than 200 mm. If primary 9 is not present primary 10 is longer than 165 mm. If neither primary 10 or 9 is not present, primary 1 longer than 140 mm…….…..……..….**Adult Male**

2b. All primaries rounded, primary 9 if present, less than 199 mm in length. If primary 9 is not present, primary 10 is less than 160 mm. If neither primary 10 or 9 is present, primary I is less than 140mm ….…….….**Adult Female**

3a. Primaries 10 and 9 pointed, worn, faded, secondary 1 broad and round...…....…….……...4

3b. Primaries 10 and 9, and possibly 8 and 7 pointed, new, not frayed and not rounded, secondary 1 full in and pointed[b]…….……..…….……....….5

4a. Primaries 10 and/or 9 pointed, worn, faded, secondary 1 broad and round. Primary 9 if present, more than 200 mm, if primary 9 missing, primary 10 is greater than 160mm..……**Yearling Male**

4b. Primaries 10 and or 9 pointed, worn faded; secondary 1 broad and round. Primary 9 if present less than 198 mm, if primary 9 missing, primary 10 is less than 160mm……**Yearling Female**

5a. Primaries 10 and 9 and possibly 8 and 7 pointed, new in appearance, secondary 1 pointed[b], primary 9 longer than 190 mm, primary 10 more than 160 mm in length if Juvenile primaries 8 and/or 7 present……..……..**Chick Male**

5b. Primaries 10 and 9 and possibly 8 and 7 pointed, new in appearance, secondary 1 pointed[b] primary 9 less than 190mm, primary 10 less than 158 mm if juvenile primaries 8 and 7 are present ……..……..……**Chick Female**

[a] Primaries are numbered 10 - 1 from distal (outer) to proximal (inner). Secondaries are numbered 1 - 10 from distal (outer, next to primary 1) to proximal (closest to body). Measurements are from the insertion to the tip (i.e., P 10 is measured from insertion between 10 and 9 to the tip of large P 10, etc.)

[b] Juvenile secondary 1 is replaced when adult primary 8 is E (empty) to 100 mm in length.

Table 2. Length (mm) of primary flight feathers* of sage-grouse useful for age and gender separation.

	Adult						Yearling/Juvenile					
	Male			Female			Male			Female		
Area	10	9	1	10	9	1	10	9	1	10	9	1
Gunnison	>157	>190	>140	<150	<190	<140	>157	>190	>140	<150	<190	<140
N. Color.	>160	>200	>140	<160	<200	<140	>160	>195	>140	<160	<195	<140
Oregon	>160	>195	>140	<160	<195	<140	>155	>195	>140	<155	<195	<140

*Numbered from inner (1) to outer (10)

Figure 1. Appearance of tips of primaries 10 and 9 for juvenile (left), yearling (center) and adult (right) sage-grouse.

Figure. 2. Appearance of juvenile (left) and adult (right) first secondaries of sage-grouse.

Fig. 3. Appearance of juvenile (left) and adult (right) tertial feathers of sage-grouse.

Fig. 4. Appearance of juvenile (left) and adult (right) upper wing coverts of sage-grouse).

Appendix B: Forms

Annual Sage Grouse Lek Observation Form

Lek:_____ **Warden District:** _____

Complex: _____ **GPS Datum: NAD83** **Biologist District:** _____

WGFD Region: _____

	QQ	Q	Sec	Tw	Rng	Zone	Northing	Easting
Prim. Location:	__	__	__	__	___	___	_____	_____
Alt. Location:	__	__	__	__	___	___	_____	_____

BLM Office: _____

Land Status: _____

Area:_____ **Year Discovered:** _____ **County:** _____

BLM Map:_____ **Topo Map:** _____

Comments: _____

1st Count/Survey

Date			Weather		# Grouse Observed			If no grouse observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

2nd Count/Survey

Date			Weather		# Grouse Observed			If none observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

3rd Count/Survey

Date			Weather		# Grouse Observed			If no grouse observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

4th Count/Survey

Date			Weather		# Grouse Observed			If no grouse observed, was sign (droppings/feathers)	
mm/dd/yy	Time	Observer	Wind<10mph?	PPT?	Male	Female	Unk	checked?	observed?
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Comments and field notes, incl. new location coordinates if different from above:

_____

_____

*Lek **Counts** should be conducted starting the second or third week of April through the first week of May. Visits to the lek should be made about one week apart from each other. Each lek should be visited and counted at least 3 times under good weather conditions (wind<10 mph, not raining/snowing). Lek **Surveys** can begin in mid-March and should be conducted until the lek status (active/inactive) is verified. One visit is enough to consider a lek "active" if birds are observed or signs of strutting are observed. Three ground visits, including a late season visit, are required to classify a lek as "inactive" if no birds are observed and a search for sign is not conducted.*

SAGE GROUSE OBSERVATION FORM

Observer: _____ UTM Zone: _____

Check One: Ground___ Fixed Wing___ Helicopter___ Transfer appropriate data to WOS.

Date	Live or Sign	# Grouse	UTM (NAD83) or lat/long location		Habitat Type	Cover Est.(1)	Aspect (N/S/E/W)	Relative Elevation(2)	Slope(3)	Snow Depth	Other
			Easting	Northing							

(1) Low: ≤10% shrub cover, Med: 15-25% shrub cover, High: ≥30% shrub cover; (2) Low:draw, Med:mid-slope, High:ridge top; (3) Flat, Med, Steep

SAGE GROUSE MOLT DATA FORM

Management Area:_____ **Collection Date:**_____

Collection Location/Barrel Name:_____

Adult Males

Full Molt:_____
Old P10:_____
Old P9:_____
Old P8:_____

Yearling Males

Old P10:_____
Old P9:_____
Old P8:_____

Adult Females

Full Molt:_____
Old P10:_____
Old P9:_____
Old P8:_____
Old P7:_____
Old P6:_____

Yearling Females

Old P10:_____
Old P9:_____
Old P8:_____
Old P7:_____
Old P6:_____

Chick Males

Adult P8:_____
Adult P7:_____
Adult P6:_____
Adult P5:_____

Chick Females

Adult P8:_____
Adult P7:_____
Adult P6:_____
Adult P5:_____

Other Wings in this Collection

Gray Partridge Wings:_____

Sharp-tailed Grouse Wings:_____

Pheasant Wings:_____

Blue Grouse Wings:_____

Ruffed Grouse Wings:_____

Sage Grouse Wing Analysis Summary Form

Year: _____ **MANAGEMENT AREA:** _____

Adult Males: _____ Percent of All Wings: _____
Adult Females: _____ Percent of All Wings: _____
Adult Unknown: _____ Percent of All Wings: _____
Total Adults: _____

Yrling Males: _____ Percent of All Wings: _____
Yrling Females: _____ Percent of All Wings: _____
Yrling Unknown: _____ Percent of All Wings: _____
Total Yearlings: _____

Chick Males: _____ Percent of All Wings: _____
Chick Females: _____ Percent of All Wings: _____
Chick Unknown: _____ Percent of All Wings: _____
Total Chicks: _____

Unknown Sex/Age: _____ Percent of All Wings: _____

Grand Total for all Sex/Age Groups: _____

Chick Males: _____ Percent of All Chicks: _____
Yrling Males: _____ Percent of Adult + Yrling Males: _____
Adult Males: _____ Percent of Adult + Yrling Males: _____
Adult + Yrling Males: _____ Percent of Adults + Yrlings: _____
Total Males: _____ Percent of All Sex/Age Groups: _____

Chick Females: _____ Percent of All Chicks: _____
Yrling Females: _____ Percent of Adult + Yrling Females: _____
Adult Females: _____ Percent of Adult + Yrling Females: _____
Adult + Yrling Females: _____ Percent of Adults + Yearlings: _____
Total Females: _____ Percent of All Sex/Age Groups: _____

Chicks: _____ Percent of All Wings: _____
Yearlings: _____ Percent of All Wings: _____
Adults: _____ Percent of All Wings: _____

Chicks:Hen _____