

A PRELIMINARY REPORT ON MONITORING METHODS
AND AN ECOLOGICAL INDEX FOR MEASURING
VEGETATIVE CHANGE IN GLEN CANYON
NATIONAL RECREATION AREA

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INTRODUCTION

The need for research on the impacts of livestock grazing in Glen Canyon National Recreation Area (GLCA) has been identified by National Park Service (NPS) personnel. This preliminary report represents the first phase of the research project requested by NPS staff. It contains a review of the current literature on vegetative and wildlife monitoring. Recommendations for a diverse and intensive monitoring program are included. Finally, the report discusses the development of a composite ecological index to be used by NPS personnel in evaluating the effects of livestock grazing in the GLCA.

The traditional methods of evaluating vegetation condition and trend are based on primary livestock forage species and are not well suited to the management objectives of National Park Service lands. Therefore the recommended methods of evaluation, selected from the available literature, represent a system adapted specifically to the needs of Glen Canyon. The resulting monitoring program is broad-based to cover the variety of ecological communities found in the recreation area. Data obtained from the program can be adapted to an ecological index formula and used to rate the condition and trend of the various communities. The results should serve as a useful guide for NPS staff when evaluating grazing management in Glen Canyon.

IA. VEGETATION MONITORING

There are a variety of vegetation monitoring techniques available to the land manager. Among the most commonly used are variations of frequency* and cover*, measures of utilization*, and diversity indexes*. Frequency and cover are indicators of vegetative trend*. Utilization estimates the proportion of the current year's growth that is used or destroyed by grazing animals. Diversity serves as an indicator of the structure of the community. Each of these can provide useful information, but the data collected are site specific and cannot be transposed over other, similiar vegetative communities.

A. FREQUENCY AND COVER

There are eight common methods for monitoring vegetative trend.

1. The first technique is the use of photo plots. These are permanent photo points and are used to show foliar and basal cover, composition by cover, presence of key species, and density. The plot is either a permanent point marked by a stake, or a frame placed over permanent markers. Two photos are taken; one, a close-up of the plot, and two, a general view of the study area. Each consecutive reading of the plot requires the photos be taken from the same point, in the same direction, and at a similar time of day. The advantages of method are that it provides a visual picture of change over time for a specific

site. It also offers an estimate of vegetative cover and composition. The disadvantages are the extremely small area surveyed (the plot frame), the difficulty in identifying small plants, and the variability between observers. If used to provide a visual picture as a supplement to other trend monitoring, the photo plot technique can be very useful. However, used alone little inference can be reached, and no statistical data is provided.

2. The community structure analysis method, (CSA), assigns a relative "importance value" to each species to describe its status in the community (Pase 1981). The status is based upon the relative values of frequency, cover, and density for each species. CSA indicates foliar cover, density, frequency, and composition by cover and density. A 100-pace transect is read using a micropot frame (5x10 cm) and a 9.6 square-foot, or smaller, circular plot. The circular plot is read every 10 paces. Foliar cover is estimated for each perennial species within each microplot. Density and frequency data are collected for all plant species in the circular plot. Advantages of this system are the ease of data collection and interpretation. The values are relative, not absolute, so estimator error and fluctuations due to precipitation changes are reduced. Limitations are the size of the circular frame, the small number of circular plots surveyed, and the use of two plot sizes. Use of a 9.6 square-foot frame is prohibitive in rough terrain where foot travel is required to reach the study site. The ten circular plots read do not represent a good statistical sample

size for frequency analysis. Finally, the two plot sizes cannot be compared to each other so the data collected must be interpreted separately.

3. The Daubenmire method provides an estimate of canopy cover, frequency, and composition by cover. A 20x50 cm plot frame is placed along a transect line. Forty to fifty plots are needed to obtain statistically valid results. Daubenmire developed six cover classes for determining percent canopy cover (1959). Canopy cover is estimated by standing over the frame and recording the cover class for each plant species. This method is not applicable for vegetation over waist height. Frequency and composition are recorded at the same time the cover data is collected. The Daubenmire system is relatively simple but can be time consuming to use. It may fail to differentiate between large changes in canopy cover due to climatic changes with no relationship to management practices.

4, 5 & 6. The pace frequency, quadrat frequency, and nested quadrat methods determine species frequency and general cover (basal, litter, rock). The three techniques achieve essentially the same results. Pace frequency involves reading four parallel transects of 50 plots each. The plot frame size is usually 40x40 cm, however, the size may be adjusted if overall frequencies are too high or too low (greater than 80% or less than 20%). Frequencies are determined for each plant species and cover data is read using a point along the base of the frame for each plot. The method is easy and rapid to use. Bias between readers over time is minimized because estimations are not required. However,

discrepancies occur if the observers lack an adequate knowledge of plant taxonomy or if the plots are read too early in the growing season and seedlings cannot be properly identified. This method is not for use in homogenous rangeland seedings because it fails to show significant change in trend before the seeding is lost.

The quadrat frequency method is similar to the pace frequency method. However, instead of four parallel transects the quadrat frequency method requires 10 or 20 transects of 20 or 10 plots respectively. The transects are established from a permanent baseline and reread from the same baseline on a regular basis. Quadrat frequency also indicates general cover (basal, litter, and rock). Cover data is collected in the same manner as used in the pace frequency method. This technique is simple and rapid to use, requiring little training. However an adequate knowledge of plant taxonomy is essential. Early season readings should be avoided to prevent reader error in identifying plant species. Like pace frequency, quadrat frequency provides statistically reliable results.

The nested quadrat method also reads plots along an established transect. Consecutively smaller plots are located inside the next larger plot within the quadrat frame. Cover data may also be collected with this method using the technique described in the pace frequency information. The transects should be established according to either the pace frequency or quadrat frequency methods and 200 plots read. Advantages and

limitations of the nested frequency method are similar to those listed in the two previous monitoring methods. An additional advantage appears when monitoring rhizomatous grasses. Due to their growth form, rhizomatous species may be more abundant than other plants in a vegetation type (e.g. blue gramma). The nested quadrat allows the more abundant species to be recorded using a smaller quadrat while the remaining species are monitored with the standard 40 cm quadrat. Frequency should be recorded according to plot size for the more abundant plant species. Overall frequencies can be compared as any species which occurs in the smaller plots also occurs in the larger plot. However, the individual frequencies cannot be compared to each other or over time unless the same size plot is used consistently each time the plot is reread.

7. The line-intercept method is a linear measurement of plant intercepts along a tape. It is an indicator of foliar and basal cover, and composition by cover (Canfield 1941). The tape is marked in feet, tenths or hundredths of feet, or meters, centimeters, and millimeters. Intercepts for each species are read along the tape and percent cover at each is recorded. The advantages of this system are its adaptability to both small and large rangeland sites, and its usefulness on small plots in detailed studies. Limitations include unsuitability for annual species, dense grasslands, and areas with sparse vegetation.

8. The final trend method is the step-point transect method. An established transect of 200 points is used to determine cover (foliar, basal, litter, rock, etc.). This method has been widely

used and is a simple technique (Evans and Love 1957). It is limited due to the variation between observers. It does not provide a good indication of the species present as the less predominant species will not show up on the transects. Finally, the step-point method is not reliable for area with sparse vegetation as too much bare ground will be encountered with little plant data obtained. This method is good for use in seedings because it shows a change in trend more quickly than the frequency methods.

B. UTILIZATION

Utilization is the amount of forage* (expressed as a percent of total available forage) removed by grazing or browsing during the current year. Utilization data is important in evaluating the effects of grazing or browsing on specific areas. It provides useful information to resource managers because the data can be used to adjust management actions to achieve resource goals. If an area is consistently over or under utilized, actions need to be adjusted to achieve the proper levels of utilization required for habitat management.

Utilization studies are most helpful if some preliminary work is done prior to setting up the transects. The first step is to select the plant species to be monitored. All species can be monitored, but this is usually not necessary. Specific key

species are used to indicate utilization levels. The species selected are usually important forage species which are sensitive to grazing/browsing pressure.

A map of general utilization patterns is very useful to achieve an overall picture of habitat use. The map can identify key areas that may need to be monitored due to the potential for excessive use. In addition, the map can show those areas that are under-utilized and why. For example, topographic features such as deep gulleys and rimrocks may prevent livestock from using an entire area. The presence or absence of water also determines utilization patterns. These features are more discernible on a map. The map should be done on an overlay for an aerial photo, ortho-photoquad, or topographic map. The map base should be large enough to cover the range site, but also show such physical features as vegetation types, fences, water, and roads. If overlays are used to map utilization patterns then patterns can be compared over time.

There are utilization study methods for both herbaceous use and browse use. Transects are established and a minimum of 25 to 100 points are read. Statistically, the larger the sample the less bias due to estimator error. Some of the methods require actual measurement of the forage yield. Other methods use estimations of forage. Estimation methods are easier and quicker, however they require more knowledge and training on the part of the observer.

1. The paired plot method determines herbage utilization

through the use of protected and unprotected plots. The forage within the plots is clipped and weighed at the end of the grazing season. The difference between the paired weights is the amount of herbage consumed or otherwise destroyed during that season. This method is especially useful where the season of use is short and little regrowth occurs following the end of the season. This method is a simple, direct way of measuring forage utilization and requires little training. Levels of accuracy are generally high. A limitation to the system is the time requirement to achieve an adequate sample size. The paired plot method is not appropriate for areas with a long grazing season. The regrowth which occurs during a long grazing season cannot be measured unless the cages are moved at short time intervals, thus increasing the time requirement for this method.

2. The ocular estimate method is used to measure utilization along a transect. Percent of herbage removed by weight is estimated on small plots. This is a quick and easy method to gather large amounts of data. However, accuracy is dependent upon the ability of the observer. Larger sample sized can reduce some of the observer bias. Training is essential for the accuracy of this technique.

3. The key forage plant method uses ocular estimation to determine forage utilization from one of six utilization classes. The general appearance of the range site is noted, especially that of the key species located along the transect. The utilization classes correspond to percentages and are labeled "no use, slight, light, moderate, heavy, and severe." There are

paired plot method in that it does not use exclosures. Ungrazed plants are located and identified along the transect. Therefore this method is more suited to bunch grass communities where the measurement of a single, well-defined plant is possible. The technique is not appropriate for shrubby vegetation. The method is easy and accurate. It's major limitation is the restriction to bunch grass sites.

6. The stem count technique counts grazed and ungrazed stems along a transect. It is based on the assumption that the number of stems grazed is related to the percent utilization. This method is best used on sites with single-stem rhizomatous grasses. Mixed and prairie grasslands are appropriate for this method. The technique is simple and somewhat free from observer bias.

7. The grazed-class method uses photo cards of key species at various utilization levels to estimate utilization along a transect. The photo cards show the key species at 0, 10, 30, 50, 70, and 90 percent levels of usage. Estimates are determined at the end of the growing season. This method is quick, and easy to learn. It can be used by professionals and lay people alike. The photo cards can be used in years of good and poor production. However, in years when plants do not mature due to climatic factors, the cards cannot distinguish between use and no-growth. Development of the cards is difficult and time consuming.

8. The twig length method determines utilization by measuring twigs on 25 to 50 browse plants twice during the year (Stickney

1966). The first measure occurs after full annual growth is completed and the second measure follows the season of use. The difference between the two measures is the amount of browse consumed. Each browse species has a separate transect. This method is useful only for those browse species which clearly show annual twig growth. The technique provides accurate information as the twig growth is measured, not estimated. In addition, if seasons of use by wildlife and livestock are separate, utilization levels by each group can be determined. This can show forage competition between groups. The limitations to this method are the time and effort used to collect data twice each year, and the restriction to species which clearly show annual growth.

9. The Cole browse method uses data collected along a transect on 25 to 50 plants of a key browse species. Data is collected on age and form class, availability and hedging, estimated utilization, and growth and use indexes of the browse species. This data is then used to estimate annual utilization and trend. Separate transects are used for each browse species. The key species must clearly show annual growth. This method is quick, but less accurate as it is based upon estimates rather than on measurements. There may be wide variations in estimates between observers. In addition, factors such as plant growth characteristics, climate and site conditions are not accounted for and may influence plant appearance more than browsing.

10. The extensive browse technique determines utilization from a 100 point transect. Data on species composition, age class,

form class availability, and hedging is also collected. This method measures all browse species along one transect. It can be used on those species which do not exhibit annual growth leaders. This system is rapid and adapted to use on large areas. It less accurate in determining utilization because values are estimated. However, the large sample size (100 points) eliminates some personal bias and maintains consistency.

C. DIVERSITY

Diversity indexes measure the ratio between the number of species and the number of individuals (Odum, 1959). Diversity can be determined based on species composition information derived from weight or cover data. Weight and cover data are obtained from such monitoring techniques as the dry-weight-rank method or Daubenmire's cover method. Two formulas are commonly used to calculate the diversity index. The Simpson Index is a measure of dominance and is weighted in favor of the most common species. The Shannon Index is a measure of diversity and favors the rarer species. Used together, the indexes make a good two-sided profile of diversity (Odum, 1975). Formulas for both indexes are given in Appendix 1.

A diversity index determines the structure of the population at a point on the scale of 0-1. The higher the value (the closer to 1) the more diverse the population. It is generally believed

that higher values are more desirable than lower values. Higher values are usually associated with steady-state (climax) systems. Here diversity and stability are directly correlated, but diversity does not necessarily produce stability (Odum, 1975). It should be noted that lower values are indicative of environments with severe limiting factors such as low moisture, salinity, and poor soil conditions. Low values may also indicate a rapidly expanding community where there is severe competition for limited space and nutrients (Odum, 1959).

IB. WILDLIFE

The use of wildlife species, especially birds, to monitor habitat quality is an accepted technique employed by wildlife biologists. Indicator species* are selected for each habitat type studied. The next step is to choose an appropriate monitoring technique to detect changes in population trend over time. The following techniques are for nongame birds.

A. BIRD CENSUS TECHNIQUES

There are numerous methods used to census bird populations. Much effort and analysis has been expended to develop and refine each of the following techniques. However, it should be noted that each of these methods has inherent flaws which produce indexes of bird numbers rather than accurate counts of a total population. The following summaries are drawn from a detailed analysis of common census methods by R.W. Mannan and E.C. Meslow (1980).

1. The spot-map method marks the number of territories within a specified area by plotting songposts* and the interactions of territorial males over several days during the breeding season (Robbins, 1970). A composite map of all daily observations is made for each species and the numbers of territories are inferred from the clusters of observations from each composite map. The presence and location of female and nests are also noted. Since each territorial male is assumed to be mated, the population

density is derived by doubling the total number of territories (Mannan and Meslow, 1980). This is one of the more accurate methods for monogamous, territorial, breeding birds. It combines easily with other bird studies including nesting behavior (Best, 1975). One disadvantage of the spot-map method is the difficulty in interpreting the composite maps caused by unmated males and changes in territories during the breeding season. Another problem is that the amount of time required to adequately census an area restricts the study site to small plots (less than 25 hectares). Birds with large territories (raptors and woodpeckers) may not be adequately counted and rare species may be missed. Finally, this method cannot be used to accurately census polygamous, nonterritorial, or nonbreeding birds (Mannan and Meslow, 1980). Statistical analysis cannot be derived from this method as population density cannot be determined for each observation day and therefore cannot be replicated.

2. Nest location provides a reliable estimate of density for raptors and other large or rare species. All active nests within a study area are located and recorded. Ground location and aerial photographs are used to locate nests. The obvious disadvantage to this method is the amount of time needed to find all the nests. The method is useful only during the breeding season, and only small areas can be surveyed.

Note: The following census methods are based upon the ability of the observer to detect and estimate distance to birds seen and heard. Most of the methods use transects. Birds are located

according to their distance from the transect.

3, 4 & 5. The strip-census method, the sample count method, and Emlen's variable width transect method are all variations of strip transect methods. The strip-census method requires the observer to walk a transect, at a steady pace, and detect all possible birds within a strip on either side of the transect line. The width of the strip should vary with the structural complexity of the habitat and the detectability of the birds. A wider strip is used in open habitats or when censusing hard to locate species. The opposite criteria are used for narrow strips. The length of the transect depends upon the length of the habitat type and the length of the optimum census period. (There are two, 2-hour optimal time periods daily. The first is after sunrise, and the second is at sunset when light conditions replicate those at sunrise.) An advantage to the technique is the ease of use. Observers only estimate whether a bird is inside or outside the strip. Limitations are the selection of strip width to census both common and rare species, and the reaction of some species to the presence of the observer. Birds which are attracted to the presence of the observer may be overestimated while birds which avoid the observer will be underestimated (Emlen, 1971).

The sample count method involves set stations and a transect line between stations. Birds are counted in a radius around the station and within a set distance of the transect while the observer is moving between stations. The use of fixed stations

assists the observer by creating a set period time for each observation station, thus standardizing the total time spent censusing. Fixed stations also reduce the effect the observer has on bird activity and allows the observer more time to look around instead of watching a transect (Reynolds et al., 1980). However, there is a greater chance of repeating observations where the fixed points and transects intersect.

Emlen's variable width transect method uses strips of various widths, up to a maximum total width of 250 meters, to detect birds along a transect. Species are recorded according to their location within a strip or band (Emlen 1977). This method eliminates the problem of trying to fit a single strip to all species. Rare or uncommon birds are also detected using this technique. However, all species will not be detected within the various bands, especially during the breeding season when density is estimated on the basis of singing males. At this time males sing at different times of the day and may not be heard by the observer during the observation period. It is important that the distance from the observer be correctly estimated for mapping and to reduce variation between observers. In addition, birds may move away from the observer along the transect and be undetected.

6. The Finnish transect method utilizes one band of a set width on either side of the transect. As the observer moves along the transect, birds are recorded as either "in" or "out" of the band (Jarvinen and Vaisanen 1975). This method assumes that birds are most detectable on the transect and become gradually less detectable as they move toward the outer edges of the bands.

However, this implies that all species show a similar decline in detectability. This does not account for species that may not sing near the observer but do sing when some distance away from the human influence. Uncommon species are detected using the Finnish transect method. Also observer error is reduced as the observer only estimates in or out for one set distance from the transect.

7. The variable circular plot method is similar to Emlen's variable strip method except as the name implies, this technique uses circular bands around set listening posts. An actual transect is not used. Instead fixed stations (10-15) are located and the observer pauses at each one up to 10 minutes to listen for, and record the presence of all bird species locatable at the site. The advantages and disadvantages of this system are similar to those of Emlen's.

One final note on the use of birds as indicators of change in habitat. Morrison (1986) states that bird populations are susceptible to a variety of environmental conditions including human disturbance, natural catastrophes, disease, and environmental contamination. Birds respond to changes in vegetative habitat too, but unless a clear relationship between the species and habitat changes exists, a change in population cannot be inferred as the result of a habitat change. Birds will indicate that a change has occurred, but the land manager must sort out the reason why from many possible causes.

B. RIPARIAN MONITORING TECHNIQUES

Riparian habitats are an essential, and under-studied, aspect of wildlife monitoring. Ohmart and Anderson (1986) estimated that more than 60 percent of the vertebrates in the Southwest require riparian habitats to survive. An additional 10-20 percent used riparian zones at least part of each year. The loss of riparian habitats could potentially eliminate 60-80 percent of the native wildlife species in the western states. A riparian system as defined by Lowe (1964) is "a riparian association of any kind (excluding marshes) which is in or adjacent to drainageways and/or their floodplains and which is further characterized by species and/or lifeforms different than that of the immediately surrounding non-riparian climax." Monitoring riparian habitats is essential when studying wildlife populations. A change in habitat may signal a potential change in the local wildlife population. In the following methods, vegetation change is used to indicate habitat change.

Within the US Forest Service and the Bureau of Land Management there is an increased emphasis on riparian monitoring. As with other forms of vegetation monitoring, no one method has been proven superior over the other techniques. The agencies have been allowed to choose the method(s) most appropriate for their management needs. In general the techniques have broad, general functions rather than specific titles. These systems can be grouped according to function such as inventory, density, and

stratification by age and size class.

Inventory techniques require sampling a study site and recording all the vegetation species encountered. This may be done with a line transect or in a circular plot (20 meter radius for example). The transect method is the line-intercept method mentioned earlier. (Cover data need not be recorded for an inventory study.) The line-intercept method is especially useful in small, vegetatively diverse areas such as riparian areas. Another type of line transect is the belt transect. It is also useful in riparian areas. The line transect is walked by the observer and all large vegetation (shrubs and trees) within a 2 meter "belt" along the line is recorded for species, density, size and age class. This is an effective method for combining several types of riparian monitoring along a single transect line.

The circular plot inventory requires a 20 meter tape stretched from a center point and rotated to mark the edges of the circle. All of the vegetation present within the plot is identified and recorded. The size of the circular plot may be adapted for narrow canyon bottoms and to allow multiple plots to be monitored. In this case the size would be reduced to 5 meters and several plots would be located along a riparian area. Any of these techniques are adaptable to other monitoring methods mentioned here. These techniques indicate the range of plant species present but may miss rare plants if these are outside the sample space.

Density measures indicate the number of individual plants per unit area. Two common density methods are Bitterlich's variable radius method for trees, and the density quadrat method for shrubs and trees (Chambers and Brown 1983). Bitterlich's method measures basal area of trees and density. An optical wedge, prism, or angle gage is used to select which trees will be tallied. Only those trees selected are recorded, all others are ignored. Trees are identified by species and density is calculated on total trees per area (basal area per acre/basal area per tree).

The density quadrat method uses square or circular quadrats randomly located throughout the sample area. All shrubs and trees within the quadrat are counted and recorded by species. Only those shrubs and trees rooted within the quadrat are counted. The size of the quadrat is dependent upon the size and spacing of the individual woody species. Square quadrats (4x4 m) or circular quadrats (3.5-5.0 m) are recommended (Chambers and Brown 1983). The actual shape of the quadrat has little effect on density in uniformly distributed vegetation.

Stratification is the vertical distribution of the vegetation. The two components of stratification are age and size class of the woody vegetation. The quadrat sizes mentioned in above section on density can be used here. All the woody species located within the plot are measured according to size and age class. For both density and stratification, a minimum of

10 plots are required on a study site (Anderson and Ohmart 1986).

Additional riparian monitoring may be required as needed. However, the combination of stratification, density and inventory measures will provide a good picture of the individual site for comparison against management goals over time.

C. SMALL MAMMAL CENSUS TECHNIQUES

Small mammal populations can also serve as indicators of habitat change (Call 1986). There are two general categories of measurement for small mammal populations. The first is an estimation of species occurrence and relative density. The second is an estimation of the species population (number of individuals). Both categories require some form of trapping to collect the data.

Species occurrence and relative density data is best collected using snap traps set along parallel transect lines (Anderson et al. 1977, Kepner 1978). The lines are usually 210 meters in length and 15 meters apart. The traps are set at stations 15 meters apart along each transect (15 stations total).

Best et al. (1979) used parallel transects 125 meters in length with 10 stations set 12.5 meters apart in riparian area.

The traps are baited and set in the early evening. The lines are checked every hour until midnight. The traps are set again at midnight and rechecked in the morning. The traps are left unsprung until the next evening. This is repeated for three consecutive nights using the same transect lines and stations each night. Each site is trapped only once during the year.

Victor rat traps or live traps may be substituted if trapping medium-size rodents. Dead animals must be removed from the traps early in the morning to avoid decay in the desert heat. If live traps are used shade must be provided against the morning heat.

Population estimates are performed using one of three separate techniques (Call 1986). When collecting population data each site must be trapped at least twice within the same season, usually a few days apart. The first method is the strip census method for medium-sized animals. Here a straight transect is established and the observer walks the transect recording animals observed at right angles to the transect. This method has some inherent weaknesses. First, some animals will hide in burrows and not be observed at all. Second, if an animal runs ahead of the observer, along the transect, it may be recorded more than once. Finally, some animals such as jackrabbits tend to circle back to their dens and may be counted twice.

Within a species, sex and habitat quality effect the size of the individual territory. The time of year effects activity levels and the presence or absence of some species.

II. RECOMMENDATIONS FOR MONITORING METHODS

A. VEGETATION MONITORING

Quadrat frequency is a form of plant frequency monitoring. This method is relatively simple and produces statistically acceptable data. Quadrat frequency monitoring (QUAD) has ten parallel transsects of twenty paces each. Statistically, this method can be analyzed using normal statistics or a binomial distribution. With this method a nested quadrat frame is recommended (see discussion of trend monitoring). It is our recommendation that this method be adopted for use in monitoring the rangelands within Glen Canyon National Recreation Area.

There is extensive research on the use of frequency to monitor vegetative change (trend) over time (Hironaka 1985, West 1985, Despain et al 1987). Frequency has been shown to be an effective early warning signal for detecting change in key or indicator plant species (West 1985). It is especially good for monitoring vegetation change as a result of management practices (Hironaka 1985). Other advantages of frequency monitoring are that it is a simple and rapid way to collect data on several plant species concurrently. The data is statistically reliable. The techniques are easy to learn and require little training beyond a knowledge of plant species identification.

The major disadvantage of frequency monitoring is that while it is a good indicator of change, it cannot explain why the

change occurred. Management decisions cannot be made on frequency data alone. However, in combination with other forms of monitoring, frequency is a useful tool to the land manager.

In addition to frequency data we recommend that cover data and dry-weight-rank data be collected. Cover data is supplemental to the frequency data and should be read at each plot along a transect. The actual techniques have been discussed earlier in this paper. Cover is broken down into groupings including vegetative (basal) cover, litter, rocks, and mature cap or immature cap for bare soil. The information is valid statistically.

The dry-weight-rank method is a simple method of estimating species composition by weight (Mannetje and Haydock, 1963). In this method the observer ranks only the three species which contribute the highest percentage to the weight of the plot (Smith and Despain 1987). The method is easily used as the observer is not required to estimate an actual weight for the plant species present. The top three species are rated in order of weight as 1,2, or 3. Each plot along a transect is read and provides the observer an idea of the relative importance of each species present in the sample area (community). This is one method of evaluating range condition (Smith and Despain 1987).

Diversity information can be obtained from the information collected from the above monitoring methods. Frequency and dry-weight-rank provide a species list and composition by weight needed for the diversity index formulas. Additional species not

recorded on the transects, but observed within the site, should be noted and their relative abundance estimated. This information is combined with the recorded data to project diversity on the site.

All four of the recommended monitoring methods (frequency, cover, dry-weight-rank, and diversity) combine easily. Each can be used along the same transect lines and read simultaneously. In total the data derived will be extremely useful and provide a good overall picture of the trend and condition for the Glen Canyon rangelands.

Monitoring the utilization of important members of the natural vegetative community should be another component to the vegetation monitoring program. There are several separate methods for both grasses and shrubs (see discussion of utilization monitoring techniques). However, we recommend a method which will allow shrubs and grasses to be measured at the same time and along the same transect. This will prove to be more efficient than the use of separate methods. The key forage species technique is adaptable to both grasses and shrubs. It will allow NPS staff to monitor those plants deemed most important in a "natural community." The technique is simple and requires little training. The same transect used for the other monitoring methods may also be used for determining utilization in the study site. However, utilization patterns will vary throughout an allotment or pasture. More than one utilization transect may be necessary in order to obtain an accurate picture of the overall use in an area.

The final monitoring method we recommend is the use of permanent photo points located at each monitoring site. The points are marked by permanent stakes which are relocated and matched to previous photos each time the picture is taken. This provides a visual aid for interpreting the monitoring data from the other methods.

B. BIRD MONITORING

The Glen Canyon area contains a variety of habitat types suitable for bird censusing. To insure efficiency in data collection and useful analysis we recommend a uniform monitoring system which is adaptable to the various habitat types. This system combines three techniques to insure maximum accuracy and makes full use of the observer's time on each site.

The first method we recommend is the use of variable width strip transects. The observer will walk the strip noting the presence of singing males and location. In addition, listening posts will be utilized to increase the potential of detection and reduce the tendency of birds to move in front of the observer along the transect line. Selection of sites is important. The location of riparian areas in strips along the canyon bottoms makes a strip method more desirable than the circular plot method. The observer will travel through the study area during the early morning hours when most species are singing.

The nest count technique is also recommended for use in conjunction with the transect. Following the transect recordings, the observer may use the remaining hours on site to locate all possible nests in a circular plot (20 meters in diameter). Rarely will all nests be located, but this will give a good indication of the presence of breeding species using the area and may indicate species not detected by listening for songs.

The final recommendation is that the observer make detailed notes on species located visually and their activities (feeding, nesting, etc.) In addition, notes should be included on vegetation species present and any other site information possible to provide the most accurate picture of the study site. This information will be essential to the land manager when changes in bird population need to be explained.

These methods combine easily to provide a wide variety of information necessary for accurate interpretation of the bird census data. Many years of data are needed before any inferences on population changes can be made. Finally, bird populations are cyclic and fluctuate naturally between years. A recorded change must be monitored carefully in order to determine if the cause is due to current management practices or due to circumstances out of the control of the land manager (precipitation, disease, migration casualties, etc.).

The alternative to an intensive bird monitoring is to perform a simple census at each study site. A strip transect of 250 to 500 meters would be walked and the location of all bird species observed within a 50 meter band noted on the transect form. After the transect has been walked once, the observer should pause 10 to 15 minutes and then return along the transect to the original starting point noting species again on the transect form. This will produce two replications for each site. This method does not produce statistically valid data or a good estimate of use throughout the breeding season. However, it will

provide an indication of habitat use for the site at that particular time.

One final note on monitoring birds concerns the season of use for a site. Birds are most active, and therefore most detectable during the breeding season. In the canyonlands of southern Utah and northern Arizona the season of use for most sites begins in March and is completed by mid-June. Monitoring for all sites should be completed during this time period. Following the breeding season some species will be undetectable and any census will necessarily be biased. Due to the time and manpower constraints of the 1988 field season, we strongly urge the NPS staff to consider deferring any monitoring of birds, aside from general observations, to the following year. At such time a monitoring plan could be implemented to provide site access within the critical season of use.

C. RIPARIAN MONITORING

In Glen Canyon NRA the riparian ecosystems may be either wet meadows or stream/lakeside vegetation. Each of these areas must be monitored with a different method. Wet meadows may not have the corresponding overstory of woody vegetation present along riparian channels. In the earlier discussion of vegetation monitoring the nested quadrat technique was examined. This technique is useful on herbaceous meadows as it allows the observer to select the appropriate quadrat size for the study site. We recommend the use of the nested quadrat method for

meadow monitoring with the actual quadrat size to be selected after field testing.

In those riparian areas with woody overstories, the use of an inventory technique, density method, and stratification is recommended. The most efficient system would combine density and stratification with the belt transect method for species inventory. These three methods will combine easily and can use the same transect for an individual study site. The canyon bottoms of the NRA are a good example of the type of habitat suited to this combination of methods. A transect placed along the streamside (or across the stream) could be used to record species diversity, emerging vegetation (willows, cottonwoods, etc.), older trees, the density of the vegetation, and the vertical layering which is important for cover and bird habitat. The transect length and width would be determined after field testing. Several transects would be placed throughout the riparian system.

The results for the above methods could be combined in an ecological index as a second wildlife component. In addition, the information from a site could serve as a baseline for comparison to management goals and ecological change over time.

Finally, the use of permanent photo plots (see vegetation monitoring) is essential for visual comparison and to serve as an additional information source to explain vegetative change. Periodic flooding may wipe out any permanent transect, vegetation, and alter the stream course. Permanent photos are

the only means of maintaining ongoing records following such catastrophic events.

D. SMALL MAMMAL MONITORING

The small mammal populations in Glen Canyon NRA form a diverse community which will be difficult to study with great accuracy under time and manpower constraints. The amount of replications needed to collect data for population estimates makes this form of study prohibitive. However, species occurrence and relative density will provide adequate information on the small mammal communities. Due to the time and labor intensiveness of live trapping of small mammals we recommend the use of snap traps to measure species occurrence and relative density. These studies will be conducted at the same site used for the vegetation monitoring so the information on vegetation, cover, etc. can be used to describe the mammal habitat.

The time constraints on the study period will reduce the trapping nights at each site to two instead of three. The traps will be set up and monitored according to the method stated earlier. The technique used by Best et al. (1979) will be followed thereby reducing the number of traps needed and the length of the transect. The shorter transect will be most useful in the riparian areas where continuous, homogenous vegetation may be difficult to find. Finally, as the same methods should be used in following years, the use of fewer traps will result in a smaller taking of the population should this be a concern.

C. SOILS MONITORING

The soils in Glen Canyon National Recreation Area represent an important part of the ecosystem and do need to be monitored. The destruction of cryptogamic crusts, active water and wind erosion, loss of soil cover (vegetative and litter) and soil compaction are concerns for the NPS staff. Unfortunately at this time there is no accepted, reliable method of soil erosion monitoring.

The Universal Soil Loss Equation (USLE) was developed by the Soil Conservation Service for use on the croplands of the Midwest. It has been revised for use on rangelands, but still has several serious flaws which lead to inaccuracies in estimating erosion levels. In response to the need for a more accurate method of erosion prediction on public lands, the US Department of Agriculture and the US Department of the Interior are working together on a new system called the Water Erosion Prediction Project (WEPP). Both the Soil Conservation Service and the BLM will adopt WEPP when it is available in 1992. However, as the title suggests, WEPP is for water erosion and does not consider wind erosion which is an important force in Glen Canyon.

Therefore we recommend that the NPS monitor the soil in an informal manner using the cover data collected during the frequency monitoring with additional notes on the presence of such active erosion as rills, gullies, soil mounds around plant

bases, and broken soil crusts. The information cannot be applied to soil erosion potential as given in the soil surveys, but it can be used to note changes in the soil trends on a site.

III. STUDY PLAN

A. BLM MONITORING

The Bureau of Land Management is required to monitor all allotments (Federal Register, 1987). Allotments are categorized in either an "I" (Improve), "M" (Maintain), or "C" (Custodial) category. "I" category allotments are managed for improvement and therefore are the most intensively monitored, followed by "M" and "C" allotments. "M" allotments are currently under management to maintain satisfactory conditions. "C" allotments require minimal management to protect current resource values (Federal Register, 1987). The types of monitoring performed vary between resource areas, but a few general guidelines hold true. "I" category allotments must have utilization, actual use, and trend studies. Utilization is usually read on an annual basis. Actual use is also reported annually. Trend must be read at least once every three years. On "M" category allotments utilization and actual use records are maintained. Trend studies are read once every five years minimum. "C" allotments receive little monitoring and may have photo points only which are read every five years. Additional monitoring is at the discretion of the resource area .

For those allotments located wholly, or in part, within the recreation area a variety of monitoring studies are in place. The BLM is monitoring utilization using both the paired plot and key species methods. Actual use is reported by the livestock user. Trend is measured by the use of photo points, pace

frequency, quadrat frequency, and step-point transect methods. A matrix of current monitoring for each resource area is shown in Appendix 3.

A complete listing of the type, location, and schedule of monitoring is being compiled with cooperation from BLM staff. Current monitoring data is not available on all allotments. A complete analysis of available data will require personal visits to each resource area associated with Glen Canyon. These visits are tentatively planned for spring 1988, prior to the start of the field season.

The BLM monitoring program, as a whole, has a serious flaw. The program lacks a cohesive, standard set of techniques uniform between the resource areas and districts surrounding Glen Canyon NRA. Each resource area is allowed to select its own methods. There is great variation among resource areas and between districts. This creates communication problems within the agency, and makes interagency communication breakdowns inevitable. It can be argued that the BLM monitoring guidelines allow each resource area to select the methods best suited to its various ecological communities. However, the canyonlands of southern Utah and northern Arizona could be served by a single set of techniques recording trend, cover, and utilization. This would make monitoring information easier to analyze for the region and facilitate interagency communication.

Analysis of monitoring data is useless without some original information/documentation for comparison. Change cannot be

measured without knowing what a community has changed from. The range condition evaluation developed by the Soil Conservation Service, and used by the BLM, provides this comparison information. "Range condition is determined by comparing existing plant communities with the presumed climax* plant community for a specific range site*, regardless of the value of the individual plants or the plant community for specific uses" (SCS National Range Handbook). As stated, comparisons are made and the current range conditions are classed as "excellent," "good," "fair," or "poor" for increasing digressions from climax, respectively. "Excellent" is most similar to climax and "poor" is least similar.

Smith (1979) finds several flaws with the concept of range condition as a comparison tool for management purposes. In the arid southwest most vegetational communities vary widely from climax. The changes are attributed to climatic changes, fire prevention, and overgrazing. Many of the plant communities will not return to near climax condition naturally without the restoration of fire and previous moisture levels.

A second flaw in range condition assessment is the assumption that climax is the most desirable level for management. In fact, some stage below climax may be preferable depending on management goals. For example, deer are dependent upon fire or some other disturbance to remove decadent brush and increase shoot production in bitterbrush (Ceanothus sp.). Smith contends there is a danger that a rangeland managed for a

specific purpose below excellent or good condition will be assumed to be poorly managed by laymen even though it meets management objectives (1979).

Grasslands are assigned condition ratings, but woodlands are not rated. The presence of woody species (trees) removes the site from the SCS rating system and offers no alternative means of comparison. If the basic purpose of range condition and trend assessment is to evaluate the effects of management on site stability and habitat quality, this purpose is as important on woodlands and it is on grasslands (Smith, 1979).

The use of condition information is another serious flaw in the BLM monitoring plan. At present there is no viable alternative accepted by the Bureau. Therefore, when assessing current condition and trend it is essential to remember the weaknesses in the system in order to arrive at ecologically correct conclusions.

In addition to a cohesive monitoring plan, there needs to be joint cooperation between the NPS and the BLM for Glen Canyon NRA. The Bureau of Land Management has its own set of constraints in the form of regulations (Federal Register, 1987), funding and personnel. The BLM cannot be expected to monitor to meet NPS expectations where these differ from the legal requirements for allotment monitoring. Therefore, the NPS must make a commitment to its own monitoring program designed to meet the specific needs and goals of the GLCA management plan. This will require an annual commitment of personnel and funding.

Expected budget constraints should be accounted for when selecting a specific program. Data must be collected on a regular basis by trained personnel if it is to be useful to management. Lack of commitment will be a waste of both NPS man-hours and dollars.

B. SENSITIVE AREAS

Glen Canyon NRA contains diverse biological communities. The task of monitoring each community at various sites throughout the recreation area is too large and costly a venture to initiate at this time. Instead we recommend that a few sensitive or critical sites be monitored at present, with future expansion as personnel and funding levels permit.

Examples of the sensitive area to be monitored include riparian areas, relict grasslands, cultural sites, and other vegetation types unique to the Glen Canyon area. Determination of study site locations will be finalized after a field survey is completed with NPS staff. Factors to be considered in site selection include presence of key species, a homogeneous area of adequate size for monitoring, ease of access, time and expenditure required for each site and the overall area.

Appropriate monitoring methods will be selected in cooperation with NPS staff. Training will be provided in the corresponding techniques. A monitoring schedule will be developed to facilitate NPS staff in achieving monitoring goals and to insure the consistent collection of data for statistical

analysis. Sample data collection forms will be provided.

Data will be analyzed statistically according to the monitoring technique selected. The resulting analysis should provide NPS staff with useful information for determining management goals and actions. Analysis instructions will be provided.

IV. ECOLOGICAL INDEX CONCEPT

Ecological indexes have been used in studies of stream habitat (Karr, et al. 1984) and vegetative diversity (Odum 1975). Each index is made up of several components mathematically combined to reach a total. (The components are derived from monitoring data obtained on a specific study site.) The total is then used to rate present conditions against a set of standard values. The index value shows change (positive, negative, or no change) in the area studied. If necessary, management adjustments are made to achieve the desired values for management goals. A sample index is demonstrated in Appendix 4.

It is possible to create an ecological index for Glen Canyon NRA. This index would combine information on vegetation and wildlife to provide an indicator value for ecological condition. Those habitats with a greater diversity of vegetation and more vegetative cover would be favored as those communities are often considered more desirable biologically (Odum 1975).

The development of an ecological index will require an intensive, diverse monitoring program. Several years of study and data collection are necessary to form an accurate information base. The initial data collection will serve as a baseline for future evaluations for each site. From this point the direction of change (positive or negative) can be detected. Several years of initial data are required to minimize the influence of changes due to climatic fluctuations. Once begun, the monitoring must be

repeated in a regular and timely manner. Recorded changes cannot be analyzed accurately without this ongoing information.

The adoption of an index system of analysis has several inherent limitations. This is an expensive system to initiate and maintain. The amount of monitoring required to achieve statistically reliable results is costly in both money and manpower. In addition, in arid environments annual rainfall is extremely variable in both timing and amount. By nature these systems have greater annual vegetation fluctuations as a result of the varying precipitation. The differences within a site require expertise and a thorough knowledge of the site to interpret the data and make an accurate analysis of the changes observed. This system is not a shortcut to be used by inexperienced persons. Correct analysis of the outputs is not possible without an understanding of any changes in the inputs and their individual effects.

A composit index loses sensitivity in two important ways. First the index lacks sensitivity to various range sites. If the index was developed with data from a riparian ecosystem, it will not be applicable to arid shrublands or grasslands. This means several indices need to be developed to cover all the critical habitats to be monitored. Secondly, the composit loses the sensitivity of its individual components. When lumped together the individual members are lost and a significant change in any one is lost in the total change. A total change of 10 percent would be statistically significant. However, if this change is

from 85-95% does it reflect a change in the total habitat or a change in one of the components? Is this same 10% change significant in terms of the biological system? Does the change reflect an actual environmental "improvement" from one rating class to another ("fair" to "good", or "good" to "excellent") or a change within a class? These questions are an example of the limitations of the index concept. Land managers are required to analyze all aspects of the system in order to correctly interpret the results.

Finally, if the reasoning behind the ecological index concept is to develop a system for judging and revising management decisions, alternative systems may be considered. Land management goals set by NPS personnel can be used as a baseline for monitoring studies. The movement toward these goals by the ecological community would be a positive trend. Another alternative is to manage according to the Resource Value Rating suggested by the Range Inventory Standardization Committee (RISC), Society for Range Management (1983). This system evaluates each site according to its approximation to the "potential natural plant community"* of the ecological site. High ratings go to those sites which more closely resemble the potential community. Determination of the potential natural plant composition of an area can also serve as a baseline comparison for future monitoring data. The RISC report is included in Appendix 5.

Both of the above mentioned alternatives to the ecological index system are worthy of consideration. These systems are less

costly and may be more adaptable to the needs of GLCA than the index system.

GLOSSARY

Climax: the biotic community that would become established if all successional sequences were completed without interferences by man under the present environmental conditions. The final or stable community in a successional series. Includes naturalized non-native species. Synonymous with "potential natural community."

Cover: total cover including basal cover, canopy cover, foliar cover, and ground cover.

basal cover - the cross sectional area of the stem or stems of a plant or of all plants in a stand. Herbaceous and small woody plants are measured at or near the ground level; large woody plants are measured at breast or other designated height. Synonymous with basal area.

canopy cover - the percentage of ground covered by a vertical projection downward of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included. It may exceed 100 percent. Synonymous with crown cover.

foliar cover - the percentage of ground covered by a vertical projection downward of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded. Foliar cover is always less than canopy cover. It may exceed 100 percent.

ground cover - the percentage of material, other than bare ground, covering the land surface. It may include live and standing dead vegetation, litter, gravel, cobbles, stones, boulders, and bedrock. Ground cover plus bare ground would total 100 percent.

Community: an assemblage of populations of plants and/or animals in a common spatial arrangement.

Critical area: an area which must be treated with special consideration because of inherent site factors, size, location, condition, values, or significant potential conflicts among uses.

Density: the numbers of individuals or stems per unit area. In vegetative studies density does not equate to any kind of cover measurement.

Diversity index: a measure of the richness and evenness of the species composition of biological communities. Richness is an expression of the number of species in the population while evenness is the distribution of abundance among species.

Ecological site: a kind of rangeland with a specific potential natural community and specific physical site characteristics, differing from other kinds of rangeland in its ability to produce vegetation and to respond to management. Synonymous with range site.

Ecological status: the present state of the vegetation of a range site in relation to the potential natural community for the site.

Forage: browse and herbage which is available and may provide food for animals or be harvested for feeding.

Frequency: a quantitative expression of the presence or absence of individuals of a species in a population. It is defined as the percentage of occurrence of a species in a series of samples of uniform size.

Herbage: the above-ground material of any herbaceous plant (grasses and forbs).

Indicator species: a certain species, representing a population, and used to indicate environmental change. An organism or ecological community so strictly associated with particular environmental conditions that its presence is indicative of the existence of these conditions.

Inventory: the systematic acquisition and analysis of information needed to describe, characterize, or quantify resources for land-use planning and management of public lands.

Key area: a relatively small portion of a rangeland selected because of its location, use, or grazing value as an area on which to monitor the effects of grazing use. It is assumed that key areas, if properly selected, will reflect the effects of current grazing management over all or a part of a pasture, allotment, or other grazing unit.

Key species: (1) those species which must, because of their importance, be considered in a management program; or (2) forage species whose use serves as an indicator to the degree of use of associated species.

Range condition: a generic term relating to present status of a unit of range in terms of specific values or potentials. Specific values or potentials must be stated. (see ecological status).

Range site: (see ecological site). Range sites are defined and described with soil, species composition, and production emphasis.

Riparian zone: the banks and adjacent areas of water bodies, water courses, seeps, and springs whose waters provide soil moisture sufficiently in excess of that otherwise available locally so as to provide a more moist habitat than that of the contiguous flood plains and uplands.

Song posts: a prominent position within its territory from which the male bird sings, especially during the breeding season,

Stratification: subdividing an area into units which are, more or less, internally homogeneous with respect to the (those) characteristic(s) of interest.

Trend: the direction of change in ecological status or in resource value ratings observed over time. Trend in ecological status is described as "toward" or "away from" the potential natural community or as "not apparent."

Utilization: the proportion or degree of current year's forage production that is consumed or destroyed by animals (including insects). May refer either to a single plant species, a group of species, or to the vegetation as a whole.

Wet meadow: a meadow where the surface remains wet or moist throughout the summer, usually characterized by sedges and rushes.

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APPENDIX 1

VEGETATION TRANSECT FORMS

The recommended vegetation monitoring methods can utilize the same transect and be read simultaneously. The information collected for each method needs to be recorded on the same form. Examples of the forms commonly used are attached. Location and aspect information for the photo plots can be recorded on one of these forms in a separate section.

TREND STUDY DATA
NESTED FREQUENCY METHOD - TEN TRANSECTS

PAGE ____ OF ____

[illegible]

NOTES (USE OTHER SIDE OR ANOTHER PAGE)

1-2

PAGE _____ OF _____

STUDY NUMBER	DATE	EXAMINER

[illegible]

This image shows a full page of graph paper. The grid consists of horizontal and vertical dashed lines forming small squares across the entire page. There are no margins, text, or other markings present.

1-3

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Illustration 4
Page 1

UTILIZATION STUDY DATA
KEY FORAGE PLANT METHOD

STUDY NUMBER				DATE				EXAMINER			
ALLOTMENT NAME & NUMBER				PASTURE							
KIND AND/OR CLASS OF ANIMAL				PERIOD OF USE							
		KEY SPECIES				KEY SPECIES					
CLASS	INT	NO BY	NO X	CLASS	INT	NO BY	NO X	CLASS	INT	NO BY	NO X
INTERVAL	(M)	COUNT	(C)	INTERVAL	(M)	COUNT	(C)	INTERVAL	(M)	COUNT	(C)
NO USE											
0-5%	2.5										
SLIGHT											
6-20%	13										
LIGHT											
21-40%	30										
MODERATE											
41-60%	50										
HEAVY											
61-80%	70										
SEVERE											
81-100%	90										
		TOTALS				TOTALS					
AVG. = $\frac{\sum CM}{\sum C}$											
UTIL. = $\frac{\sum CM}{\sum C}$											

Herbaceous Utilization Classes. (Browse utilization classes are on the other side.)

1. No use (0-5%). The rangeland shows no evidence of grazing use; or the rangeland has the appearance of negligible grazing.
2. Slight (6-20%). The rangeland has the appearance of very light grazing. The key herbaceous forage plants may be topped or slightly used. Current seedstalks and young plants of key herbaceous species are little disturbed.
3. Light (21-40%). The rangeland may be topped, skimmed, or grazed in patches. The low value herbaceous plants are ungrazed and 60 to 80 percent of the number of current seedstalks of key herbaceous plants remain intact. Most young plants are undamaged.
4. Moderate (41-60%). The rangeland appears entirely covered as uniformly as natural features and facilities will allow. Fifteen to 25 percent of the number of current seedstalks of key herbaceous species remain intact. No more than 10 percent of the number of low value herbaceous forage plants are utilized. (Moderate use does not imply proper use.)
5. Heavy (61-80%). The rangeland has the appearance of complete search. Key herbaceous species are almost completely utilized with less than 10 percent of the current seedstalks remaining. Shoots of rhizomatous grasses are missing. More than 10 percent of the number of low value herbaceous forage plants have been utilized.
6. Severe (81-100%). The rangeland has a mown appearance and there are indications of repeated coverage. There is no evidence of reproduction or current seedstalks of key herbaceous species. Key herbaceous forage species are completely utilized. The remaining stubble of preferred grasses is grazed to the soil surface.

NOTES (USE OTHER SIDE OR ANOTHER PAGE, IF NECESSARY)

*WHERE C = THE NUMBER OF OBSERVATIONS WITHIN EACH CLASS INTERVAL (C COLUMN),
M = THE CLASS INTERVAL MIDPOINT (M COLUMN), AND Σ = THE SUMMATION SYMBOL.

FORMULAS FOR DIVERSITY INDEXES:

Simpson:

$$DI = \frac{ni(ni - 1)}{N(N - 1)}$$

s = number of species in the sample

ni = number of individuals for a species

N = number of individuals in the sample

Shannon index:

$$H = \left(\frac{ni}{N} \right) \log \left(\frac{ni}{N} \right)$$

ni = actual cover of species i

N = Actual cover for all species

The recommended monitoring methods for birds combine readily and are easily performed during a single study period. Each method requires a separate form for recording data. Examples of commonly used forms for birds and small mammals are attached.

BIRD CENSUS

Location: _____
Census point: _____

Date: _____
Time start: _____
finish: _____
Weather: _____

Species:

Band :

COMMENTS :

APPENDIX 3

BLM MONITORING METHODS ON GLCA

<u>BLM Resource Area</u>	<u>Trend</u>	<u>Utilization</u>
Arizona Strip		
Escalante	Nested Photo Point	Key Forage Species
Henry Mountain	Photo Point/ Quadrat frequency	Key Forage Species
Kanab	Nested quadrat	Key Forage Species
San Juan	Photo Point	Key Forage Species

The use of biological indexes as a rating method for ecological systems has been attempted previously. Diversity indexes such as the Shannon and Simpson formulas, and erosion potential indexes such as the Universal Soil Loss Equation used by the Soil Conservation Service are examples. Karr (1981) introduced an Index of Biotic Integrity for use in evaluating fish community data. However, an "ecological" or "natural communities" index has yet to be developed for use in rating ecological condition and trend. The following hypothetical illustrations demonstrate how such an index might be developed and used.

EXAMPLE 1

An ecological index comprising values for both vegetative and wildlife components might be as follows:

Vegetative Component (50%)

Cover

Trend (frequency)

Composition (dry weight rank)

Wildlife Component (50%)

Bird index (composition, density)

Pellet counts (composition, density)

Total (sum of all the parts)

EXAMPLE 2

A variation on the above method can be developed if the bird

component is viewed as an indicator of habitat (vegetative) quality. In this case the vegetative component is weighted at 75% and the bird component is weighted at 25%. The values are again summed to obtain a total value rating.

EXAMPLE 3

Another alternative is to develop two separate indexes for the individual vegetative and wildlife components. The two values would not be combined, but would be used separately to rate condition and trend.

** ** ** ** **

As the index is developed, a system of rank must be organized for comparison. The categories for condition and trend could be "excellent, good, fair, or poor." An alternative ranking might follow a similarity rating such as the one used by RISC (1983). The closer a community resembles the "potential natural community" for the site, the higher the rating. A percentage rank (20%, 40%, 60%, or 80%) would be set and management goals would define the desired percent similarity to achieve those goals.

For ease in mathematical calculations, a 100 point scale could be used with 100 being the highest, possible score. Examples of this analysis are as follows:

EXAMPLE 1

In an "excellent to poor" system, composite scores would

match the following categories.

EXCELLENT	GOOD	FAIR	POOR
76-100	51-75	26-50	0-25

EXAMPLE 2

In a percentage system the number of rank categories is dependent upon how specific the resulting information needs to be. A breakdown of 5 categories does not provide the same information as 10 categories will. However, unless there is an essential reason for an increased number of ranks, five categories should be more than sufficient for comparison. The following breakdown could be used.

81-100%	61-80%	41-60%	21-40%	0-20%
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Descriptive titles could be added to the above ranks but is not necessary.

The following guidelines are the results of the report of the Range Inventory Standardization Committee for the Society for Range Management. The terminology and guidelines will be used for our research and to improve communication between all parties involved in this work.