A SCIENCE-BASED TOOL FOR ASSESSING AVAILABLE FORAGE AND GRAZING CAPACITY OF GSENM GRAZING ALLOTMENTS TO MEET RANGELAND HEALTH STANDARDS

A tool provided to the GSENM range staff, provided by the Southern Utah Land Restoration Project

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SECTION 1: INTRODUCTION

For public lands that support livestock grazing, grazing permits focus on two key variables, which are the number of allowed livestock measured in animal unit months (AUMs), and the season of grazing. The number of AUMs granted in a permit is contingent on enough forage being available for this quantity of AUMs. The decision regarding the number of AUMs to assign to an allotment requires an assessment of the average forage biomass produced in that allotment and then the assignment a fraction of the total forage to domestic grazers. This section of the guidance document develops a model to use in calculating the amount of forage that can be allocated to livestock while still allowing for the ecological needs of the land to be met.

The economic viability of ranching and the continued existence of ranching-dependent communities is tied to the health and productivity of rangelands. Today we recognize that we need to take a new look at the past and current use and management of rangelands. As the BLM itself has noted, “the land itself is in jeopardy, and the variety of products and values that this land has produced may not be sustained for future generations unless ecosystems are healthy and productive” (Utah BLM 1997). In addition to this general recognition by the agency that “the land is in jeopardy,” we make a very strong case elsewhere in this guidance document that, on a site specific level (in this case, in GSENM), indeed the rangelands in the Monument are impaired as well.

Part of the reason that BLM lands are “in jeopardy” is likely because many BLM grazing permits currently over-allocate existing forage. Most permitted levels of grazing on BLM lands are the result of forage capacity assessments conducted by the agency long ago. Unfortunately, these past forage capacity assessment methods are in conflict with BLM’s current rangeland health standards. Originally designed for grazing use for sustained yield, these earlier capacity assessment methods failed to meet ecological needs of the land and, as a result, many allotments today produce less than their potential. Since the new Utah rangeland health standards were established in 1997, the BLM has developed several analysis tools to implement these standards. However, BLM still lacks a tool to assess forage capacity consistent with these new rangeland standards.

Based on a wide array of range science, the ecologically-based forage capacity analysis described below is a tool to help BLM determine appropriate stocking levels for livestock in the GSENM. This forage capacity model uses computer mapping and ecological field data to estimate the amount of grazing that a grazing permit can allow, while still being in compliance with the standards and guidelines.

1.1 Past practices used to determine stocking levels.

Levels of livestock use on BLM lands have not always been determined as the result of a range capacity analysis. Early livestock numbers assigned to grazing allotments were developed over a half-century ago. In many cases, the number of livestock that were allowed to graze was
the result of regional political processes that relied on personal experience and subjective data from field trips as part of a politically negotiated settlement (Grazing Service 1946).

In the 1960’s, BLM began estimating the number of livestock that could graze on BLM lands based on a calculated production of forage. Some allotments have records from this capacity analysis and others do not. The method involved calculating forage production based on the size of the area and the forage production as assumed on a per acre basis. The forage needs for one cow/calf pair for a month was used to calculate the number of AUMs that an allotment could support. The methods and policies behind the capacity model of this earlier era are not remembered by most BLM staff, and have yet to be discovered by the authors.

In the mid and late 1970s, a number of public land laws generated a change in BLM’s approach to range management. The Federal Land Policy management Act of 1976 and the Public Rangeland Improvement Act of 1978 required BLM to maintain rangeland inventories. The Soil and Water Resources Conservation act of 1977 required the Soil Conservation Service to establish a national resources inventory.

As a result of these laws, the BLM under the Carter Administration developed the Soil-Vegetation Inventory Method (SVIM) in 1979. Originally designed to standardize rangeland sampling for grazing Environmental Impact Statements (CRC 1984), SVIM included calculations of forage capacity on an allotment basis. Field forage was clipped and weighed. Data collected included plant community composition and forage productivity. Areas with common soil and plant communities were the unit used in calculating the expected forage production for rangelands. The results were converted into estimated forage production using adjustment factors for phenology, precipitation and proper utilization factors for livestock use (Menke and Miller, 1984). A cow/calf pair (or AUM) was assumed to consume 800 pounds of forage per month (Jensen 1984).

Range capacity often applied the concept of “take half and leave half” (50% utilization). Page __, elsewhere in this guidance document, explains the origins of the 50% utilization policy now central to many BLM range decisions. BLM commonly recommends stocking levels which assume that livestock will consume 50% of the annual production of grasses and forbs. The assumption made is that this level of consumption by livestock leaves adequate forage for wildlife, while allowing for sustained production of the forage itself. Many have questioned this assumption, especially on arid lands (e.g. Caldwell 1984, Galt et al. 1999, Holechek et al. 2001).

The capacity analysis built into SVIM focused on sustained forage production. As a result, this method did not consider key ecological factors such as plant community composition, excessive grazing use in key habitats such as riparian areas, soil nutrient cycle maintenance, and nongame wildlife needs. Yet in spite of these shortcomings, SVIM was a major step forward in range management.

In the early 1980’s, BLM discontinued SVIM. This was replaced with a monitoring program that did not include collection of data on plant community productivity. Klemmendson (1984) reported that the chief reason the BLM discontinued SVIM was political, and driven by
the response of the ranching community during 1983-84. For the past twenty years, BLM has not used forage capacity analysis in determining stocking levels. Based on the acknowledgement above by the BLM that “the land is in jeopardy,” as well as the general degraded state of BLM rangelands in southern Utah, I think we can say with some certainty that the policy of abandoning forage capacity analyses over the past 20 years “is not working.”

This must change as BLM implements the new rangeland health standards developed six years ago. The standards call for management of grazing in deference to the health of ecosystems. Ecosystem health is linked to the productivity of the land and its ability to service local communities on a sustained basis (CSC 1997). The loss of biodiversity, and ecosystem structure and function, has long-term implications for the health of watersheds and the ability of the land to provide abundant forage for a number of uses. BLM needs to undertake forage capacity analyses that will allow the standards to be met, restore and maintain ecosystems, and provide for ecosystem resilience that maintains the productivity of the land over time.

1.2 The timeliness of grazing capacity analysis in the upcoming grazing EIS.

BLM’s need for forage capacity analysis as part of the upcoming grazing EIS for the GSENM is justified by community needs, agency policy (both current and proposed), rangeland science, and the agency’s legal requirements. Such an ecologically-based forage capacity analysis is timely because grazing capacity has not been systematically reviewed for GSENM allotments for at least two or perhaps four decades. BLM is required to periodically adjust management decisions based on ongoing inventories, and this DEIS will be renewing permits for most, if not all, grazing allotments in the Monument. Furthermore, range capacity based on ecological needs was raised as a significant issue in the GSEN M grazing EIS. BLM has a legal requirement to consider this issue as part of the EIS.

In theory, the concept of “working landscapes and sustainable ranching” is consistent with new forage capacity estimates based on ecological function. Functioning ecological systems possess the productivity and resilience that will sustain both the health of the ecosystem and continued uses.

The material that follows will develop and illustrate a science-based model for determining appropriate stocking levels for cattle in GSENM grazing allotments. This new formula for calculating forage availability and capacity is based on both the range science literature and updated estimates of actual available forage for particular soil types. We have divided the ecological needs of the land and wildlife into several categories. These are: wild herbivore needs; insect and nematode forage needs; and plant community viability, resilience, and regeneration, including soil stability and (lack of) erosion. Based on literature on these topics, below we develop an ecological allocation of the plant community to be used in the forage capacity model. We demonstrate the utility of this new model by using an actual example in the Monument: the Upper Hackberry allotment.
The next section (Section 2.0) describes the method used in the new protocol. Then, Section 3.0 features the results of our test run of the new procedure in the Upper Hackberry allotment. This is followed by Section 4.0, which specifically makes the case for using our proposed capacity model for the GSENM Grazing DEIS, chiefly because it will ensure that allotments in the Monument will conform with the Standards and Guidelines in the future.

SECTION 2: METHODS

This section outlines the methods used in our proposed science-based formula for determining appropriate stocking levels for cattle in GSENM grazing allotments. This process begins by identifying these areas that are capable and suitable for livestock grazing. For those lands suitable for livestock grazing, the forage produced each year is estimated for each individual soil community based on current field data and existing data collected as part of past BLM, Soil Conservation Service, and National Resources and Conservation Service surveys.

Vegetation requirements for wild herbivores, insects, nematodes, soil stability, nutrient recycling, plant regeneration, and plant resilience lead to an estimate of the amount of forage required to meet ecological needs. Measuring the composition, structure, function and various ecological processes for each specific habitat site in all GSENM allotments is beyond anyone's resources at this time. As a practical necessity, we must resort to the use of indicators to monitor ecosystem health and function. Total annual production of plant biomass and soil litter, for example, can be sampled while energy flows and soil nutrient regeneration are impractical to measure. When assessing the amount of forage that can be removed from an allotment, critical ecological considerations include soil nutrient recycling, soil resilience to erosion, wildlife habitat needs, and plant community productivity and resiliency, to name a few.

Below, we describe how the use of a GIS to take various data inputs and generate a stocking rate that an allotment can support and still meet rangeland health standards. The work reported here is derived from a study that is still underway. As we continue to refine this work, some changes may be incorporated, but these are not likely to make significant changes to our model and its outcomes.

2.1 Initial Adjustments made for Capability of the Pasture to Support Cattle.

Below, we rely on current range science and criteria used by the U.S. Forest Service. These involve the application of quantitative criteria to adjust for the physical limitations of the land to support livestock grazing. Holechek et al. (2001) provide recommendations for adjusting the stocking rate for cattle in order to account for distance from water and steepness of slope. Galt et al. (2000) have indicated that the Natural Resources Conservation Service (NRCS) has adopted these guidelines for slope adjustments. Suggested reductions in grazing capacity with distance to water and increasing slope are provided in Table 1.
Table 1. Adjustments for distance to water and slope for cattle (Holechek et al. 2001)

<table>
<thead>
<tr>
<th>Distance from Water (miles)</th>
<th>Percent Reduction in Grazing Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 1</td>
<td>0</td>
</tr>
<tr>
<td>1 – 2</td>
<td>50</td>
</tr>
<tr>
<td>&gt;2</td>
<td>100</td>
</tr>
</tbody>
</table>

Slope (%)

| 0 – 10                      | 0                                   |
| 11 – 30                     | 30                                  |
| 31 – 60                     | 60                                  |
| >60                         | 100                                 |

They note that on cold desert ranges of the U.S., snow reduces water availability problems in winter. Also, sheep do not require water every day and can use areas further than two miles from water. Literature cited shows that sheep on New Mexico winter ranges used slopes of less than 45% with no adjustment necessary for slope, whereas slopes greater than 45% were hardly used.

The Caribou National Forest has produced a detailed process paper for determining rangeland capability and suitability for both cattle and sheep ranges (Caribou NF 2001). It is based on criteria used in Region IV of the Forest Service. 36 CFR 219.20 defines capability as “the potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends on current conditions such as climate, slope, landform, soils and geology, as well as the application of management practices, such as silviculture or protection from fire, insects and disease.” Range surveys have historically been used to identify the land areas that were capable and then by knowing the average forage production, applying a utilization rate, the estimated grazing capacity of the allotment could be determined. This was then validated through on-ground monitoring, or that was the intent.

The Caribou National Forest lists the following criteria for determining capability.

1. Areas with less than 30% slope for cattle and less than 65% slope for sheep (note that here the Caribou differs from Region IV in that Region IV uses 45% slope for sheep)
2. Areas producing more than or having the potential to produce an average of 200 pounds of forage/acre on an air-dry basis over the planning period.
3. Areas with naturally resilient soils that are not unstable or highly erodible.
4. Areas where ground cover (vegetation, rocks, litter) is sufficient to protect the soil from erosion. They specify a minimum of 60% cover unless local data is available for setting more specific ground cover requirements.
5. Areas accessible to livestock (without dense timber, rock or other physical barriers)
6. Areas within one mile of water or where the ability to provide water exists.
Suitability criteria employed by the Caribou NF include consideration of the following as they determine whether livestock grazing is compatible with management goals for the areas described:

1. Developed recreation use sites or special use sites.
2. Special area designations such as Research Natural Areas.
3. Administrative sites, research facilities or study sites.
4. Key wildlife habitat areas.
5. Important habitats for Threatened, Endangered or Sensitive (TES) species.
6. Noxious weed infestations where forage is not used by livestock or use would contribute to an increase of the infestation.
7. Unique habitats such as bogs, fens, jurisdictional wetlands, or rare plant communities.
8. Areas where livestock grazing is impracticable due to economic considerations, either from a permittee or agency standpoint.
9. Transitory range created by timber harvest where the associated mitigation costs to protect timber resource values is excessive.
10. Areas where the social consequences and values foregone are not acceptable.
11. Non-functional streams or stream segments where livestock grazing is the primary cause for the less than satisfactory condition.
12. 303D listed streams or stream segments where livestock grazing is the primary cause for the less than satisfactory conditions.
13. Areas with significant amounts of dispersed recreation.

We combine various features of the suitability and capability criteria used by the Caribou National Forest that are representative of criteria used by most National Forests in the Intermountain Region. These, along with other sources (cited below) are used to make our recommendations for adjustments to the land area that is suitable for grazing and capable of providing forage for grazing in the GSENM. These are:

Areas not capable:
1) Areas inaccessible to livestock (because of cliffs, canyons or other physical barriers)
2) Unstable or highly erodible soils (as defined by NRCS)
3) Areas producing less than or having the potential to produce an average of 19kg/ha (17 lb/acre) on an air-dry basis over the planning period (BLM 1981)\(^1\)
4) Areas with greater than 30% slope
5) Areas more than 2 miles (3.2 km) from water (Fusco 1995, Holechek et al. 2001).

\(^1\) Holechek (1996) stated, “When forage production drops below 100 lbs/acre, financial losses are likely even under high cattle prices and above average precipitation.” While the current version of our forage capacity model retains the BLM’s production threshold of 17 lb/acre (19kg/ha), we may raise this threshold in updated versions of the model, based on Holechek’s recommendation.
Areas not suitable:
1) Key, identified habitats for TES species (i.e. critical habitat identified by FWS or UDWR)
2) Unique habitats such as jurisdictional wetlands and springs
3) Rare plant communities
4) Areas that receive high levels of recreation use (i.e. canyon bottoms, like the Gulch)

The capability and suitability factors selected for our capacity model reflect the practical nature of grazing practices in the semiarid lands of southern Utah, ecological and biological considerations that should be of priority in a national monument (i.e. rare plant communities and TES habitat), and current BLM capacity methods. For example, the 19kg/ha (17lb/acre) forage requirement for productivity was borrowed from a 20 year-old grazing EIS for this area (BLM 1981). Note that the minimal forage production threshold the Forest Service uses (see above) is more current and much higher, 200 lb/acre. In addition, the distance from water factor for forage is appropriate for grazing in arid lands during the warmer time of the year. Most of the allotments in the Monument are spring and summer allotments. While cattle may benefit from snow, standing snow in this region is infrequent and does not remain for long periods of time, and thus cannot be relied on in making grazing management decisions. Even winter grazing, based on our experience in GSENM, relies on surface water sources most of the time. For these reasons, areas greater than 3.2 km from a surface water source are considered unsuitable for livestock grazing in terms of assessing the capacity for livestock grazing of an allotment.

Section 2.4 explains how to use a GIS to determine the amount of the grazing unit (pasture or allotment) that is capable and suitable for supporting livestock.

### 2.2 Determination of Forage Biomass in Allotment

Once the above capability and suitability adjustments to the grazing unit (pasture or allotment) are carried out, the next step is to estimate the kg/ha of annual production of grasses and forbs that are in the unit. We recommend three options for making this assessment (tiered in order of our opinion of what is most sound and credible, from a scientific standpoint):

- The first and most desirable option is for the land manager to perform actual clipping studies in the grazing unit being assessed. Methods of determining forage production that rely on plot clippings are described in BLM (1996). Our measurements were made using the beltline transect method (FSM 2209.21) to assess both cover and annual forage production (for all

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2 This analysis is not to be confused with the analysis mandated by FLPMA’s multiple use management mandate and the Comb Wash case, which we explain elsewhere in this guidance document. While some of the factors relevant to the Comb Wash/FLPMA balancing may be similar to those referenced here, the purpose of Comb Wash/FLPMA balancing is to determine if grazing is an appropriate use of particular public lands. A determination that grazing is not an appropriate use would likely necessitate closing some or all of a particular allotment to grazing. Here, in contrast, we maintain that certain attributes and uses of the land mean that the forage there should not be included in the calculation of available forage as explained above. Forage analysis to determine stocking rates is appropriate only where the BLM has already determined that grazing is an appropriate use of a particular area. In other words, Comb Wash/FLPMA balancing should happen first.
grasses and forbs, not shrubs) for each Range Site Type in the grazing unit. Earlier BLM monitoring practices used prior to 1996 also used similar sampling methods (DOI 1984a, DOI 1984b, DOI 1985). At the end of each of five 100 ft. radial transects for each site, we clipped the standing vegetation within a 1 m² frame to arrive at estimated production of standing crop of grasses and forbs. We did not limit clippings to palatable species only, but clipped all grasses and forbs. This could overestimate the available forage for a site. If time allows, be sure to replicate sampling in multiple patches of each Range Site Type, in which the number of replicate patches sampled is determined by the relative abundance of that Range Site Type in the grazing unit. Apply the forage production values for each Range Site Type to others of the same type in the grazing unit, using a GIS (as described below and in Section 2.4).

- If time and/or resources are not sufficient to conduct the clipping studies described above, we then recommend that the user obtain the **actual field data from the NRCS** that were recently used to revise NRCS estimations of forage biomass for Range Site Types in southern Utah. This data, which exists for almost all (if not all) Range Site Types known to occur in the Monument, is an improvement over the traditional NRCS estimates of Range Site Type production (DOI 1984c), as these new clippings were completed for a variety of rangelands including many grazed by livestock. The values used in the traditional Range Site Type estimates made by the Soil Conservation Service and BLM were chiefly based on relict sites. Therefore, the raw clipping data recently collected by the NRCS on a variety of Range Site Types is more applicable to GSENM rangelands, most of which are grazed. Apply the forage production values for each Range Site Type (for all grasses and forbs, not shrubs) to all other Range Site Types of the same type in the grazing unit, using a GIS (as described below and in Section 2.4).

- If the new NRCS raw clipping data are not available for all Range Site Types in the grazing unit being assessed, we then recommend that the user utilize the old NRCS forage production predictions (DOI 1984c), but only for those Range Site Types where the new NRCS clipping data does not exist. These earlier estimates and soil surveys often have average, low, and high production estimates based on precipitation at, below or above normal precipitation years. Based on our field clipping survey and a review of these earlier NRCS forage estimates, we suggest using the below average forage productions if using the old NRCS predictions. These estimates seem to better reflect forage production on both typical years and drought conditions, which seems to be a common occurrence. In the absence of more current data (described above), apply the forage production data from these earlier NRCS forage

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3 As the reader knows, the Natural Resources Conservation Service (NRCS) provides key spatial data for use in this capacity analysis. NRCS soil surveys have developed soil map units which possess common soil characteristics, climate, and composition of the plant community. A grazing allotment usually contains a number of discrete soil map units. The description for a soil map unit includes a certain vegetative community (called “Range Site Type”) and the NRCS estimates the annual amount of forage that the Service believes is typically produced for that specific soil unit type. This estimation, broken down into species, is usually based on relict sites and predicts the pounds per acre of annual production one would expect on a healthy and fully productive potential natural plant community for that soil map unit.

4 The Natural Resources Conservation Service is about to release a new soil survey with updated information. When these data are available, capacity analysis can be run with more current information.
estimates to the relevant Range Site Types as attributes in the GIS coverage for the allotment. This is described in more detail later in this section.

Using one of the three methods described above, the land manager should add to the GIS coverage production data as attributes to the coverage for soil map units. This tabular data associated with the coverage will later be exported from the GIS and, in a spreadsheet program, be used to calculate the capacity of the allotment. Additional discussion on the use of GIS and the spreadsheet program can be found in Section 2.4, below.

2.2.1 Do results obtained from first two steps necessitate a “recovery prescription?” We must stress that we mean for this forage capacity model to only be used to assess the carrying capacity of rangeland that has forage production quantities in the “good” or “excellent” range. This means that the amount of forage is 50% or greater of the potential production of the site, as defined by NRCS. If one is using our model to calculate stocking rates we are assuming that the allotment is currently meeting rangeland health standards or is moving towards its potential plant community.

Thus, if the range manager does follow our recommendation to clip the forage in the grazing unit and finds that the actual forage (grass and forb biomass) on the grazing unit is less than 50% of the potential plant community predicted for those soil types, then we argue that the allotment should receive a special management prescription that we call “recovery mode.” See page___ of this guidance document for further discussion of this prescription.

Little research exists concerning the level of livestock grazing that can occur on “recovering” arid or semi-arid rangelands where productivity is fair or poor. Further, the literature is inconsistent as to exactly “how much rest” is required to recover degraded rangelands in arid or semi-arid environments. Below, we highlight some of the key literature that clearly shows that, in general, the recovery of impaired rangelands appears to require long periods of time – certainly more than a year or two of rest.

The literature confirms that total, long term rest is effective. Potter and Krenetsky (1967) found that grass densities and total ground cover tripled following 25 years of non-grazing. Blydenstein et al. (1957) similarly determined that perennial grass densities and the palatable shrub Krameria grayi increased in a Sonoran desert grassland protected from grazing for 50 years, and were most taken by the notable increase in overall plant cover and density. More recently, Anderson et al. (2001) found landscape-scale changes in plant species abundance (greater) and biodiversity (greater) of a previously grazed sagebrush steppe over 4 years of rest, with perennial grasses experiencing a 13-fold increase in cover during that time. Analyzing riparian areas, Platts and Nelson (1985) determined that herbaceous vegetation can recover within several growing seasons and woody vegetation within 5-10 years if grazing stress is

5 While there are a number of studies that have looked at changes in rangeland plant communities with the removal of livestock, little is known about the continued forage use by wild herbivores during recovery. Any recovery plan must account for the plant consumption needs for wildlife, soil organisms and insects. In many cases, these forage consumers have depleted populations that need to be restored.
removed from a deteriorated riparian area and sufficient residual shrubs are present to allow regrowth and expansion.

At the same time, others have concluded that short term rest from grazing may not sufficiently allow for recovery of ecosystem values. McPherson et al. (1990) compared ungrazed and a formerly grazed (with 5 years of rest) juniper woodlands, finding that the ungrazed plot had more grass, the grazed more forbs. The authors concluded that “[t]he effects of long-term continuous cattle grazing persisted 5 years after removal of livestock” and that the “succession following grazing will proceed slowly or will be unpredictable.” In a study of the Kaiparowits Basin, Jeffries and Klopatek (1987) compared heavily grazed sites, a site ten years into recovery from heavy grazing, and a relict, never-before grazed site. The authors found that the relict site had significantly more herbaceous cover (comprised mostly of perennial grasses) than all other sites. There were no significant differences between the heavily grazed site and the recovering site for any of the measured parameters, leading the authors to conclude that recovery from grazing can take a very long time indeed.

An interesting study in Canyonlands National Park offers some insight into the difficulty of range recovery. Kleiner (1968) compared two rangelands sites with the Needles District of the Park: Chestler Park and Virginia Park. Grazing in Chestler Park occurred for one or two months at most in the winter and was dependent on snow as a water source for livestock. Four years before Kleiner collected his data, this grazing impact was removed. Virginia Park has been ungrazed for a very long time and is a popular research area because of this. Kleiner’s study compared vegetative cover and diversity between the “recently grazed” (four years rest) and ungrazed study sites (his data is summarized in Table 2).

**Table 2. Comparison of grazed/ungrazed pastures in the Needles District, Canyonlands NP, 1968. Reprinted from Kleiner (1968).**

<table>
<thead>
<tr>
<th>Comparison of grazed/ungrazed transects</th>
<th>Virginia Park (ungrazed)</th>
<th>Chestler Park (ungrazed 4 yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hectares</td>
<td>97</td>
<td>389</td>
</tr>
<tr>
<td>Plant species richness /sample site (average)</td>
<td>21.5</td>
<td>15.4</td>
</tr>
<tr>
<td>Cryptobiotic species richness/sample site (average)</td>
<td>6.1</td>
<td>2</td>
</tr>
<tr>
<td>Total living cover, %</td>
<td>54.5</td>
<td>21.8</td>
</tr>
<tr>
<td>Vascular plant living cover, %</td>
<td>16.8</td>
<td>16.8</td>
</tr>
<tr>
<td>Litter cover, %</td>
<td>11.5</td>
<td>9.8</td>
</tr>
<tr>
<td>Contribution of annuals to the total vegetation (%)</td>
<td>11.8</td>
<td>15.5</td>
</tr>
<tr>
<td>Average number of species / sample site</td>
<td>7.1</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Records are incomplete on the amount of grazing that occurred over time in Chestler Park. Kleiner reported that, typically, 30-35 horses grazed in Chestler Park for one or two winter months depending on snowfall each year. Rough, “back of the envelope” calculations indicate that this level of livestock grazing was equivalent to about 50 AUMs, at a density of 8 acres per AUM. If we make the assumption that this area produces about 600 lb of forage per acre on average (based on the typical Range Site Types that occur in the Park), then Chestler Park would produce on average about 230,000 lb. of forage. Based on these numbers, the grazing use on
average amounted to between 15 and 20% of the average forage produced. This is usually considered to be a level that is “lightly grazed.”

The importance of this example is that even at this “low” grazing intensity and with four years of rest, the plant diversity, ground cover, cryptobiotic soil cover, and productivity was significantly less at Chestler Park than Virginia Park. Photos taken of Virginia and Chestler Park do not reveal the key differences between these sites, such as forage production and plant community diversity. Photographs that show details of ground conditions, however, do reveal differences, such as a loss of litter and cryptobiotic crusts in Chestler Park. The lesson that Kleiner teaches us is that so-called “light” grazing can lead to a substantial loss of plant community health. Moreover, had Chestler Park been grazed during the growing season, further degradation of the vegetative community would have been the likely result. We conclude that 15-20% winter utilization of forage in southern Utah is still too high to ensure recovery of rangelands to their potential plant community.

So, what level of grazing can occur on degraded rangelands that are only 50% or less of their potential productivity, while still allowing them to recover? As evidenced by the Chestler Park example, we feel the answer is likely to be none, at least for a few years. It is even more likely that complete rest for much longer periods, up to several decades may be necessary to allow even slight progress towards restoration of community diversity and production. Certainly the study by Anderson and Inouye (2001) shows that progress is very slow over a period of nearly 50 years in which the plant community still had not reached potential. How much rest is necessary to bring back the desired productivity of these impaired ranges? We don’t have an answer to this question. However, as outlined above, the literature is filled with evidence that prescriptions of short periods of rest (like those used with rest-rotation schedules) are not enough to ensure recovery in semiarid desert lands. Is the answer 5 years, or 10 years, or 25 years? We look to the Monument to heed its own call for strong science within its borders, and establish long-term exclosures to study the effects of long term rest from grazing, to help determine an effective “rest prescription” for those allotments that clearly need to be put into “recovery mode.” Further, the Monument must establish quantitative and significant goals against which to measure restoration progress either by comparison to exclosures or as gains toward potential productivity as described by NRCS and towards potential ground cover as the literature cited herein describes.

2.3 Forage allocations for ecological needs of the land

Those managers using our new capacity model will have by this point determined forage production for each Range Site Type in the grazing allotment. The next step requires that allocations of that available forage base be made to ensure: 1) needs of native mammals for cover and forage, 2) invertebrate forage needs and 3) viability and resilience of the native plant community, including soils, and in the face of drought. These allocations are based on the ecological literature regarding the specific needs of vegetative communities and native wildlife on lower elevation lands of the Colorado Plateau.
2.3.1 Allocations for mammalian herbivores. We recommend that an allocation of about 225 kg/ha (see Table 3) be allocated for mammalian herbivores in the Monument.\(^6\) In order to calculate this allocation amount, we selected three primary herbivores (or in the case of folivorous/omnivorous rodents, a guild) that fairly adequately represent the mammalian herbivores present in the GSENM (we chose mule deer, jackrabbits, and rodents). We conducted a thorough search of the scientific literature and located 50 studies that report on both typical densities of these herbivores and their eating habits – reported as biomass of forage (forbs and grasses) consumed. We strove to primarily include studies that were conducted in lower elevation habitats of the Colorado Plateau, though a few others were located in various locations in the intermountain West and southwest.

To calculate the rough amount of forage consumed by these herbivores a year, we used the kilograms of total forage consumed per individual per day, then calculated the percent of the individual’s diet that is herbaceous material, then extrapolated that forage amount to total consumed per year by species/guild by multiplying by days of the year and average herbivore densities (Table 3).

Table 3. Kg/ha/year of forage (grass and forb) biomass necessary to support typical mammal herbivore populations in southern Utah.

<table>
<thead>
<tr>
<th>Species</th>
<th>Density (individuals per hectare)</th>
<th>Average total forage per individual (kg./day/individual)</th>
<th>Herbaceous forage in diet (percent, %)</th>
<th>Herbaceous forage per individual (kg./day per individual)</th>
<th>Herb. forage per population per day (kg/ha/day)</th>
<th>Herb. forage per population per year (kg/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td>0.11</td>
<td>1.58</td>
<td>22.40%</td>
<td>0.325</td>
<td>0.035</td>
<td>12.73</td>
</tr>
<tr>
<td>Jackrabbits</td>
<td>2.01</td>
<td>0.13</td>
<td>74.70%</td>
<td>0.097</td>
<td>0.199</td>
<td>72.66</td>
</tr>
<tr>
<td>Rodents</td>
<td>16.3</td>
<td>0.056</td>
<td>43%</td>
<td>0.024</td>
<td>0.39</td>
<td>142.3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL HERBACEOUS FORAGE ALLOCATION FOR MAMMALIAN HERBIVORES = 227.6 kg/ha/yr


\(^6\) In order to convert this to a percent for use in the GIS forage capacity analysis for the Upper Hackberry allotment described in Section 3, we calculated the percentage this numerical value represented of the (grass and forb) forage predicted by the NRCS Range Site Type descriptions for those range site types in the Upper Hackberry Allotment.
The purpose of this exercise is to roughly estimate, based on the literature, the approximate forage biomass required by mammal herbivores on southern Utah rangelands. Certainly, more research on this topic is needed. The estimates presented here represent the best information we could locate, and more studies are needed to validate these estimates for the monument. The proposed allocation we came up with does not include the needs of other mammals (i.e. cottontail rabbits, elk, bighorn sheep, pronghorn), nor do we anywhere in this model account for the forage needs of folivorous birds or reptiles. As such, we argue that this allocation, which we mean to represent all forage and cover needs for all native wildlife on GSENM allotments, is conservative.

2.3.2. Allocations for insects and soil invertebrates. Insects and soil invertebrates such as nematodes and mites are a critical part of rangeland systems. These have important relationships with plant development, soil nutrient recycling, species interactions, and wildlife that is under-appreciated by many. Loss of invertebrate biomass in rangelands can have a significant effect on the ecosystem.

While we have a fairly complete list of range plants found in Utah’s rangelands, knowledge of the invertebrates found on our public lands is less understood. What we do know is that these occupy a significant niche in the southwest deserts. For example, harvester ants have colony populations of tens of thousands of individuals. Even in the driest and hottest parts of North America, the total biomass of one species of harvester ants (Messor veromesso pergandei) has the same approximate total biomass as the rodent population in the same area (Hölldobler and Wilson 1990). On a side note - one of the many important ecological functions that ants provide in addition to their role in nutrient cycling, is assisting in the dispersal of plant seeds, as the result of accidental abandonment of seed caches near the nest (Moggridge 1973).

Insect populations vary more radically than most other rangeland components. Super abundances of, for example, the desert locust can consume the equivalent of what 150,000 head of cattle eat (Bullen 1996). The forage capacity model used here will focus on the typical needs of insect population in southwest deserts. Where populations of insects over a short period of time reach extraordinary populations, we suggest that those situations be treated with range management actions taken during a time of drought.

A number of studies have reported the percent of plant growth consumed by insects. For grassland and savannah, insect consumption of a single species varied from less than 1% to 19% with a mean of 3.5% (Wiegert and Peterson, 1983). Rangeland grasshoppers consume between 1-3% in typical years (Mispagel 1978) and up to 99% in periods of super abundance (Nerny and Hamilton 1969). Hewitt and Onsager (1983) suggest that between 21-23% of available range forage is consumed by all grasshopper species in the western U.S. each year.

Nematodes and other soil invertebrates perform critical soil nutrient and structural functions. This complex array of species normally has a higher diversity and biomass than any
other rangeland flora and fauna combined. They should be considered as an important component in the consumption of rangeland plants. Ingham and Detling (1984) estimated that nematodes consumed between 6 and 13% of below-ground net productivity in the mixed grass prairie. Another study by Scott et al. (1979) and Anderson (1987) found that root feeding arthropods and nematodes consume between 7-26% of the net productivity in normal years.

The evidence is clear that a substantial part of the plant community is consumed by invertebrates on a regular basis. Without this consumption, ecological change may occur that may contribute to the long-term loss of ecological health and productivity. Many of the studies just cited occur in habitat conditions somewhat different from that found in the Grand Staircase-Escalante National Monument. But one thing we know for certain is that the soils of this region do support nematodes and insects, which together form a critical component of the southern Utah desert ecosystem. To understand the consumption needs of insects and nematodes within the Monument, the needs for a long list of currently unknown species would need to be compiled. Clearly this is not possible at this time. However, as we continue our research and as more knowledge become available, we hope to refine the number used in this model for invertebrate consumption.

For this analysis, we assume that 10% of the annual forage production is required to support invertebrate populations. We suspect that additional research will find that this allocation is indeed too low.

2.3.3 Allocations for biomass to provide necessary cover to avoid soil erosion, and to ensure resiliency and regeneration of vegetative community in the face of drought. We focused on published reviews to find information regarding (1) potential ground cover (vegetation, litter, crust) for vegetation types occurring in the Colorado Plateau region, (2) the need for a certain “baseline” of cover to protect these communities from soil erosion, and (3) the principle needs of grasses to regenerate and have resiliency in the face of both livestock grazing and drought. More detailed research of source documents is ongoing. Using these three avenues of research, we propose a percent of the forage biomass to be set aside to meet the needs of the soils and vegetative communities in GSENM. Again, we stress that this third and final ecological allocation in our forage capacity model is still under development.

(1) Predicted ground cover in typical vegetation types in GSENM: Much of the research on plant community characteristics for the Colorado Plateau has been conducted as well as summarized by Dr. Neil West of Utah State University Department of Natural Resources. It is important to know potential ground cover in order to approximate historical (pre-livestock) erosion rates and to establish targets for grazing management or restoration. It should be noted that in many of these plant communities, much of the seed pool has been lost due to nearly continuous removal by livestock over the past century, so recovery in arid areas such as this will be slow as Anderson and Inouye (2001) have so well documented.

Sagebrush Semi-Desert vegetation occurs in the Great Basin and Colorado Plateau at intermediate elevations between 1300 – 1800 m in areas of precipitation ranging from 158 – 419 mm. In the Colorado Plateau, these vegetation types are generally associated with mesa tops,
benches or pediments with sandy to gravelly soils. They occur immediately above the salt desert shrub type. A survey of a relict site on Cedar Mesa yielded six species of grass including: *oryzopsis hymenoides*, *boutelea gracilis*, *hilaria jamesii*, *sporobolus airoides*, *sporobolus cryptandrus* and *stipa speciosa*. Sagebrush usually makes up over 70% of the relative cover and 90% of the biomass with absolute cover of higher plants ranging from 10 to 40%. Generally, perennial plants are found associated with shrubs and occur in the mounded portions of soil occupied by shrubs. Beneath the shrubs, the ground is litter-covered, with the interspaces between shrubs occupied by crusts. Annual net production varies between about 500 and 1500 kg/ha, most of which is sagebrush. The original estimated livestock grazing capacity for sagebrush semi-desert vegetation had been reduced from about 0.83 AUM/ha to 0.31 AUM/ha by 1970, mostly due to loss of perennial grasses (West, 1983a).

Salt Desert Shrublands occur in the Great Basin and Colorado Plateau at lower elevations and generally in valley bottoms in alkaline or saline soils where precipitation is generally less than 200 mm. Total cover of higher plants varies from 0 on salt pans to 25% on upland sites. Shrubs generally occur in clusters. Native grasses found in these types include: *boulela gracilis*, *elymus cinereus*, *hilaria jamesii*, *oryzopsis hymenoides*, *sitanion hystrix*, *sporobolus airoides*, *sporobolus cryptandrus* and *distichlis stricta*. Innerspaces between shrubs are generally lacking in vascular plants and the soil is covered with microphytic crust. Biomass of crust has been measured at 200 kg/ha. Forage production measured at the Desert Experimental Range in Utah varied over 800% between wet and dry years. Forage yield on a shadscale-winterfat range at the Desert Experimental Range varied from a minimum of 34 kg/ha in 1943 to a maximum of 190 kg/ha in 1947. (West, 1983b; Blaisdale and Holmgren, 1984; West et al, 2000).

Southeastern Utah Galleta-Threeawn Shrub Steppe (semi-desert grassland) type is found in deep silty and sandy wind-blown deposits derived from sandstone. Precipitation is a mixture of winter snow and late summer convectional storms. The flora consists of bunch and sod-forming grasses including (cover from transects in Canyonlands NP in %): *hilaria jamesii* (5%), *stipa comata* (5%), *oryzopsis hymenoides* (2%), *bouleloua gracilis* (9%), *vulpia octoflora* (1%), *sporobolus cryptandrus* (2%), *aristida fendleriana* (1%), *sporobolus flexuosus* (trace), *sporobolus airoides* (1%) and *sitanion hystrich* 1%). Vascular plant cover ranges from 25 – 60% and microphytic crust occupies nearly all the bare ground in ungrazed relict sites. In ungrazed Virginia Park in Canyonlands, microphytic crust cover was 38%, in adjacent grazed Chesler Park, crust cover was 5%. Productivity potential of forage on these sites averages 900 kg/ha in favorable years (West, 1983c).

Pinyon-Juniper Woodlands are described briefly by West and Young (2002) as having highly variable understory to compared to adjacent grasslands. On the Colorado Plateau, warm season sod grasses dominate. Total vascular plant cover varies from 40 – 80% with shrubs, herbaceous plants and microphytes occurring in the interspaces between trees. Litter accumulates beneath the tree crowns. Grazing by livestock has depleted what once appeared much like a savanna where fires were frequent enough to keep trees restricted to steep, rocky or dissected topography.
Microphytic Crusts are best developed in semi-arid shrublands. Pedicelled (pinnacled) crusts are abundant in pinyon-juniper and sagebrush communities typical of the Colorado Plateau, while rough lichenized crusts are more typical in greasewood and shadscale communities (Johansen, 1993). The soil-holding capabilities of crusts are destroyed by trampling and compaction, resulting in increased runoff. “Total crust cover is inversely related to vascular plant cover, as less plant cover results in more surface available for colonization and growth of crustal organisms.” (Belnap et al, 2001). This is also documented in the community-specific references cited earlier.

As the literature cited shows, microphytic crust cover potential is high in the Colorado Plateau vegetation types described, which include those in the Upper Hackberry allotment, where we applied the proposed capacity model (Section 3). Personal surveys of relict areas (John Carter, co-author) as recent as spring 2003 in Grand Staircase indicates that ground cover in the sandy soil types described is greater than 90% including large portions of crust, generally covering the soil between plants.

(2) Erosion and Livestock Grazing. White et al. (1983) found sediment yield 20-fold higher in a grazed watershed when compared to an ungrazed watershed. USDA (1981) reported that topsoil erosion rates from grazed forest and rangeland were 4.2 tons/acre-year and 3.1 tons/acre-year compared to less than 1 ton for healthy forest and range. Packer (1998) documented that loss of soil in Utah and Idaho watersheds through erosion and runoff increased as ground cover decreased. A decrease in ground cover from 40% to 16% resulted in 6 times more runoff and 5.4 times more sediment yield. Trimble and Mendel (1995) estimated that peak storm runoff from a 120 ha basin in Arizona would be 2 to 3 times greater when heavily grazed than when lightly grazed. Lusby (1979) studied grazing systems including removal of livestock from control watersheds in Badger Wash, Colorado. He found that during the period 1953 to 1973, complete exclusion of livestock resulted in over a 40% decrease in runoff and a reduction of 63% in sediment yield.

The following figure (Figure 1) was taken from Packer (1998) in order to show how soil erosion varies with slope and ground cover by plants and litter. This figure was derived from 5-minute rainfall simulations. At the lowest gradient of 5%, erosion begins to rapidly accelerate when ground cover drops below 60%. At 35% slope, erosion is accelerating rapidly as ground cover decreases below 100%. The fine-grained sandy soils occurring on the Hackberry allotment are susceptible to both wind and water erosion and will erode rapidly when ground cover declines below potential. Management must be designed to minimize trampling of uplands by livestock in order to allow microphytic crusts to return to potential cover values and impede the rapid erosion observed in GSENM.

While the above literature demonstrating the relationship between livestock grazing and erosion rates is certainly instructive, even more telling are those studies that have measured both vegetative cover and erosion rates on both grazed and ungrazed sites in arid regions. For example, Gamougoun et al. (1984) found that the 3-year average of standing biomass in a grazing exclosure in New Mexico was 1,550 kg/ha, whereas a nearby moderately grazed pasture contained a 3-year average of 637 kg/ha of standing biomass. The same study found that the erosion rate (measured as the mean wet sediment production resulting from simulated rainfall)
on the ungrazed site was 38 kg/ha, whereas the erosion rate on the moderately grazed site was 153 kg/ha. In a similar study conducted by Meeuwig (1965) in Utah, it was found that combined grass and forb cover on the ungrazed site was 58.4%, whereas forb/grass cover on the grazed site was 49%. The same study found that the erosion rate (measured as the mean wet sediment production resulting from simulated rainfall) on the ungrazed site was 173 lb/acre, whereas the erosion rate on the moderately grazed site was 840 lb/acre.

(3) Ensuring resiliency and regeneration of plant community. The normal utilization standard of 50%, developed from research on root-growth stoppage as a result of grazing (Crider 1955) and sometimes known as the “take half and leave half” policy, is inappropriate for the Colorado Plateau. Crider grew several Mid-western perennial grasses under ideal precipitation and nutrient conditions and monitored root growth changes due to clipping over a period of two months. Crider concluded that root growth at the end of the growing season was not impaired when a single clipping removed 50% or less of the above ground biomass.

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Relationship between vegetative cover, slope and soil erosion. Reprinted from from Packer (1998).
The results of Crider’s research do not reflect a number of factors that come into play on BLM lands in the arid West, including the applicability to the broad diversity of rangeland plants, grazing practices commonly found on BLM lands, semiarid or arid conditions, plant regeneration, soil nutrient recycling, litter generation, plant community composition, and wildlife habitat structure. As a result, range scientists have concluded that there is no scientific basis behind BLM’s 50% policy for utilization (Caldwell 1984). Still, allowable utilization rates of 50% seem to dominate AMPs on BLM lands in the intermountain West, while recent Forest Plans such as the Wasatch-Cache and Caribou are reducing utilization rates well below this figure to 30 – 40% for areas with much greater precipitation than GSENM. While the range literature does not support even these lower levels, they still represent significant departures from the “take half leave half” philosophy.

Even within Crider’s narrow area of research, current grazing utilization policy does not actually follow his recommendations. Crider was only looking at root growth of perennial grasses under ideal growing conditions. Under those conditions, he concluded that up to 50% of the aboveground biomass could be clipped once without root growth being significantly impaired. He further concluded that repeated clipping (which more accurately represents multi-month grazing periods common on BLM allotments) would significantly inhibit plant growth when a total of 50% of the biomass is removed. BLM was incorrect to apply the “take half and leave half” utilization level where grazing leads to numerous clippings, and on arid lands.

This research tells us that, at the very least, 50% of the above-ground biomass needs to remain each season, to ensure that the plant community remains viable, and can regenerate itself and remain resilient, even in the face of drought (which we know we have to assume on the Colorado Plateau). In fact, Jerry Holechek, well known Range Science Professor and textbook author from New Mexico State University, along with others are now recommending allocations of forage in arid areas that provide residuals of 50% for watershed protection aside from wildlife needs and livestock use (Holechek et al 2001).

Our recommended allocation for grass/forb biomass necessary to protect soils from erosion, while ensuring resiliency and regeneration of plant community. In addition to the suggested forage allocations to mammal herbivores and invertebrates outlined above, we recommend an additional allocation, as do the current leading range scientists such as Holechek, that will ensure the needs of the soils to resist erosion and the vegetation community itself to be able to regenerate and be resilient in the face of both grazing and assumed drought. While our research on this topic is ongoing, the literature featured above clearly shows us that (1) ground cover potential in GSENM is high and most allotments are not currently exhibiting predicted or historic levels of cover, (2) the reduction in ground cover because of livestock grazing definitively increases erosion potential, and (3) no more than 50% of the above ground biomass can be “clipped” (or eaten) by wildlife, invertebrates and livestock each season if the plant community is to remain viable and resilient. Because the nature of the scientific literature is such that it is difficult to exactly say what percentage of annual productivity must remain on the land to resist erosion, for now we are simply recommending, as do Holechek et al (2001), that a 50% allocation of biomass be set aside to ensure the soil and vegetation needs in GSENM.
This allocation does not “overlap” with those we recommend for invertebrates and native mammals, as these allocations represent biomass that will be removed from the vegetative community over the course of a year, and the plant community needs to retain a certain minimum percentage (i.e. 50%) of its biomass to simply remain viable, resilient and regenerate itself. We argue that this 50% allocation is conservative.

2.3.5. Allocation of remaining forage for cattle. Once the above allocations are made, the remaining kg/ha of available forage production can be allocated to cattle. Currently, the BLM divides the available forage by 800 lbs based on the presumed average weight of cattle. For now, we also utilize the 800 lb. (or rather, 364 kg) allocation for our capacity model since this is a standard used by the agency. However, we anticipate revising this number in future iterations of our model. The 800 lb. allocation may not reflect the increased livestock size now seen on many BLM lands. Holechek et al. (2001) uses 1000 lbs. as the average weight of cattle. We recommend that the Monument use the Holechek number for mature cattle (1000 lbs) in order to reflect the larger size of animals today. A check of the USDA market statistics at http://www.ams.usda.gov/mnreports/lm_ct166.txt reveals that these animals are very large today with average weights of mature cattle above 1000 lbs, more like 1200 lbs with calves running several hundred pounds each. It is erring to the low side to consider a cow/calf pair as 1000 pounds.

We anticipate using Holechek’s cattle weight the same in later versions of our model. But as stated above, we resort for now (in the following Upper Hackberry example) to the cow/calf allocation used by the BLM, thus rendering our model even more conservative.

2.4 Using a GIS to assess available forage and make ecological allocations

This section describes how to apply a GIS, incorporating the above recommended capability and suitability adjustments and ecological allocations of forage, to determine the amount of forage that might be available for livestock after these ecological needs are met. Our recommended forage/capacity model utilizes ArcGIS ESRI (Environmental Systems Research Institute, Inc.) software, and a spreadsheet program such as MS Excel or Corel Quattro Pro. The GIS data needed for this analysis includes a digital coverage of the grazing allotment boundaries, a soil coverage delineating NRCS soil map units, and a coverage that identifies areas as incapable and/or unsuitable (see page 7) for livestock grazing. Each soil map unit comes with an associated description of the geology, soil, and plant community.7

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7 In the early 1980s BLM, in coordination with NRCS (then the Soil Conservation Service) conducted range surveys as part of the preparation of a soil survey. These soil map unit descriptions were reported as “Site Write-up Areas” (SWAs). The SWAs recorded the percent weight of the total aboveground plant biomass grown each year for each observed plant species. The total annual plant growth (in lbs/acre) was also recorded. A number of other factors were sometimes recorded including percent bare ground, percent ground cover, and slope.
The steps outlined below explain how values are achieved that are used in our suggested forage/capacity formula. The formula applied to each soil map unit for forage capacity estimation is as follows:

\[ S = F_s(1-E)AD_w/800 \]  

where:

- \( S \) = Stocking capacity in terms of animal unit months
- \( F_s \) = total Seasonal Forage production
- \( E \) = Ecological forage allocation, here assumed to be 85%
- \( A \) = Area (in acres or hectares) of the soil map unit
- \( D_w \) = Distance to water factor (0-1.6km is 1, 1.6 to 3.2km is 0.5 and over 3.2 km is 0)

The first step of the forage analysis and capacity model requires that the user assemble the necessary information for the capability and suitability of the grazing unit (i.e. pasture or allotment). This includes a topographic coverage depicting slopes of the grazing unit and areas inaccessible to livestock (because of cliffs, canyons or other physical barriers), a hydrographic coverage, and coverages showing other important factors that may render portions of an allotment unsuitable for grazing (i.e. important habitats for TES species, rare plant communities, high recreation use areas, etc.). Using the clipping feature of the GIS, those parts of each soil map unit on the allotment that are either incapable or unsuitable for grazing are removed. Calculate the area within the grazing unit that remains within each soil unit. Enter this value in the “Area” entry in the forage/capacity model formula.

Once the incapable and unsuitable portions of the grazing allotment are removed from each soil map unit, the land manager next determines the amount of available forage in the remaining area. The NRCS soil coverage is used for this purpose. A soil map unit may consist of several intermingled plant communities. For example, soil map unit 15 (SWA L151), consists of 75% semidesert sandy loam big sage, 20% semidesert loam, and 5% semi desert shallow loam vegetation communities. In our forage capacity model, only grass and forb production is used when estimating the available forage on the grazing unit. This decision is supported by research on livestock use of forage. Kinuthia et al. (1992) found that for spring and summer diets of cattle in the Wyoming big sagebrush plant community, 96% of the diet for cattle was graminoids. Holechek et al (2001) report that cattle consumption of forage is comprised of 76% grasses and 10% forbs in Utah sagebrush communities. In salt desert shrub communities, more consumption of shrubs will occur. In most areas, the assumption that cattle forage capacity can be accurately represented by only considering grasses and forbs appears valid.

The estimated forage for each of these plant communities is multiplied by the percent of the soil map unit comprised of that community type. Repeat this step for each community type within the soil map unit, and add these values together to determine the total forage available on the soil map unit. Enter this value as the “forage production” entry in the forage capacity model formula.

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8 Be sure to see pages 7-8 where we make recommendations on how forage for each vegetation community type, or Range Site Type is estimated.
Next, determine the total percentage of available forage (grass and forb biomass) that is allocated to (1) mammal herbivores, (2) invertebrates, and (3) the needs of the soil and vegetative community. Our model suggests 10% allocation to invertebrates, 50% allocation for the needs of soil and vegetation, and 227 kg/ha of forage for native mammals. To convert this value into a percentage, use the estimated forage biomass that is predicted by the NRCS Range Site Type predictions for each soil unit, and determine what percentage our suggested value (227 kg/ha) is of the estimated kg/ha of forage for that soil unit. Add the percent values of (1), (2), and (3), above, to achieve the total ecological allocation for each soil type. Multiply this value with the estimated forage for that soil type, and enter this value as the “Ecological Forage allocations” entry in the forage capacity model formula.

There are many assumptions the user is making when using this model. These are:
1. Grazing use is uniformly distributed across all suitable lands.
2. The forage estimates represent the forage production of a soil map unit.
3. Livestock capacity can be adequately estimated using grass and forb production.
4. Average year precipitation and plant production occurs (during below average years such as occur nearly half the time in GSENM, plant productivity will be significantly reduced and this should be taken into account in setting annual stocking rates).
5. Grazing use is uniform among forage plants in each of the distance-to-water zones.
6. Grazing does not occur in a manner or time that prevents the growth of the predicted forage biomass. Heavy early spring grazing, for example, could curtail the total forage production for a season and grazing during drought could reduce forage production in following years (Galt et al 1999).

Obviously, there will be many situations where these assumptions are not met. With a couple exceptions (i.e. number 3 above), the forage capacity of an allotment and the resulting estimated stocking rate should usually be further reduced if these assumptions are not met.

To review, here is the sequence of steps to run the capacity model, most of which have already been discussed above:
1. Assemble spatial data for allotment (i.e. allotment boundary, soil map, and unsuitable and incapable areas, hydrology, etc.)
2. Using a GIS, clip the soil map with the allotment boundary.
3. Remove from each soil map unit those lands found to be incapable and unsuitable for grazing (steep slopes, rock outcrops, productivity of less than 19kg/ha of forage)
4. For each soil map unit, add a factor on the amount of land available to graze based on distance from water (see Table 1).
5. Export the soil map unit attributes to a spreadsheet table.
6. Determine soil map unit productivity of grasses and forbs (see pages 7-8 for our recommendations on how to do this. Actual, on-site clipping is preferred method).
7. Determine the percent of forage required for ecological needs of vegetation, soils and vegetation.

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In the Upper Hackberry example we feature in the following section, this calculation resulted in a 25% allocation of forage for herbivores across the entire allotment. Combined with the other allocations for invertebrates, and soils and vegetation, this resulted in an 85% allocation for ecological needs on the allotment.
wildlife (ecological allocations).
8. Insert values into soil map unit spreadsheet.
9. Calculate number of animal unit months (AUMs) of forage available for livestock in each soil unit.

In the following section, we present an example of how to use this method of forage analysis and capacity estimation, on the Upper Hackberry allotment in the GSENM.
SECTION 3: EXAMPLE AND DISCUSSION OF FORAGE ANALYSIS FOR THE UPPER HACKBERRY ALLOTMENT

We chose the Upper Hackberry allotment in GSENM to demonstrate how GIS might be used with soil map unit data to assess this allotment’s range capacity. This allotment was chosen in part because BLM has consistently reported that the grazing permit holder has been “doing a good job of managing their allotment” (BLM 1995), and also because this area represents Range Site Types that are generally common in the Monument. This allotment is part of a regional grazing planning effort and, for this reason, more recent digital data are available. Lastly, we chose this allotment because it is of more modest size (20,000 acres). This allowed us to easily conduct clipping studies of forage productivity.

This allotment is located a few miles south of Kodachrome Basin State Park and ten miles east of Bryce Canyon National Park (Figure 2). The area is dominated by sandy soils, pinyon juniper forests, sagebrush plateaus, sandstone escarpments, badland hills, and entrenched perennial streams on the allotment borders. Based on fifty years of precipitation data, the average annual rainfall for this area is 11 inches and drought occurs frequently.

Figure 2. Location map for Upper Hackberry allotment, GSENM
Before we conducted our own clipping survey in Upper Hackberry, we looked to the NRCS data for the soils types present to ascertain what the predicted productivity is for this allotment (Figure 3). For example, the upland loam - basin big sagebrush soil map unit (a prevalent soil type in the allotment) is predicted to produce between 300 to 800 lbs (reflecting the range from a dry year to a wet year) of annual plant growth per acre per year. The predicted composition of this potential plant community for this Range Site Type expects that 30 to 60% of the plant production would be from forbs and grasses and the rest from shrubs and trees. As described above in the Methods Section, we did not include shrubs in the forage base for livestock. Using the NRCS data, we determined that the potential production of the upland loam soil map unit for a potential native plant community would be 400 lbs per acre of grasses and forbs in an average year. Much less would be produced in a dry year.

We conducted our clipping studies of plant productivity in Upper Hackberry during a below average precipitation year (2001) and, for this reason, this analysis produced forage production values that are far less than would occur in an average precipitation year. Since below average precipitation years occur frequently, capacity analysis based on these clipping surveys is very useful, and appropriately conservative.

Thanks to BLM’s recent land use plan and upcoming grazing EIS for this area, BLM was able to supply a number of coverages that aided in this analysis. The coverages used in this analysis include Site Writeup Area (SWA) maps (which described soil map units,), grazing allotment boundaries, and surface water sources.

While most of the coverages needed already existed, some modifications were needed. We had to create a map of those lands identified as incapable and unsuitable for grazing. Also, BLM’s soil map did not show soil inventories for state and private lands, some of which are found inside the Upper Hackberry Allotment. Using geo-referenced aerial photos, we edited the soil map unit coverage to include polygons for adjacent parcels that used to be state lands.

A number of factors were used to determine which parts of the Upper Hackberry Allotment are capable, and incapable, of supporting grazing (shown in Figure 4 and summarized in Table 4, below). Those parts of the allotment incapable for grazing include those lands where steep slopes and rock outcrops render certain areas inaccessible to cattle. Many of these incapable areas were also identified by BLM in an earlier capacity assessment for Upper Hackberry (1984). We also factored in steep slopes, removing those parts of the allotment from consideration that had slopes steeper than 30% (a criteria also used by the BLM in their 1984 assessment). We also accounted for distance to water in our capability assessment, using the GIS to identify those parts of the allotment that are 0-1.6km from water, 1.6 to 3.2km from water, over 3.2 km from water. Areas over 3.2 km from water were completely removed from the capable area (treatment of the other two classes are described below). Lastly, we removed those areas with annual forage production of less than 19kg/ha (or 17 lb/acre, BLM 1981) based on our clipping studies on the allotment. These last two criteria were not considered by the BLM in their 1984 forage assessment, and we stress that more reasonable figures such as the 100 lb/acre suggested by Holechek (1996) be used as minimum criteria by GSENM.
Figure 3. Soil map units for the Upper Hackberry grazing allotment, GSENМ
There were a number of capability and suitability criteria recommended in our approach (see pages 7-8) that did not apply to the Upper Hackberry test case. We felt that unstable or highly erodible soils (as defined by NRCS) were a moot point in this case, as our slope factor removed steep, erodible slopes, and in addition, we removed the pinyon-juniper dissected slopes Range Site Type because of its extremely low forage production (as demonstrated by our clipping studies). These soil types are known to have unstable and erodible soils. As for our four suitability factors (habitat identified as important for T/E/S species, jurisdictional wetlands and springs, rare plant communities, areas that receive very high levels of recreation use) we found that these components were completely missing or present in near negligible amounts on the Hackberry allotment.

After the parts of the allotment that were incapable of supporting grazing were removed from the analysis, we applied our forage production values (from our clipping studies) to each Range Site Type in each soil map unit the Upper Hackberry GIS coverage. For each soil map unit, we added forage productivity estimates to the relational table generated by the GIS that we used to calculate the grazing capacity. Table 5 shows the forage production, in terms of expected annual growth (lb/acre) of grass and forbs, that our clipping studies indicate is available, and what the NRCS’s 1984 Site Write-up’s indicate for those soil types.

Using GIS, we added for each soil map unit (soil community) a factor that reflected the amount of forage relative to distance of the area from a water source. For a distance of 0 to 1.6 km from water, all forage is allocated and the factor is 1. For a distance of 1.6 km to 3.2 km from water, half of the forage is available or a factor of 0.5. For distances from water of greater than 3.2 km, no forage is assumed available, or a factor of 0.

Next, the GIS estimated the size of each of these soil area units with their related attributes of capability/suitability, distance from water, and plant productivity. The GIS table with these values was then exported and, using a spreadsheet program, the forage capacity model formula was applied to each individual soil community type. As described in Section 2, our proposed ecological allocation for the Upper Hackberry allotment was 85%, thus leaving 15% of annual forage productivity for cattle.

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10 The table and figure on the following section (Figure 5 on pg 29 and Table 7 on pg 30) shows that the transects the authors measured on the Upper Hackberry allotment range between 30 and 90% bare ground. Microphytic crust ranged in cover from 0 to 28% indicating that when trampling is minimal in areas where livestock don’t linger, crust potential is high and ground cover potential therefore is also high.
In addition to running the model using our own recommendations for ecological allocations, the model was also run for the traditional “take half and leave half,” or 50% allocation to cattle. The results of the capacity model are shown in Table 6. This table also depicts past capacity analyses conducted by the agency, current permitted use, and average livestock grazing use. Based on the Upper Hackberry Allotment file, the part of the allotment that has traditionally been used for grazing matches that area identified by our GIS model as suitable for grazing.
As evidenced in Table 6 below, both the permitted use and actual use on Upper Hackberry are substantially higher than the level necessary to meet the ecological needs of healthy rangelands. This conclusion is actually an understatement because this capacity analysis is only to be used for rangelands that are at or near their potential productivity, which is not the case in this allotment. Moreover, the 191 AUMs represents a grazing level for plant production found in 1984 during a normal precipitation year. The 93 AUMs represent a level of grazing based on recent plant community productivity clipping surveys during a dry year.

Table 5. Upper Hackberry soil community categories and forage production, as indicated by the authors’ 2001 clipping studies in the Hackberry allotment, and the NRCS 1984 Site Write-ups.

<table>
<thead>
<tr>
<th>Site write-up area unit</th>
<th>Map unit number</th>
<th>Ecosite</th>
<th>1984 SWA forage (lb/acre)</th>
<th>2001 forage (clipping survey) lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>L151</td>
<td>K 15</td>
<td>SEMIDESERT SANDY LOAM (BIG SAGE)</td>
<td>332</td>
<td>174</td>
</tr>
<tr>
<td>M141</td>
<td>K 14</td>
<td>UPLAND LOAM</td>
<td>5</td>
<td>77</td>
</tr>
<tr>
<td>M163</td>
<td>K 16</td>
<td>UPLAND SANDY LOAM</td>
<td>138</td>
<td>106</td>
</tr>
<tr>
<td>S149</td>
<td>K 14</td>
<td>seeding</td>
<td>600</td>
<td>150</td>
</tr>
<tr>
<td>S167</td>
<td>K 16</td>
<td>chaining/seeding</td>
<td>520</td>
<td>107</td>
</tr>
</tbody>
</table>

Table 6. Forage capacity estimates for the Upper Hackberry Allotment

<table>
<thead>
<tr>
<th>1967 BLM capacity estimate</th>
<th>1,388 AUMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit to graze</td>
<td>651 AUMs</td>
</tr>
<tr>
<td>Reported grazing use, 5 year average</td>
<td>408 AUMS</td>
</tr>
<tr>
<td>Amount of allotment BLM found suitable for grazing in 1984 (15,335 out of 22,734 acres)</td>
<td>67% percent</td>
</tr>
<tr>
<td>Amount of allotment suitable based on our proposed capacity model (5,819 out of 22,734 acres)</td>
<td>26% percent</td>
</tr>
<tr>
<td>Grazing capacity based on 50% forage use of 1984 BLM/SCS forage estimate and calculation of suitability</td>
<td>638 AUMs</td>
</tr>
<tr>
<td>Grazing capacity based on 15% forage use of 1984 BLM/SCS forage estimate and calculation of suitability</td>
<td>191 AUMs</td>
</tr>
<tr>
<td>Grazing capacity based on 15% use of 2001 WUP clipping survey forage data and calculation of suitability</td>
<td>93 AUMs</td>
</tr>
</tbody>
</table>

3.2 Discussion of results of forage capacity analysis for Upper Hackberry, in light of range conditions.

In addition to performing the necessary clipping studies to carry out our Upper Hackberry forage analysis described above, we also calculated coverage of vegetation on the allotment. These data are featured in Figure 5 and Table 7.
Figure 5. The authors’ ground cover estimates (%) for various Range Site Type cover transects in the Upper Hackberry allotment (data collected fall 2001).

Our initial results of our forage capacity estimate for the Upper Hackberry allotment indicates these pastures are currently producing forage, and vegetative cover, far below their potential. We argue that it’s important to analyze these results in light of past and current trend data, monitoring, and rangeland health assessments collected by and carried out by the BLM, in order to corroborate our findings.

BLM range monitoring and recent rangeland health assessments describe, in part, the range condition and ecological health of this allotment. In 2001, BLM visited two riparian sites and found that these riparian areas were functioning at risk, and without positive trends (Table 8). This indicates that these riparian areas were not meeting the rangeland health standards. Visits to the Rock Springs Bench site by the authors verified that heavy livestock grazing was a regular occurrence at these water sources.
Table 7. Coverage estimates collected by authors for the Upper Hackberry allotment, GSENM.

<table>
<thead>
<tr>
<th>Range Site Type</th>
<th>N</th>
<th>Ground Cover %</th>
<th>Canopy Cover %</th>
<th>Forbs lb/acre</th>
<th>Grass lb/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-desert sandy loam big sagebrush</td>
<td>10</td>
<td>0.06 ±0.2</td>
<td>38.1 ±6.5</td>
<td>45.3 ±12.0</td>
<td>10.9 ±12.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 ±2.5</td>
<td>0.4 ±0.5</td>
<td>3.1 ±1.5</td>
<td>25.5 ±24.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25.8 ±39.1</td>
<td>63.2 ±82.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland loam</td>
<td>15</td>
<td>0.04 ±0.2</td>
<td>43.5 ±14.0</td>
<td>35.8 ±6.4</td>
<td>11.7 ±6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.0 ±2.5</td>
<td>0.2 ±0.4</td>
<td>4.2 ±2.5</td>
<td>15.4 ±5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.4 ±6.0</td>
<td>81.9 ±67.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland sandy loam</td>
<td>10</td>
<td>0</td>
<td>29.1 ±6.2</td>
<td>46.8 ±7.0</td>
<td>15.9 ±9.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5 ±1.8</td>
<td>1.4 ±1.7</td>
<td>3.2 ±1.7</td>
<td>13.6 ±6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.6 ±7.0</td>
<td>103.5 ±48.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland shallow dissected slopes pj</td>
<td>5</td>
<td>1.8 ±3.0</td>
<td>42.0 ±6.4</td>
<td>29.4 ±7.0</td>
<td>1.8 ±1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 ±4.1</td>
<td>0.9 ±1.6</td>
<td>1.5 ±0.8</td>
<td>11.4 ±3.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.4 ±9.2</td>
<td>6.4 ±12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chaining</td>
<td>10</td>
<td>0</td>
<td>55.7 ±5.6</td>
<td>30.6 ±5.3</td>
<td>0.06 ±0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.06 ±4.3</td>
<td>1.1 ±0.5</td>
<td>0.4 ±1.6</td>
<td>2.1 ±3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 ±3.4</td>
<td>5.3 ±3.4</td>
<td>5.3 ±3.4</td>
<td>186.1 ±162.7</td>
</tr>
<tr>
<td>Seeding</td>
<td>5</td>
<td>0</td>
<td>91.2 ±5.4</td>
<td>3.2 ±3.9</td>
<td>5.6 ±1.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.3 ±1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 ±1.8</td>
<td>0</td>
<td>0</td>
<td>137.4 ±37.3</td>
</tr>
<tr>
<td>Upland shallow loam pj</td>
<td>10</td>
<td>0</td>
<td>38.9 ±19.0</td>
<td>37.2 ±13.0</td>
<td>15.6 ±16.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.1 ±5.3</td>
<td>0.4 ±0.6</td>
<td>0.3 ±0.6</td>
<td>1.3 ±1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 ±1.6</td>
<td>21.5 ±11.7</td>
<td>0.7 ±1.7</td>
<td>28.32 ±42.6</td>
</tr>
</tbody>
</table>

1. Number of transects and plot clippings
2. Shrub or tree trunks or branches at the ground surface
3. Chained and seeded

Table 8. Riparian properly functioning condition assessments for the Upper Hackberry Allotment*

<table>
<thead>
<tr>
<th>OBS_ID</th>
<th>Riparian/ Wetlands Area</th>
<th>RATING</th>
<th>TREND</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>LE0505</td>
<td>Rock Springs</td>
<td>FAR</td>
<td>DOWNWARD</td>
<td>This area is a small spring in a drainage on an upland slope so it's probably naturally marginal conditions.</td>
</tr>
<tr>
<td>LE1003</td>
<td>Spring below rockfall on Hackberry</td>
<td>FAR</td>
<td>NOT APPARENT</td>
<td>Trailing from recreation &amp; possible livestock. Contact Spring in Kayenta. Headcut at mouth that may not be active. Part of wetland cut down to bedrock. More willow would better hold wetland together...</td>
</tr>
</tbody>
</table>

* These data are reproduced from BLM’s database created for the upcoming grazing EIS. The notes are directly taken from BLM’s records for these two observation sites.

We believe that BLM’s rangeland health assessments for this allotment (Table 9) understate the ecological problems found in this allotment. Field clipping data on plant community productivity was not collected by BLM when these assessments were made. Based on our field data for Upper Hackberry, standing forage biomass is believed to be between 10 and 20% of its
potential. According to the BLM’s criteria for evaluating rangeland health indicator No. 15 (plant production), this indicator should have received a rating of 2 rather than 3.\textsuperscript{11} Yet another problem with the Monument’s rangeland health assessments for this allotment is that no ecological reference site was identified for the Upper Hackberry Allotment. This would lead one to conclude that no suitable reference sites exist in this allotment, which is an unfortunate commentary on the ecological state of affairs in this area.

Table 9. Rangeland health indicator ratings for the Upper Hackberry Allotment. These are not ratings for individual indicators, but rather suites of indicators that describe similar categories (soils, hydrology, biotic integrity) are averaged together.

<table>
<thead>
<tr>
<th>Observation Site ID</th>
<th>Pasture</th>
<th>SWA soil identification</th>
<th>Soil stability</th>
<th>Hydrologic Function</th>
<th>Biotic Integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0545</td>
<td>Rock Springs</td>
<td>S167</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>E0527</td>
<td>South Jody</td>
<td>L172</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>E0528</td>
<td>South Native</td>
<td>M207</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0546</td>
<td>South Native</td>
<td>L172</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>E0530</td>
<td>South Native</td>
<td>M163</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0531</td>
<td>South Native</td>
<td>L172</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0532</td>
<td>Rock Springs</td>
<td>L182</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0538</td>
<td>Rock Springs</td>
<td>M163</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0539</td>
<td>Rock Springs</td>
<td>L172</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0535</td>
<td>South Jody</td>
<td>S149</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>E0536</td>
<td>South Jody</td>
<td>L172</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>E0537</td>
<td>South Jody</td>
<td>M191</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>E0529</td>
<td>South Native</td>
<td>M191</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0533</td>
<td>North Jody</td>
<td>L182</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0534</td>
<td>Middle Jody</td>
<td>M141</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>E0540</td>
<td>Middle Jody</td>
<td>S149</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Permanent trend plot sites have been in place in the Upper Hackberry Allotment since 1969. The data from these trend plots are presented in Table 10, which depicts percent ground cover for key grass species, such as crested wheatgrass (\textit{Agropyron cristatum}, a seeded exotic) and other, native, grasses. While these native species receive much less monitoring, that which is conducted shows that coverage of these species is much less than that predicted by the NRCS as the potential plant community, confirming the plot clipping results we obtained represent degraded conditions.

In summary, based on BLM’s records and the authors clipping studies, the plant community composition and productivity of this allotment are not currently meeting the standards for

\textsuperscript{11} Part of the problem with this indicator is that in rangelands dominated by trees and shrubs, the indicator may not adequately describe loss of forage production in the common situation where forb and grass production is extremely low and shrub and tree production high.
rangeland health. The productivity is much lower than it should be. This capacity model assumes that the allotment under analysis meets rangeland health standards and has productivity of at least half or better of the potential productivity for the site. This is not the case for the Upper Hackberry Allotment. Thus, the Upper Hackberry allotment is a likely candidate for the “recovery prescription” described above, and elsewhere in this guidance document.

Table 10. Upper Hackberry Allotment monitoring data from permanent trend plots, provided by BLM. Some data is missing.

<table>
<thead>
<tr>
<th>Key Species</th>
<th>Plot</th>
<th>Date</th>
<th>Pasture Name</th>
<th>% ground cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGCR</td>
<td>2-50 A</td>
<td>7/1/1969</td>
<td>Jody Pt.</td>
<td>5</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-50 A</td>
<td>7/1/1993</td>
<td>Jody Pt.</td>
<td>1</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-50 A</td>
<td>7/1/1996</td>
<td>Jody Pt.</td>
<td>3</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-50 B</td>
<td>7/1/1969</td>
<td>Jody Pt.</td>
<td>6</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-50 B</td>
<td>7/1/1993</td>
<td>Jody Pt.</td>
<td>11</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-50 B</td>
<td>7/1/1996</td>
<td>Jody Pt.</td>
<td>11</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-50 B</td>
<td>9/15/1996</td>
<td>Jody Pt.</td>
<td>11</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 A</td>
<td>7/1/1969</td>
<td>Jody Pt.</td>
<td>6</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 A</td>
<td>7/1/1976</td>
<td>Jody Pt.</td>
<td>8</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 A</td>
<td>7/1/1993</td>
<td>Jody Pt.</td>
<td>10</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 A</td>
<td>7/1/1996</td>
<td>Jody Pt.</td>
<td>13</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 B</td>
<td>7/1/1969</td>
<td>Jody Pt.</td>
<td>6</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 B</td>
<td>7/1/1976</td>
<td>Jody Pt.</td>
<td></td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 B</td>
<td>7/1/1993</td>
<td>Jody Pt.</td>
<td>15</td>
</tr>
<tr>
<td>AGCR</td>
<td>2-51 B</td>
<td>7/1/1996</td>
<td>Jody Pt.</td>
<td>15</td>
</tr>
<tr>
<td>BOGR</td>
<td>HB-2B</td>
<td>9/16/1996</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>MUHLY</td>
<td>HB-2B</td>
<td>9/16/1996</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>ORHY</td>
<td>HB-2A</td>
<td>7/13/1982</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>ORHY</td>
<td>HB-2B</td>
<td>7/13/1983</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>ORHY</td>
<td>HB-2B</td>
<td>9/11/1984</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>ORHY</td>
<td>HB-2B</td>
<td>9/11/1984</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>ORHY</td>
<td>HB-2B</td>
<td>5/16/1988</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>ORHY</td>
<td>HB-2C</td>
<td>7/13/1982</td>
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SECTION 4: CONCLUSIONS AND RECOMMENDATIONS

We offer a new way to assess forage availability and grazing capacity of southern Utah rangelands that uses up-to-date science and technology. The proposed methods provided in this work are all firmly grounded in the latest ecological literature and range science (with numerous allocations borrowed directly from Holechek et al. 2001). Moreover, the widespread adoption of GIS by land managers is aiding many with important management decisions such as setting permitted stocking levels. It is time for the Monument to also use this tool in this important capacity. The grazing capacity analysis described above promises to give permittees and land managers a tool for addressing grazing problems that they have not had before.

One of the key findings outlined in Section 3 (above) is that the forage/grazing capacity of the Hackberry allotment as determined by our proposed model is much less than that currently assumed by BLM. Section 3 also demonstrates many indicators of current overgrazing in the Upper Hackberry Allotment. There are many reasons that the BLM should seriously consider adopting our proposed method (or a variation of this method) to set stocking rates throughout the Monument during this DEIS process. At this time stocking rates established in current grazing permits appear without a systematic analysis of the forage production capacity.

The chances of actually meeting the Standards and Guidelines are going to be much better if our capacity model (or a form of it) is used in this process. As we point out elsewhere in this guidance document, only about 35% of Monument allotments are so far meeting all four Standards (compared to about an 80% success rating on other Utah BLM lands thus far), and our analysis above indicates these might have been more favorably rated that actual data collection would show. It clearly behooves the Monument to use all available tools at its disposal to strive to do a better job meeting these standards in the future.

Our model reaffirms the need for key plant community data generated from ongoing monitoring. Plant community composition, forage biomass production, litter, and bare ground are a few of the key monitoring data necessary to assess the amount of livestock grazing that is consistent with rangeland health standards. Further, the trend plot data currently collected by the BLM provide inadequate information to analyze the range condition requirements established by the Standards and Guidelines. It is important that the Monument establish a quantitative monitoring protocol to ensure that forage allocations are not exceeded in order to protect ecological health, including plant productivity and wildlife habitat. This protocol must also measure ground cover in order to ensure that this vital component is restored and protected at near potential in order to correct the severe erosion evidenced across the Monument.

In closing, we stress that this is a work in progress. The material presented here will soon be submitted to an academic journal for further peer review. The review and suggestions by Monument DEIS staff is requested and values. We intend to run the
model on additional GSENM allotment(s), and this will include new clipping studies. We look forward to working with Monument range staff in these endeavors.

5.0 Literature Cited


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