Appendix D

Stock Use and Meadow Monitoring and Management Strategy

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Wales Creek
Photo Courtesy of R. Pilewski

APPENDIX D:

STOCK USE AND MEADOW MONITORING AND MANAGEMENT STRATEGY

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STOCK USE AND MEADOW MONITORING AND MANAGEMENT STRATEGY

This appendix describes the strategy for monitoring and managing stock use the NPS would implement under the preferred alternative described by this Draft Wilderness Stewardship Plan and DEIS. The following sections provide an overview of these parks' meadow resources, review the history of stock use and management in SEKI, and identify approaches for monitoring and managing stock use in such a way as to minimize and mitigate impacts while providing continued access to wilderness for visitors travelling with stock.

INTRODUCTION

Pack and saddle stock have been used in the southern Sierra Nevada since the mid-nineteenth century, first for exploration and then in conjunction with sheep and cattle grazing and mining. In the late nineteenth century, and progressively into the twentieth century, stock were used for access to the mountains of the region for recreational purposes. The numbers of stock used for recreational trips increased and peaked in the 1930s, dropped in the 1940s, increased again in the 50s, and have since declined. Pack stock have been used to support the development and administration of the remotest areas of the two parks—e.g., for trail building and maintenance and ranger patrols—since their establishment. The use of stock for administrative and recreational purposes is still recognized as a traditional, historically and culturally significant, and legitimate activity that will continue in the wilderness of Sequoia and Kings Canyon National Parks (NPS GMP 2007).

The Act that created the National Park Service states that its "purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for future generations." NPS Organic Act (16 USC 1) National Park Service policy and the legislation that created these parks require that ecosystems in wilderness be protected and preserved while allowing for their use and enjoyment. Where grazing is permitted, National Park Service policy directs the use of best management practices, with particular attention being given to protecting wetland and riparian areas, sensitive species and their habitats. Grazing is managed so that ecosystem dynamics and the composition, condition, and distribution of native plants and animal communities are not significantly altered (NPS Management Policies 2006, 8.6.8.2).

Many kinds of disturbance occur naturally in meadow ecosystems; here we address those associated with human activities and stock use. Some disruption of natural ecosystems and processes by stock is expected and considered acceptable as the consequence of a form of primitive wilderness use that is appropriate in Sequoia and Kings Canyon; the impacts of such use, however, are potentially significant enough to compel development of a program for its management.

The environmental impacts associated with stock use are discussed in detail under the impacts topics addressed in chapters 3 and 4 of this DEIS.

OBJECTIVES OF THE STOCK USE AND MEADOW MONITORING AND MANAGEMENT STRATEGY

A goal of wilderness management in Sequoia and Kings Canyon National Parks is to provide for recreational and administrative saddle and pack stock use within guidelines that will protect the parks' natural and cultural resources and values, the processes that shape them, and the quality of visitor experience distinctive to them.

Chapter 1 of this DEIS further articulates the desired conditions which guide protection of the natural quality of wilderness as follows:

- The natural quality of wilderness would be preserved by mitigating the impacts of modern civilization on ecosystem structure, function, and processes.
    - The NPS aspires to minimize or localize adverse impacts caused by visitor use and administrative activities. In the wilderness, natural processes would dominate:
        - ecosystem structure and function
        - native biodiversity
        - water quality and quantity
        - decomposition, nutrient cycling and soil forming processes
        - meadow and wetland productivity
        - fire regimes
        - soundscapes, dark skies and viewsheds

Some or all of these desired conditions may not be fully attainable due to factors unrelated to visitor use or parks administrative activities such as climate change and air pollution. The ability of the parks to achieve desired conditions that are either tangentially or unrelated to visitor use and administrative activities are being systematically evaluated through a "climate-smart" lens in the parks Resources Stewardship Strategy (RSS).

The following objectives for stock use and meadow monitoring and management provide a more specific interpretation of how the NPS will meet these goals:

- Establish Controls: Limit stock induced changes to plant composition, density, cover and/or vigor, and productivity, and to prevent adverse effects to soils and associated sod that may lead to accelerated erosion, prevent changes to springs, seeps and water courses that could alter hydrologic processes, and to promote recovery from past overuse where necessary.
- Minimize the Effects of Stock on Trails and Camps
- Minimize the Effects of Stock on Hydrology and Water Quality
- Protect a Range of Meadows: Ensure that a series of meadows (or definable parts of meadows), including representatives of all major types within these parks, be protected from stock use so that they are perpetuated as--or allowed to become--natural functioning ecosystems to the greatest extent possible. Ungrazed meadows will provide an opportunity for visitors to experience naturally functioning meadows, and will enable us to study the re1ative effects of climate, plant succession, and grazing.
- Monitoring Strategy: Design and implement a monitoring strategy to provide information about the effects of stock on the resources of the parks that enables adaptive management given uncertain future conditions and ensures that objectives 2.1-2.4 are met.

BACKGROUND INFORMATION

DESCRIPTION OF THE MEADOW RESOURCE

Meadows and uplands, including woodland meadows, forest grasslands, and alpine vegetation, are among the most attractive and important natural resources within Sequoia and Kings Canyon National Parks. Meadows are the principal destinations of many wilderness travelers. Meadows and their environs are important to those visitors who ride and/or pack into the backcountry, both for camping nearby and traditionally as places to graze their stock.

Meadows and associated uplands serve as important sources of food, birthing sites, nesting areas, and hunting grounds for many species of wildlife. Meadow areas also provide an opportunity for scientific research and observation. Natural (or near natural) vegetation may serve as a baseline to which the professional resource manager can refer to evaluate the effects of use on areas used by stock. The value of such baseline conditions contributed to earning these parks International Biosphere Reserve status (Natural Resource Management Reference Manual #77).

Meadows are complex ecosystems, varying widely in character and composition (Benedict and Major 1982, Ratliff 1982). The plant associations and physical conditions of a meadow determine its tolerance to the effects of grazing and trampling. Because meadow vegetation exhibits a high degree of spatial and temporal heterogeneity, only a very broad, relatively insensitive, classification system can be employed at the meadow level. Since it is often of limited value to generalize about the vegetation of meadows as a whole, it is important to understand the characteristics and tolerances of the plant associations that combine to form meadows. Traditionally, meadow classifications have been based primarily on vegetation and soil characteristics (Klikoff 1965, Benedict and Major 1982, Ratliff 1982, Ratliff 1985). Recognizing the importance of the environmental factors underlying and shaping these assemblages, Weixelman et al. (2011) have developed a classification system for Sierra Nevada meadows that incorporates both hydrology and geomorphology. This system has been widely adopted by ecologists and public land managers in the Sierra Nevada as it represents a more functional approach to the characterization of these complex systems.

Stock use is not confined to open meadow environments. Forests and woodlands include extensive areas of species palatable to stock including grasses, sedges, rushes, and other herbaceous plants found within aspen or conifer stands along streams, in seeps, or as an extension of the forest meadow transition. Upland forbs and grasses may provide abundant and nutritious forage, especially when bunch grasses are present (Sumner 1941). Horses and mules spend a considerable amount of time in forested areas where they are protected from wind and mosquitoes and are able to keep their hoofs dry. Alpine vegetation may also provide forage for stock, but in general these areas are lightly used by stock parties (Frenzel and Haultain 2013), in part due to the limited availability of forage and cover for animals and the challenges faced in constraining stock in treeless terrain, and in part due to restrictions on campfires.

Ecologists have begun to investigate the importance of peat-accumulating wetlands (fens) in the Sierra Nevada over the past decade. Fens are peat-forming wetlands, supported by nearly constant groundwater inflow (Bedford and Godwin 2003). This state of permanent saturation leads to the development of oxygen-deprived soils characterized by very low rates of decomposition, allowing for the accumulation of organic matter produced by wetland plants. Fens develop and are maintained only under hydrologic conditions that create perennial soil saturation on the time scale of millennia (Wood 1975, Sikes et al. 2013). As is true for most of the Sierra Nevada, most fens in Sequoia and Kings Canyon National Parks occur in meadow complexes consisting of areas of wet meadow (usually saturated for 1-2 months; Benedict 1983) intermixed with peat accumulating areas that stay saturated for most or all of the year.

Concern over the conservation of these relatively rare and distinctive wetlands has grown, as it is thought that activities leading to the disturbance of the hydrologic regime or soil temperature of a fen, causing drying or warming, may threaten its functioning (Sikes et al. 2013). Alternatively, fens may be more resistant to change than wet meadows due to more stable hydrologic regimes associated with springs and other hydrogeomorphic features (Gage et al. 2014).

HISTORY OF STOCK USE AND ASSOCIATED IMPACTS

Sheep and cattlemen of the gold rush era found the meadows and plateaus of the High Sierra unaffected by early Spanish immigrants (Strong 1964). Large numbers of domestic sheep and cattle were first herded into the southern Sierra Nevada during the great drought years of 1862-1864 (Burcham 1957).The next forty years can be characterized as a period of heavy, unregulated use. Tens (and perhaps hundreds) of thousands of sheep were driven into the High Sierra annually. Use was locally heavy (Muir 1877; Reports of the Acting Superintendent of Sequoia and General Grant National Parks, 1892, 1894; Dudley 1896, 1898, 1899; King 1902), and it is assumed that virtually all of the areas now included within the parks that were accessible to sheep were grazed. Cattle were also common in the area but were generally confined to the more easily accessible plateaus and drainages.

Sequoia and Kings Canyon National Parks were established in stages spanning the years 1890-1940 (Strong, 1968), and thus different areas have different grazing histories. Sequoia National Park was established in 1890 but was not expanded to include the Kern Canyon and Sierra Crest regions until 1926. Kings Canyon National Park was established in 1940. Prior to this time, that area was administered by the U. S. Forest Service. With establishment of Sequoia and Kings Canyon National Parks, grazing by sheep and cattle was virtually eliminated. Exceptions included a considerable amount of trespass grazing from 1890 to 1905, special wartime grazing permits during and immediately following World War I, and lifetime grazing permits extended as a condition of establishing Kings Canyon National Park. Although the Forest Service regulated grazing by permit on its lands after 1905, grazing pressure was heavy with maximum herd sizes on allotments peaking in the 1920s and 1930s (Harper, 1974). Thus, many meadows in Kings Canyon National Park were degraded at the time of its establishment (Sumner 1941). Detailed accounts of the use of the Sierra Nevada by domestic 1ivestock during pre-park and early park periods are presented by Burcham (1957), Otter (1963), Loughman (1967), Vankat (1970), Harper (1974), Holmes and Dobson (1976), DeBenedetti (1977), Vankat and Major (1978), and DeBenedetti and Parsons (1979), and summarized by Neuman (1990).

Recreational use of pack and saddle stock on land now included within these parks predates their establishment. Large stock-assisted Sierra Club outings began visiting this area in the early 1900s. Loughman (1967) reported that the use of stock for recreational purposes increased steadily after World War I and peaked in the 1930s. Following a decline in the 1940s, use again increased in the early 1950s, only to decline again through the early 1960s (Briggle et al. 1961). Use levels ranged between 8,800 and 11,500 stock nights during the seven years from 1977-84 (National Park Service Annual Stock Use Reports 1977-84). This level of use as measured by the number of stock nights spent in the wilderness was about one-third of the level of the early 1950s and have been as little as one-sixth of the peak levels of the 1930s. Use levels have continued to decline since the 1980s , with an average of 7,594 annual stock nights reported for the period 1993-2002, followed by an average of 6,775 annual stock nights reported for the years 2003 to 2012 (ranging from a low of 5,434 nights in 2012 to a high of 8,218 nights in 2003) (Hopkinson et al. 2013).

Wilderness meadows in Sequoia and Kings Canyon National Parks have been the object of much study, with early work being mostly qualitative in nature. Beginning with Sumner (1941), these reports were the result of observations that many meadows seemed to be in a deteriorated condition; the cause of this deterioration was believed to be overgrazing by pack stock, cattle, and/or sheep. There has been much controversy over both the definition and the magnitude of the effects of historic grazing. The Sumner series of observations (1940, 47, 48, 68), in conjunction with Sharsmith (1959), suggested that many meadows in the 1930s and 1940s were undamaged even with heavy use. Other areas, at the same time, were assessed as seriously deteriorated. None of the authors, however, proposed that areas they examined were unaltered compared to what would have been their condition without grazing by livestock. For example, Ratcliff (1956) noted during a survey of the Rock Creek areas that the Rock Creek, Crabtree, and Wright Creek areas were in good condition considering the past and then current levels of use. Near Timberline Lake, however, he reported damage due to trampling. He noted that his report should not be extrapolated to represent conditions in Kings Canyon. Sharsmith (1959) also found Crabtree meadows in good shape. Damage reported by Sumner, Sharsmith, and Ratcliff was, in general, proportional to use the area received. Strand (1972) observed that, "many strategically located meadows along popular trails had been severely damaged by pack stock, and their recovery from earlier abuse either prohibited or delayed."

The need to objectively define what constituted "damage" resulted in a shift from qualitative to quantitative assessment (e.g., Bennett, 1965 and Strand, 1972). Bennett selected ten meadows and determined their condition, trend, and causes of such trends, and made recommendations for their future management. Strand revisited Bennett's transects in search of detectable trends in condition. Strand found some meadows in slightly deteriorating or slightly improving condition; others showed no trend. In general "those meadows which received the greatest amount of grazing were also those determined to be in a state of deterioration or which showed the least amount of recovery from a previously deteriorated state. This was determined by changes in the relative densities of forage species, low value species, and "invasion species" (Strand 1972). Mazzu (1987) reread transects in four of the original meadows sampled by Bennett and Strand, and found that the meadows closed to grazing showed increased species diversity relative to those that had continued to be grazed.

Grazing had been restricted on the meadows assessed by Strand and Bennett after the earlier Sharsmith and Sumner reports. The 1960 Backcountry Management Plan (Briggle et al. 1961) was the first attempt to formally implement the recommendations of Sharsmith and Sumner:

> Ecological studies in these Parks clearly indicate that overgrazing, not drought cycles and floods, has been the primary cause of meadow deterioration despite the beliefs of a few stockmen to the contrary (Briggle et al. 1961).

Both the 1960 and the 1986 plans agreed that the history of scientific study indicated that (1) prior to the use of restrictions, locally significant damage (i.e., deteriorating vegetation and soils) existed in the parks; (2) the result of restrictions had been a general slowdown in deterioration and, in many areas, improvement; (3) there is finite level of use which results in unacceptable impact, and past use patterns give some idea of what this level may be.

Widespread turn of the century grazing by sheep and cattle in the Sierra Nevada destabilized meadow wetlands by weakening sods, which allowed erosion channels to form, resulting in lower water tables and loss of meadow sediments. From the 1930s to 1980, park managers in Sequoia and Kings Canyon National Parks attempted to conserve soil and restore moisture in meadows by constructing check dams and fences, logging invading trees, rerouting trails, and altering grazing management. These efforts are documented in park file reports describing the activities of the dedicated Soil and Moisture Crews and were summarized for named meadows by Neuman (1990).

Popular and strategically located meadows and forage areas, many of which were reported to be in deteriorated condition during surveys conducted as late as 1959 (Sumner, 1941; Sharsmith, 1959) have been the continued focus of monitoring and management. Modern recreational and administrative stock use remains more localized than historic livestock use, with use concentrated along the primary trail corridors, on the Hockett Plateau, in the Roaring River area, and in the Kern Canyon. Of the total meadow area in SEKI, approximately half is currently open to grazing. During the period following implementation of the 1986 Stock Use and Meadow Management Plan (SUMMP), some level of use has been documented in approximately half of the meadows open to stock (Frenzel and Haultain 2013).

Stock grazing has declined in volume since the 1960s, with a trend towards more concentrated use in the past two decades (Hopkinson et al. 2013). In an analysis of use levels between 1985 and 2009, Hopkinson et al. found that grazing levels were relatively light in the majority of meadows, with almost half of the grazed meadows having less than one animal unit night (AUN)/acre per year reported. The number of meadows with at least one season of grazing over 90 AUN/acre decreased from 17 meadows between the years 1985-1997 to only 7 meadows in the period 1998-2009. Stock use on individual meadows was highly variable, with some meadows having significant use in one year and none in the next. Detailed discussions of recent use patterns can be found in the meadow sections of the Natural Resource Condition Assessment (Hopkinson et al. 2013), and in the annual summaries of stock use and grazing (e.g., Frenzel and Haultain 2013).

The Natural Resource Condition Assessment (NPS 2013) also assessed the condition of grazed meadows in the two parks through analysis of several decades of monitoring data. In an analysis of monitoring data collected from 25 grazed meadows between 2001 and 2009, Hopkinson et al. (2013) found a trend of increasing residual biomass, or the amount of vegetation left on a meadow at the end of the growing season, while that from comparable ungrazed meadows showed no statistically significant trend. It is likely that this reflects improved meadow condition due to an increased emphasis on residual biomass to inform stock management, with use levels managed to maintain acceptable levels of residual biomass in grazed meadows.

To evaluate stock grazing effects on plant species composition, data have been collected on a set of five paired grazed-ungrazed meadows over the past twenty-five years. Supporting earlier analyses of these data by McClaran and Neuman (1989) and Abbott et al. (2003), Hopkinson et al. found very little evidence for grazing-related compositional differences in the 5 paired meadows. They also reported that percent cover of bare ground was never statistically significantly different for any of the five meadow pairs' grazed and ungrazed meadows, and that temporal trends in bare ground were generally in tandem for paired grazed and ungrazed meadows. Based on these results, the authors found no strong evidence that current management of stock use has resulted in vegetation change in the five meadow pairs sampled. They were careful to note, however, that based on a five year grazing experiment in mountain meadows in Yosemite National Park, Cole et al. (2004) concluded that when grazing impact is light, species composition change is a less sensitive indicator of meadow condition than changes in productivity and ground cover; thus, the lack of strong differences in species composition between grazed and ungrazed meadow pairs may not definitively demonstrate that stock grazing has had no effect on the meadows.

A number of recent mapping efforts have addressed the value of spatially explicit information on the distribution of meadows in the two parks, both in support of grazing management and to establish a broader ecological knowledge base. Early maps of the meadows used by stock were based on black and white aerial photographs and delineated on 15 minute topographic maps (Neuman 1990). National Wetland Inventory maps based on remotely sensed imagery were created for the parks in 1996 (USFWS 1996); these included many of the wet meadow types, but by definition did not delineate upland types. In 2007 the first comprehensive association-level map of the vegetation of the two parks was completed (NPS 2007). Based on 1:15840 color infrared photography and traditional photo-interpretation methods, this map incorporated the information captured by the earlier wetland and meadow mapping efforts. In 2013, park ecologists completed the first map distinguishing peat accumulating wetlands and wet meadow complexes within park meadows (Pyrooz et al. 2014 in review), providing a level of detail that had not been discernible from the parks' 2007 vegetation map and insights into the distribution of peat accumulation across the landscape.

In addition to these mapping efforts, the hydrogeomorphic classification system developed by Weixelman et al. (2011) has recently been applied to a majority of the park meadows used by stock. Taken together, these studies and mapping efforts have made significant contributions to the understanding of the distribution, use and condition of park meadows.

PACK AND SADDLE STOCK MANAGEMENT HISTORY

Prior to the implementation of the 1986 SUMMP, grazing management in these Parks was not systematic. Heavily grazed meadows were identified sporadically and specific regulations established to lessen effects. Due to evidence of grazing effects, a framework for a systematic approach to meadow management was proposed in the early 1940s (Sumner 1941; Armstrong 1942). Flexible opening dates for specific forage areas based upon site conditions, limits on herbage removal, and long-term trend monitoring were to be the foundation of the system. All meadows then would receive protection based upon ecological factors and site-specific characteristics. Although the Armstrong-Sumner system was not implemented at the time, in many ways this approach was similar to that described and implemented by the 1986 SUMMP.

Concern about the condition of many wilderness meadows led to NPS support of an inventory of meadow conditions in 1959 (Sharsmith 1959). Sharsmith visited many Kings Canyon meadows previously surveyed by Sumner (1941) as well as meadows in Sequoia National Park. He qualitatively described trends in specific meadows through comparative photography and narratives. He concluded that many popular and strategically located meadows were in worse condition than at the time of Sumner's survey and were continuing to deteriorate. As a result of these studies, several meadows were added to the 1ists of those meadows closed to all grazing or subject to restricted grazing (NPS 1937, 1949, 1960-1964; Briggle et al. 1961). Use limits were established, including: head limits for specific forage areas (NPS 1949); closure of certain meadows to grazing and opening dates for meadows (NPS 1960-64; Briggle et al. 1961); and a limit of 20 head per stock party in 1966. At the same time, the NPS expanded management tools to include opening dates for meadows. A program to reroute trails out of meadows was initiated; lodgepole pine and other woody species thought to have encroached into meadows as a result of historic grazing were removed in several places. No cohesive set of criteria defining acceptable or allowable impact accompanied these actions, however.

In 1985, an effort to compile available information on the meadows and forage areas in the two parks was initiated (Neuman and McClaran 1989). Park ecologists expanded this work and in 1990 *Past and Present Conditions of Backcountry Meadows in Sequoia and Kings Canyon National Parks, 2nd Edition* (Neuman 1990) was completed. Building on an early inventory and classification of park meadows developed by DeBenedetti (1984), the resulting narrative recognized 333 forage areas and brought together site specific information on vegetation associations, use levels, management history and regulatory status, and condition from a wide variety of sources. The report also included maps of the meadows and forage areas derived from black and white aerial photographs (1964, 1:16000). This work provided a detailed history of the meadows in the park and established the context for implementation of the 1986 SUMMP.

The 1986 SUMMP established the first formal system for the management of stock use in SEKI. The plan identified which meadows would be open to grazing, and established a network of meadows to be permanently closed to grazing for the purposes of long term protection and study. It identified areas open to off-trail travel, and specified tools for managing stock use, including night and party size limits and the use of opening dates for controlling the onset of grazing. The plan also established minimum impact regulations and guidelines for the use of drift fences.

Recognizing that long-term information is necessary to document changes in conditions and to provide information on the effectiveness of the management program, the 1986 SUMMP also established a monitoring program. The objectives of this program were to track use levels, measure changes in plant species composition and bare ground over time, and using a system of photographic records, document coarse changes in meadow condition.

THE MANAGEMENT SYSTEM

The goals of managing recreational grazing in a National Park wilderness differ from those in areas devoted to the production of livestock; within the park, the protection of naturally functioning meadow ecosystems is given greater weight than the provisioning of forage for stock. Grazing by recreational stock is inherently less predictable than that of production oriented livestock systems, as different numbers and types of animals, led by different handlers, arrive at varying times throughout the season. A successful management system must have the flexibility to address the variable nature of the timing and intensity of grazing by recreational stock, site-specific responses to grazing, and the inherent variability in productivity of meadow systems in response to changing weather and climate.

Under the preferred alternative, management of stock use in the wilderness of Sequoia and Kings Canyon would continue to use the grazing management tools described in the 1986 SUMMP, which are based in part on traditional range management techniques and adapted for use in the wilderness setting. In their review of pack stock monitoring and management in wilderness, McClaran and Cole (1993) recognized the strengths of the program established by the 1986 SUMMP. However, they also called attention to two weaknesses: the application of a single uniform grazing standard to all park meadows, and the absence of defoliation standards. The management and monitoring systems described below represent an attempt to correct those deficiencies, through 1) the development of site specific grazing capacities that can be modified to take into account different management objectives at the meadow scale, and 2) the continued implementation of residual biomass monitoring in frequently grazed meadows.

Management actions would continue to be applied at the scale of the forage area. Forage areas are defined as the primary meadows and their associated forested or upland grasslands, which are commonly used by stock for grazing. Other areas within accessible proximity of the trails and travel zones open to use, although not designated as forage areas and not having an established use level, may also be used for grazing by stock. The 1986 SUMMP recognized that the primary meadow within each of the forage areas was likely the most sensitive to the influence of grazing and would reflect early change. The primary meadow would continue to be the focus of monitoring and used as a barometer to guide decisions on future adjustments in timing and level of grazing use.

Stock permitted within Sequoia and Kings Canyon National Parks would continue to include only horses, mules, burros, and llamas. Goats would remain specifically prohibited as they can carry diseases that threaten native bighorn sheep.

GRAZING MANAGEMENT TOOLS AND TECHNIQUES

Opening Dates

Opening dates are established for all park forage areas. These dates are designed to prevent mechanical disturbance to surface soil and vegetation that results in the breakage of the root-soil complex to the point that vigor of individual plants (or networks of plants) deteriorates as evidenced by deeply incised hoof prints, change in species density, or composition, or both. Such breakage increases soil erosion over what would be natural without grazing. Opening dates also allow for adequate plant development to replenish carbohydrate stores expended in spring and allow plants to reproduce. Meadow vegetation provides an important source of floral and seed forage for native fauna (Frase and Armitage 1989, Hatfield and Lebuhn 2007, Hoffman Black et. al. 2011, Holmquist et al. 2001, Smith and Weston 1990). Delaying grazing in meadows thus may allow for many species of wildlife, such as birds, small mammals, invertebrates, and amphibians, to complete critical portions of their life cycles prior to the onset of grazing.

Specific opening date estimates for the parks' major forage areas are based on quantitative data gathered from individual meadows between 1977 and 1984. Moisture conditions and associated physical impacts by stock were tracked in specific plant associations throughout the season in several dozen meadows over the course of the entire study period. A number of other meadows were evaluated less frequently. In meadows where specific data did not exist for all types of hydrological years, or where only one data point was available, extrapolations were made based on similar vegetation, location, and comparable meadow physiography.

In the initial five-year (1977-81) effort to monitor moisture conditions in individual plant associations in specific forage areas, it was found that moisture was retained at or near the surface for two to four times longer than the norm for that site when the water content of the April 1 or May 1 snowpack exceeded 150 percent of the long-term average. The actual time beyond the norm required for meadow vegetation to dry to a point where trampling damage does not occur depends primarily upon the type of plant associations present in the meadow. Late spring and early summer weather conditions, the topographic position of the meadow, and the size of the watershed it resides in may also cause some variation in this date. Correspondingly, meadows were found to retain moisture for a period of one to three weeks less than the norm during the years where the April 1 or May 1 snowpack was below 50 percent of the long-term average. While these relationships certainly occur along a gradient, the 50 percent and 150 percent level breaking points were found to correlate well with obvious wet (i.e., 1969, 1973, 1978, 1980) and dry (i.e., 1972, 1976, 1977) years.

Based on these results, opening dates for wet, dry, and normal years have been prescribed for the major forage areas based on the water content of the May 1 snowpack. Years in which the May 1 snowpack represents 50% to 150% of the long-term average are characterized as ‘normal’; those ranging from 50% or less of the long-term average are characterized as ‘dry’; and those 150% or more of the long-term average are considered ‘wet’.

Opening dates are keyed to sensitive vegetation and soil within the forage area. Sensitive vegetation and soils are defined as the plant associations and soil surfaces that are most susceptible to trampling damage and would be expected to be trod upon by free-roaming animals when present; or that are especially sensitive to herbage removal. The key plant association may not necessarily comprise a majority of the specific meadow. In nearly all cases, the key association accounts for at least 15 percent of the total meadow area.

Opening dates vary considerably depending on both climatic and topographic factors, as described above. The general range is from mid-July to mid-August for normal years, with some locations earlier or later depending on their characteristics. Opening dates in wet years are later and dry years earlier. Opening dates are established so that, generally, once a given drainage basin is open to use, the entire basin is open. Necessary protection of the resource is provided and the system is simplified for both the stock user and park management. Actual opening dates are seldom the specific dates predicted by the May 1 snowpack because field conditions vary from year to year. For example, on a year classified as normal it may be found that the actual conditions for a specific meadow or basin trend toward dry, so the actual opening date would be set somewhere between the normal and dry season date. Similarly, late lying snows in what would otherwise be characterized as a normal year can lead to delays in opening until soils are sufficiently dry. Opening dates remain flexible according to actual field conditions and staff in the field would continue to be able to make adjustments as needed to respond to observed conditions.

Tentative opening dates would continue to be made available following the April l snow survey. Opening dates for specific forage areas would continue to be established immediately following receipt of the results of the May l snow survey each year. Specific opening dates are listed in Table D-1.

Table D-1: Anticipated Opening Dates by Travel Zone and Moisture Year

TRAVEL ZONE	FORAGE AREA NUMBER	NAME OF TRAVEL ZONE OR FORAGE AREA	DRY YEAR <50% of average snowpack	NORMAL YEAR 50%-150% of average snowpack	WET YEAR >150% of average snowpack
28		Goddard Canyon	1-Jul	15-Jul	1-Aug
33		Evolution	15-Jun	1-Jul	15-Aug
33		McClure/Colby	7-Jul	1-Aug	31-Aug
33		McGee Canyon	15-Jul	1-Aug	31-Aug
34		Evolution Basin	15-Jul	1-Aug	15-Aug
38		Blue Canyon	1-Jul	15-Jul	1-Aug
39		LeConte	1-Jul	15-Jul	15-Aug
42		Dusy Creek	1-Jul	15-Jul	15-Aug
45		Upper Palisade Creek	1-Jul	15-Jul	15-Aug
46		Upper S. Fork Kings River/Above JMT Jxn.	15-Jul	1-Aug	15-Aug
46		Upper S. Fork Kings River/Below JMT Jxn.	1-Jul	15-Jul	15-Aug
47		Cartridge Cr.-S. Fork Kings River	15-Jul	1-Aug	15-Aug
51		Gnat Meadow	1-Jul	15-Jul	1-Aug
51		Simpson Meadow	1-Jul	15-Jul	1-Aug
52		Kennedy Canyon	1-Jul	15-Jul	1-Aug
53		N. Side Granite Pass	15-Jul	1-Aug	15-Aug
53		Horseshoe/State Lakes	15-Jul	1-Aug	15-Aug
53	7	Shorty's Meadow	1-Aug	15-Aug	31-Aug
54		Granite Basin	20-Jun	7-Jul	1-Aug
56		Twin Lakes	1-Jul	15-Jul	1-Aug
57		Woods Lake Basin	15-Jul	1-Aug	15-Aug
58		Castle Domes	1-Jul	15-Jul	1-Aug
58		Baxter	7-Jul	21-Jul	1-Aug
58	2	Woods Creek Crossing	7-Jul	21-Jul	1-Aug
61		Sixty Lakes Basin	7-Jul	21-Jul	20-Aug
63		Charlotte	1-Jul	15-Jul	1-Aug
65		Vidette	1-Jul	15-Jul	1-Aug

TRAVEL ZONE	FORAGE AREA NUMBER	NAME OF TRAVEL ZONE OR FORAGE AREA	DRY YEAR <50% of average snowpack	NORMAL YEAR 50%-150% of average snowpack	WET YEAR >150% of average snowpack
66		Junction Mdw. (Bubbs)	15-Jun	1-Jul	20-Jul
67		East Lake	1-Jul	10-Jul	20-Jul
68		Sphinx Creek	15-Jun	1-Jul	20-Jul
69		Roaring River	10-Jun	25-Jun	20-Jul
70		Cloud Canyon	10-Jun	1-Jul	20-Jul
71		Deadman Canyon	15-Jun	1-Jul	20-Jul
72		Sugarloaf	15-Jun	1-Jul	15-Jul
72		Ferguson	15-Jun	1-Jul	20-Jul
72		Crowley Canyon	15-Jun	1-Jul	20-Jul
73		Ball Dome Area	15-Jun	1-Jul	20-Jul
74		Clover-Silliman Creeks	15-Jun	1-Jul	20-Jul
75		Lone Pine Creek	1-Jul	15-Jul	1-Aug
77		Cliff Creek/Pinto Lake	15-Jun	1-Jul	1-Aug
77		Redwood Meadow	1-Jun	15-Jun	1-Aug
77	1	Bearpaw Meadow	15-Jun	1-Jul	1-Aug
79		Milestone	1-Jul	15-Jul	5-Aug
79		Kern/Kaweah	1-Jul	15-Jul	1-Aug
80		Tyndall Creek	20-Jun	1-Jul	25-Jul
81		Wright/Wallace Creeks	20-Jun	1-Jul	25-Jul
81	2.3	Wallace Creek Waterfall	1-Jul	15-Jul	10-Aug
82		Junction Mdw. (Kern)	25-Jun	5-Jul	25-Jul
86		Funston/Upper Funston	1-Jun	15-Jun	1-Jul
83		Lower Crabtree	20-Jun	1-Jul	1-Aug
83	4	Upper Crabtree	5-Jul	15-Jul	20-Aug
84		Lower Rock Creek	20-Jun	1-Jul	1-Aug
85		Upper Rock Creek	1-Jul	15-Jul	15-Aug
86		Lower Kern Canyon (Hot Springs to Kern Ranger Station)	1-Jun	15-Jun	1-Jul
87		Chagoopa/Big Arroyo	20-Jun	10-Jul	10-Aug
88		Big Five	15-Jul	25-Jul	15-Aug
88		Little Five	1-Jul	15-Jul	10-Aug
89		Rattlesnake/Forester	15-Jun	1-Jul	1-Aug
89		Rattlesnake >9,000 ft.	1-Jul	15-Jul	15-Aug
90		Hockett	10-Jun	20-Jun	20-Jul

TRAVEL ZONE	FORAGE AREA NUMBER	NAME OF TRAVEL ZONE OR FORAGE AREA	DRY YEAR <50% of average snowpack	NORMAL YEAR 50%-150% of average snowpack	WET YEAR >150% of average snowpack
91		South Fork Kaweah River	1-Mar	15-Mar	1-Apr
92		Monarch-Franklin Creeks	1-Jul	15-Jul	1-Aug
93		White Chief-Eagle-Mosquito Creeks	1-Jul	15-Jul	1-Aug
94		Mineral Creek	1-Jul	15-Jul	1-Aug
95		North Fork Kaweah River	1-Mar	15-Mar	1-Apr
96		Redwood Canyon	1-Jun	15-Jun	1-Jul

Grazing Levels

The total amount of grazing in each of the meadows and related forage areas open to grazing would be guided by the estimated grazing capacities described in attachment 1. Due to the inherent delays in use reporting and the variability in the timing and intensity of recreational grazing, actual use of individual areas may be somewhat higher than the estimated capacity in some years and lower in others. For this reason administrative use of specific forage areas which are also used by the public would be kept below the estimated capacity and work would be planned to minimize competition for grazing.

Traditional methods of adjusting grazing levels and patterns would be employed when necessary, including:

- adjusting the number of nights a given party may graze an area
- adjusting the number of stock per party that may graze in a specific area
- allocation of grazing to specific users (administrative, commercial, or private)
- adjusting opening dates
- closing an area to grazing (or a portion of it, if feasible) temporarily, as conditions warrant.

For the purpose of calculating grazing levels, an overnight stay by one pack or saddle animal is referred to as a stock night. Because the amount of foliage consumed is related to the size of the animal, grazing by different animals (horses, mules, burros, and llamas) can be expressed on a common scale of animal unit nights (AUN) based on the amount of forage consumed by a 1000 lb. animal in one night. Thirty animal-nights are equal to one animal unit month (AUM). An overnight stay by a horse or mule is defined as 1.25 AUN, by a burro is 0.5 AUN, and by a llama 0.35 AUN.

Certain forage areas have traditionally received heavier use and would be monitored annually to detect departure from natural conditions as determined through the monitoring program. If use pressure lessens on any given forage area, monitoring frequency could be reduced. As a guideline, areas receiving high levels of use (80% or greater of the estimated capacity) would be monitored annually, those receiving moderate use (50-79% of the estimated capacity) would be monitored biannually (or annually if resources are available), and those areas that are lightly used (less than 50% of the estimated capacity) would be monitored at least every five years.

Forage areas may be temporarily closed to grazing due to stock impacts and when recovery has been sufficient those areas would be reopened. Such closures would be recommended to the appropriate district ranger by field personnel during the grazing season for immediate implementation, or proposed to the Superintendent following the annual review of monitoring results for implementation during the following season. All use levels would be subject to change as monitoring data indicate. Changes would be announced by March 1st of each year, with opportunity for comment by interested parties. In order to ensure that the estimated capacities reflect the most current knowledge of meadow response to grazing, capacities would undergo a comprehensive reevaluation every five years, with annual modifications as needed to ensure resource protection. Changes to capacities would be made available for public comment by March 1st of each year along with other public use limits.

Trail Use and Off-trail/Cross-country Stock Travel

The majority of wilderness stock use occurs on the primary trail system in the parks. Current regulations (36 CFR Sec. 2.16 (b)) require that the Superintendent designate areas and trails that are open to stock travel. The areas and trails proposed open to stock travel under the preferred alternative are described in chapter 2 of this WSP/DEIS (refer to figures 8a and 8b [alternative 1], figures 14a and 14b [alternative 2], 17a and 17b [alternative 3], 19a and 19b [alternative 4], and 22a and 22b [alternative 5] in chapter 2 for stock access and grazing restrictions).

Maintained Trails

Under the preferred alternative, visitors traveling with stock would continue to have access to most maintained trails in the parks (653 of 695 miles). Stock parties would be allowed to travel up to one-half mile from trails in areas where they are allowed to camp. In areas open to day-use only, stock parties would be allowed to travel up to 100 yards from trails. Approximately 534 miles of maintained trails would be open to overnight stock travel. Some trails would be open to stock parties for day use only, some would be open to overnight use for walking parties with burros and llamas (as they cannot travel as far in a day) but limited to day use for parties with horses or mules, and some would be closed to stock travel entirely for reasons including visitor safety, natural and cultural resource protection, and/or popular day use by hikers. Trails with restricted stock access under the preferred alternative are listed in chapter 2 of this WSP/DEIS.

Off-Trail Travel

Stock parties would continue to be allowed to travel up to one-half mile from trails to reach camps. Travel more than one-half mile from maintained trails would continue to be allowed in four areas of the parks: on the Hockett Plateau, on the Monarch Divide, in the Roaring River drainage, and along the western side of the Kern River watershed south from the Chagoopa Plateau (except the lower Big Arroyo, which would be closed to stock travel to protect wetlands).

Trails and areas open to use may be changed from time to time in order to provide for visitor safety or resource protection. Areas or trails that have been closed may be reopened where there is evidence that no park resources or other values would be compromised. Unless in response to emergency conditions, the public would be notified of proposed modifications of areas and trails open to stock through press release and posting on the parks website; comments would be sought before a decision is made.

Drift Fences, Hitch Rails, and Temporary Means for Holding Stock

Preventing stock from leaving a preferred grazing area and entering areas where grazing is prohibited can be challenging. In areas of higher use that are adjacent to sensitive or at risk resources, drift fences can be a tool to prevent stock from traveling away from the preferred grazing area into closed areas. Besides drift fences, users would have a wide variety of tools at their disposal which could be used to manage their stock. These tools would include electric fences, hobbles, high lines, hand grazing and in limited circumstances, pickets. These tools, often used in combination with natural features, can be effective in containing stock.

In some instances users may be able to use a temporary barrier at a pinch point to contain stock. These temporary barriers can be a very effective and low impact tool to contain stock. Temporary barriers which have been successfully used at pinch points include logs and ropes. When users are considering using a temporary barrier at a pinch point, great consideration must be given to doing so without hampering the travel of other users. Temporary barriers may only be used when stock is actually roaming free in permitted grazing areas and they must be removed when the stock is gathered. Damaging natural resources when constructing temporary barriers is prohibited.

Drift fences and hitch rails would be provided by the NPS in specific locations for visitor safety, resource protection, and visitor or administrative convenience. Fences maintained primarily for convenience would also protect resources and visitor experience, through dispersal of stock use and protection of sensitive areas. Fences and hitch rails that become unnecessary would be removed. An inventory of such installations in wilderness would be maintained by the trails program with input from wilderness field staff, and maintenance conducted under the direction of the trail maintenance program. The establishment of any new fence or hitch rail, temporary or permanent, would require separate planning and compliance, which would be conducted prior to construction. Detailed justification including a minimum requirements analysis and a description of the fence route and dimensions would be required for consideration.

The treatment of specific hitch rails and drift fences varies by alternative in this WSP/DEIS; see table 51b in chapter 2 for a list of those retained under the preferred alternative.

Minimum Impact Regulations for Stock Use

To minimize the impact of stock to camps and trails and to allow for the restoration of impacted areas, the following regulations would continue to be enforced:

1) Stock would be tethered to trees for no more than enough time to unpack the animals. Animals pawing the soil away at the base of individual trees cause soil disturbance, root damage, and debarking of trees. Deep depressions and exposed roots are visible evidence of the types of impacts this regulation is designed to prevent.

2) Stock held for periods longer than for unpacking (such as for overnight), would be tethered to a line tied between two trees or rocks. The line must be located on a hardened (flat, sparsely vegetated) site to limit impacts to tree roots and plants.

3) Picketing would be allowed for short periods of time provided that animals are moved frequently to prevent resource impacts.

4) The use of temporary electric fences is recommended for holding lead animals when stock are turned out to graze; as with picketing, such enclosures must be moved frequently to prevent resource impacts.

5) When camping, animals would not be confined within 100 feet of lakes, streams, trails or campsites except while loading or unloading. Manure deposited within or at the perimeter of camps while loading or unloading would be dispersed and scattered to points at least 100 feet

from camps, water, or trails. This distance protects water quality, lessens impact on the campsite, and helps reduce insect problems.

6) Stock present in forage areas prior to opening dates or areas closed to grazing would be confined as per (2) and (3), and fed.

7) Short-cutting trails and switchbacks would be prohibited.

8) Loose herding—when rider-less animals are not being led by ropes—would be prohibited except as necessary for safety where the exposure is great and there is danger of animals falling off the trail.

In addition to the above regulations, guidelines for minimum impact travel with stock would continue to be provided to all users.

NETWORK OF MEADOWS CLOSED TO GRAZING

A series of meadows would continue to be closed to grazing to provide opportunities to compare ungrazed meadows with grazed meadows as part of the monitoring program, to provide opportunity for scientific study of meadows that are not affected by stock grazing, and to provide opportunities for park visitors to observe a representative sample of meadows, in proximity to general travel routes, that are not affected by grazing.

For scientific study purposes, a major value of Sequoia and Kings Canyon (an International Biosphere Reserve) is that it contains ecosystems that are as undisturbed by human activities as is reasonably possible. Meadows that are representative of each significant type (by physiography, origin, plant associations, and unique features) would continue to be protected from grazing by stock. Basin, slope, and streamside stringer meadows; meadows of pre-glacial and post-glacial origins; and meadows representative of the area's common meadow plant associations were identified by the SUMMP and would continue to be included in this category. A selection of meadows closed to grazing would be accessible by trail so that they can easily be observed by the public and accessed efficiently for scientific study.

Table D-2: Network of Meadows Closed to Grazing for Scientific and Social Value

Meadows Designated in 1986 SUMMP	Proposed Additions (Under NPS Preferred Alternative)
Big Pete Meadow forested portion	Bighorn Plateau
Crabtree Ranger Station Meadow	Meadows south of Bighorn Plateau and west of the JMT and north of Wright Creek
Dragon Lake Meadow	Chagoopa Plateau #3 Meadow
Ellis Meadow	Darwin Meadow
Goddard Creek Meadows	Grouse Meadow
Guyot Creek Meadows west of trail	Guyot Creek Meadows east of trail
Lake South America Col Meadow	Lower Crabtree Meadow
Mitchell Meadow	Taboose Pass Meadow
Rock Creek Ranger Station Meadow	Woods Lake Basin Meadows
Rock Creek #2 Meadow	
Wallace Creek Closed Meadow	
Woods Lake Shoreline Meadow	
Wright Creek Closed Meadow	

Meadows that would be closed to grazing under the NPS preferred alternative are listed in chapter 2 of this DEIS.

TEMPORARY VARIANCES

Climatic conditions, accessibility to portions of the wilderness, needs and interests of wilderness stock parties, and other factors change from year to year, making it possible to consider temporary variances in site specific guidelines.

Variances could be made in opening dates, numbers of stock per trip, number of nights per area, number of stock per area, etc. Such variances would normally be granted on a case-by-case basis to accommodate special visitor needs where the effects on wilderness character, park resources and other visitors would be within acceptable limits. Short-term or one-time-only variances proposed by visitors would be considered on a case-by case basis by the Superintendent, and if approved would likely be subject to special conditions. Requests for variances should be made in writing at least four weeks in advance to provide adequate time for consideration.

RESOURCE REHABILITATION AND RESTORATION

In areas where past use has caused detrimental effects to vegetation, soils or other resources, the NPS would evaluate the effects and may undertake rehabilitation or restoration. This could include actions such as filling eroded trail beds or hitching areas and revegetating the areas. It could also include re-routing of trail segments to avoid sensitive resources, relocating camps, or the removal of nonnative plant species. Such trail management activities would be guided by the trails management plan described in appendix K of this plan, while the control of non-native plants would be guided by appendix N of this plan, the Resource Stewardship Strategy (in development) and/or a future Invasive Plant Management Plan.

MONITORING STRATEGY AND THRESHOLDS FOR MANAGEMENT ACTION

Long-term information on the condition of meadows, and on stock use levels and patterns, is necessary to provide information on the effectiveness of the management program, document changes in conditions, and to inform the management of stock and the meadow systems they use.

The strategy for monitoring stock use and meadow condition includes protocols for

- monitoring stock use,
- setting opening dates,
- monitoring residual biomass,
- monitoring species composition,
- monitoring bare soil,
- rapid assessment of meadow condition
- photographic documentation of conditions and trends.

Within each forage area, the primary meadows would be routinely evaluated to assess the status of soils and vegetation. The forage areas open to grazing under each alternative are illustrated on the stock use and grazing alternatives maps provided in chapter 2 of this WSP/DEIS. The condition of the most heavily used portions of the forage area would be used to indicate the status of surrounding and associated areas grazed by stock. If conditions in the most heavily used areas remain within established standards (see sections 5.3.1-5.3.4), the rest of the forage area will likely meet standards as well. If the species composition, density, and soil condition in the primary meadows remain comparable to similar but ungrazed meadows, it is assumed that the associated meadows will remain in good health. Because stock may graze areas outside of the primary named meadows, these areas would also be assessed during site visits but would not be the subject of the formal monitoring protocols.

STOCK USE

In this WSP/DEIS, stock users are divided into three classes: administrative, commercial, and private. Administrative users are those that are employed by the NPS and who use pack stock in order to carry out their official duties. Commercial users are entities that provide saddle and or pack stock as a paid service. Companies or individuals of this class are required to hold a NPS issued Commercial Use Authorization (CUA) or be a licensed in-park concession. Private use is packing and riding done by an individual with friends or family; only a wilderness permit is required for this class of use. At times commercial packers are employed to provide support for administrative activities. This use would continue to be attributed as commercial for tracking purposes but classified as serving an administrative function, and thus not count towards commercial service allocations.

All stock parties would continue to be required to report their itineraries after completing their trips. Monthly reports of commercial stock use would be due to the Concessions Management Office according to the requirements established by the relevant Commercial Use Authorization or concessions contract. Commercial service providers would continue to be required to report day use in wilderness, including trail rides, resupply, and spot and dunnage trips whether or not any grazing occurred. Administrative use would continue to be reported monthly, while private users would be requested to submit their reports at the end of the season.

The location of each overnight camp, the number of people and stock present, the corresponding dates, and the number of stock fed or grazed would be reported. Stock use reporting forms would be provided to commercial pack stations, NPS and USFS trailheads and administrative packers. Private stock parties would be given reporting cards when obtaining wilderness permits, or when encountered by wilderness rangers in the field. Wilderness rangers would be given a supply of cards each spring for distribution to users, and are also charged with documenting all observed use within their patrol area. The self-reported use data, along with the wilderness ranger observations, would continue to be compiled and compared against records from the wilderness permit database. This combined information would continue to be summarized and reported annually. Data would be presented in tabular and graph form, and comparison with past years use presented. Where possible, trends and patterns would be identified and the potential causes discussed. Stock use data would continue to provide information that helps show what levels of stock use resulted in present conditions and would be used to inform the annual discussion of wilderness conditions and any proposed changes to management or regulations.

Thresholds for Management Action

Meadows in which use exceeds the estimated capacity (see Attachment 1) would be monitored for impacts and their use adjusted to provide for recovery if needed. Wilderness rangers would continue to track use in the field and notify the wilderness office when the estimated capacity of a meadow is approached. Self-reported commercial and administrative use would be similarly reviewed by plant ecology staff as reports become available. If field assessment and monitoring results (e.g., bare soil, vegetation, and/or residual biomass) show any significant further departure from conditions of comparable meadows, use levels and patterns may be adjusted. Increased use may be allowed where information from the monitoring program indicates.

Opening Dates

As described above, opening dates have been prescribed for all park forage areas and would continue to be implemented as a management tool. Site conditions during early season site visits and departures from the opening dates anticipated by the May 1 snow survey results would continue to be monitored and documented.

Established opening dates would continue to be compared with on-site conditions in specific forage areas, as reflected from field data, and adjustments to the normal dates in the plan made when necessary. Actual opening dates would be documented each year and summarized as part of the annual report on stock use monitoring. Studies of the effects of early season use and its relationship to climatic conditions would continue as time and resources allow. As more information and experience are gained, the large range of moisture content included in the definition of a normal year may be narrowed, or adjusted for specific forage areas.

Vegetation and Soils

The primary emphasis of the vegetation and soils components of the monitoring program is to measure changes in productivity, species composition and bare soil over time and to provide for the early detection of nonnative plant species. Four protocols (residual biomass, species composition, bare soil, and repeat photography) developed to address these topics are described below; detailed protocols will be included in the FEIS. Each of these protocols would be implemented in a subset of targeted meadows, which will likely fluctuate in response to availability of staff time and expertise. Site visits by wilderness patrol and meadow monitoring staff would continue to be made to meadows not included in one of these sampling efforts with the goal of monitoring conditions in all meadows used by stock. Site visits would serve to document conditions in meadows used by stock using a standardized rapid assessment protocol (in development) and would include written descriptions of soil and vegetation conditions, presence of nonnative species, impacts of concern, use patterns, and any additional relevant observations.

Residual Biomass

Residual biomass refers to the amount of above ground plant material present in a meadow after grazing. In systems dominated by herbaceous plants, adequate residue serves to protect soil surfaces and plants, to replenish the soil mulch and organic layers, and to trap and hold moisture. Ungrazed vegetation also provides shelter and forage for animals that depend on meadows for all or part of their life cycles. As such, residual biomass is both an important contributor to meadow function and an indicator of grazing impacts that can provide a quantifiable and repeatable measure to guide management. In remote areas where the timing and duration of grazing is unpredictable and the collection of data on plant growth to generate precise estimates of plant productivity is prohibitively costly, monitoring residual biomass on ungrazed sites provides an efficient proxy measure of productivity.

The comparative yield method of estimating residual biomass (Haydock and Shaw 1975) was modified and adopted for use in the wilderness meadows of Sequoia and Kings Canyon National Parks in 1993 (Neuman 1993). In this method, reference quadrats are selected in the field to represent a linear scale of biomass within a designated plot. These quadrats then serve as standards against which the yields of 150-200 systematically selected quadrats are estimated by eye. The ocular estimates are calibrated using the dry matter yields of the original standards and two additional sets of standards that are clipped following the sampling. This procedure is applied to both a core (grazed) and reference (ungrazed) plot within each meadow. The protocol was specifically designed to be used by non-specialists (such as wilderness rangers and packers) and to avoid the installation of permanent markers in wilderness. Each year wilderness rangers at Sequoia and Kings Canyon would continue to undergo training in residual biomass monitoring, with field oversight and assistance provided by the plant ecology program to assure data consistency and quality.

The locations of the core and reference plots would continue to be documented using photographs and distance and direction to recognizable features. Although the plots would not be permanently marked, this allows for sampling to take place in the same area year after year. As animals tend to graze close to established camps and in favored areas, the location of the plots generally coincides with the area of concentrated use and impact.

The amount of biomass remaining at the end of the growing season would continue to be estimated using this method in approximately 35 meadows in any given year. The first priorities for residual biomass monitoring would be those meadows that are regularly grazed by stock at levels approaching the estimated capacity, and/or which show signs of heavy use. Core plots would continue to be located subjectively within the area of greatest grazing impact on the assumption that if the impacts there are considered acceptable, then the rest of the meadow will also fall within management standards (Schelz 1996). Whenever possible, an ungrazed reference plot would be located in an area that is both biotically and abiotically comparable to the core plot. Optimally the reference plot would also be located within the same meadow; where this is not possible due to the presence of grazing impacts throughout the meadow, a similar site in an adjacent meadow area may be selected. Both core and reference plots may vary in size depending on the size of the meadow being monitored.

Residual biomass monitoring data would continue to be summarized and reported annually. As with the stock use data, these data would continue to be presented in tabular and graph form, and comparison with past years presented. Where possible, trends and patterns would be identified and the potential causes discussed. This information would continue to be coupled with the stock use data and used to inform the annual discussion of wilderness conditions and any proposed changes to management or regulations.

Thresholds for Management Action

Residual biomass monitoring provides meadow production and utilization data that are essential to inform strategies for meadow management. Residual biomass data would continue to be used to identify trends in productivity in individual meadows. These meadows could then be selected for more detailed investigative study and management actions considered. Meadows exhibiting a downward trend in residual biomass or where residual biomass results indicate that actual utilization levels in the core area exceed the established standard (utilization standards, expressed as the proportion of meadow vegetation available for grazing, are provided in Attachment 1) would be candidates for such attention. Grazing levels would be then be adjusted until conditions improved. These guidelines would be periodically revised to reflect increased knowledge about the relationship between utilization and impacts.

Species Composition

To evaluate grazing effects on plant species composition, data have been collected from five pairs of grazed and ungrazed meadows over the past twenty-five years. Data were collected on the first meadow pair in 1985 and since then sampling has been conducted on four other meadow pairs, resampling every pair on an approximately 5-year rotation. Meadow pairs selected for monitoring are located at East Lake and on the Monarch Divide in Kings Canyon National Park, and on the Hockett Plateau and in the Upper and Lower Rock Creek drainage in Sequoia National Park. The meadow pairs represent several different meadow types, including fine sedge (*Eleocharis pauciflora*), medium sedge (*Carex scopulorum* var.

bracteosa)-grass-herb, tall grass (*Deschampsia cespitosa*) and sedge-herb, fine grass (*Calamagrostis breweri*) and sedge-herb, and wide sedge (*Carex utriculata*)-fine grass (*Calamagrostis breweri*)-herb (as described by DeBenedetti 1984).

The sampling protocol implemented in Sequoia and Kings Canyon National Parks was developed by McClaran and Neuman (1989) specifically for use in wilderness and is described in detail in Frenzel and Haultain (2010a) and McClaran and Neuman (1989). Briefly, a single large plot (approximately 500 to 3,000 m^2) has been permanently established in the grazed and ungrazed meadows of each meadow pair. Each plot is divided into 10–15 equal subareas; within these 10–15 subareas, 10–20 25 x 25 cm quadrats are haphazardly located (to avoid bias) during the sampling event, for a total of 100 to 200 quadrats per meadow. The number of quadrats is determined by the vegetation type and is the same for all sampling years for a given meadow. All species rooted within the quadrat are recorded, as are the presence of moss and hoof prints greater than 2.5 cm deep; percentage of bare ground within the quadrat is also recorded. The same data are collected for a 10 x 10 cm quadrat nested within the 25 x 25 cm quadrat. The resulting metric is a species' frequency of occurrence in the 100-200 quadrats of each large plot.

Thresholds for Management Action

In comparing species composition of the paired grazed and ungrazed areas beginning with the base year of the monitoring program, modifications to grazing use levels and patterns would be necessary when the grazed area shows 1) more than 15 percent change in the dominant species as recorded by the frequency plots, or 2) more than a 15 percent change in the proportion of bare ground and with observed erosion.

Bare Soil

The amount and distribution of bare soil is considered an important indicator of meadow integrity as it directly relates to site stability and susceptibility to erosion (Smith and Wischmeier 1962; Morgan 1986; Benkobi et al. 1993; Blackburn and Pierson 1994; Gutierrez and Hernandez 1996; Cerda 1999). Grazing has been linked to increases in bare soil as well as decreased plant cover, decreased primary productivity, and shifts in species composition (Miller and Donart 1981; Trimble and Mendel 1995; Olson-Rutz et al. 1996; Fahnestock and Detling 2000; Cole et al. 2004). Trampling, by either humans or stock, can produce similar results (Cole 1995; Liddle 1975, 1991) with the added impact of soil compaction that compromises root growth and water infiltration (Gilman et al. 1987; Unger and Kaspar 1994; Pietola et al. 2005).

Bare soil is considered a more sensitive indicator of meadow condition than species composition (Cole et al. 2004), as it increases at lower levels of disturbance compared with shifts in species composition in a variety of montane vegetation types of North America (including alpine meadows) (Cole 1993). Plant productivity may be more sensitive to grazing pressure than bare soil (Cole et al. 2004), but is more time consuming and costly to monitor in wilderness settings and is also subject to high interannual variability in response to climatic factors (Moore et al. 2013), such as the timing and amount of precipitation (Walker et al. 1994), snowpack, or snowmelt (Walker et al. 1995). Because bare soil measured from point data is efficient, objective, easily obtained, and repeatable across time and observers, it has been used to assess meadow condition in Sierra Nevada meadows by the USFS (Weixelman and Zamudio 2001) and has recently been adopted as an indicator of meadow condition in Yosemite National Park (NPS 2014 and 2014b).

Weixelman and Zamudio (2001) classified bare soil cover values into low, moderate and high ecological condition classes based on monitoring data from a comprehensive multi-year study in U.S. Forest Service meadows in the Sierra Nevada (table D-3). These condition classes for bare soil values are based on point-intercept data collected from 363 meadows across a broad disturbance gradient (Weixelman and

Zamudio 2001). The values for bare soil cover that define the ecological condition classes presented by Weixelman and Zamudio (2001) vary according to moisture regime and elevation. For example, to be in a high condition class, a moist (mesic) meadow would not have bare soil exceeding 6% of its surface area, and a wet (hydric) montane meadow (6,000-8,000 feet) would not have bare soil exceeding 4%. These values have recently been used as a starting point to inform condition class development in Yosemite National Park (NPS 2014a and 2014b) and are provided below as an example of how they may be applied in Sequoia and Kings Canyon National Parks. Note that the meadows included in the sample described by Weixelman and Zamudio occur at lower elevations than many park meadows, reflecting both latitudinal effects and the preference of the use of montane meadows for livestock grazing in the National Forests.

Table D-3: Bare Soil Cover Values for Ecological Condition Classes among Sierra Nevada Meadow Types

Meadow Type	High Condition	Moderate Condition	Low Condition
Montane			
Hydric meadow	0-4%	5-9%	>9%
Mesic meadow	0-6%	7-13%	>13%
Xeric meadow	0-8%	9-13%	>13%
Subalpine			
Hydric meadow	0-4%	5-8%	>8%
Mesic meadow	0-6%	7-13%	>13%
Xeric meadow	TBD	TBD	TBD

NOTES: The montane zone is about 6,000 to 9,000 feet in elevation and the subalpine zone is 9,000 to 10,000 feet in elevation in the southern Sierra.
From Weixelman et al. 2001; as presented in the Yosemite National Park Merced River Plan FEIS 2014
These values are provisional and will be subject to revision following further study in park meadows.

Estimates of bare soil (and other groundcover categories, e.g., litter and duff) would continue to be collected during residual biomass monitoring (using the step-point method) and species composition monitoring (as cover data associated with each frequency quadrat). These measures have been used in concert with residual biomass data to inform assessments of meadow condition and the need for use level adjustments (Haultain and Frenzel 2013). It is important to note that estimates of bare soil based on these data reflect conditions in a relatively small proportion of the total meadow area, which by design represents the area of highest use.

Thresholds for Management Action

A range of values for bare soil condition classes applicable to the meadows of Sequoia and Kings Canyon would be developed based on values obtained through analysis of existing data and additional data collection. NPS and USFS ecologists would gather information on bare soils in park meadows using methodology comparable to that used by the USFS and in Yosemite National Park. Data would be collected from both grazed and ungrazed meadows representing a range of use levels, elevations, and vegetation types. Results from these efforts would be used to assess the applicability of the condition classes developed by Weixelman and Zamudio (2001) to park meadows and would inform the further development of thresholds for management action (table D-4).

Table D-4: Potential Thresholds for Management Action and Rationale Based on Bare Soil Values

Threshold(s) for Management Action	Management Actions	Rationale
Threshold 1: Monitoring indicates "low ecological condition" bare soil cover value at any grazed meadow.	Apply a secondary assessment method for a qualitative evaluation of meadow condition.	Secondary assessments are diagnostic tools that provide standardized, rapid, field-based assessments of the overall condition or functional capacity of meadows. Assessing meadow condition would aid in identifying key stressors that may be affecting meadow condition. Assessment results would assist with interpretation of monitoring results.
Threshold 2: Monitoring indicates "low ecological condition" bare soil cover value at any monitored site for two successive monitoring periods AND secondary assessment indicates stock use is a contributing stressor for both monitoring periods	Increase education about minimum impact and best management practices in meadows for Wilderness visitors, park staff, and park partners.	Education in maintaining meadow condition would help prevent further increases in bare soil associated with human or stock use.
	Adjust total grazing levels or timing of use if needed to minimize impacts. Rest the meadow if necessary. Temporarily discontinue grazing until conditions improve based on secondary assessment results.	Grazing capacities constitute use levels that can be sustained in a meadow based on available forage cover, productivity and site condition, which can guide in setting an appropriate level of use. Allowing a period of meadow "rest" facilitates meadow recovery. Effects of trampling and grazing that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance.
	Monitor annually for 3-5 years or until meadow reaches moderate or high condition based on bare soil values.	Frequent monitoring would facilitate rapid detection of, and management response to, changes in ecological condition as well as inform the evaluation of the effectiveness of changes in the intensity and/or timing of use on meadow condition.
Threshold 3: Bare soil is double the value of "low ecological condition" class at a meadow OR previous management actions (such as reduction in use) have been ineffective OR assessments for 3-5 years have not shown improvement in ecological condition.	Discontinue grazing until conditions improve based on bare soil monitoring.	Allowing a period of meadow "rest" facilitates meadow recovery. Effects of trampling and grazing that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance.

Repeat Photography

The 1986 SUMMP introduced a system of using repeat photography to document gross changes in meadow vegetation over time. This system was designed to detect general changes in vegetation, e.g., a shift in dominance from grasses to sedges or sedges and grasses to forbs, enlargement or shrinking of the boundaries of vegetation types, changes in soil conditions and erosional effects and proportion of bare ground. The long-term meadow vegetation repeat photography collection was built on early work by park employees Clay Peters and Terry Gustafson (summarized in a file report prepared by T. Gustafson dated January 15, 1965), and expanded and formalized by Range Conservationist M. Neuman in the late 1980s and early 1990s. Historic scenes of park meadows were obtained, archived, and documented in a tracking database. Binders of printed photographs and associated label information were created for each wilderness patrol area, with the intention that the rangers would re-take the black and white photographs each year and return them at the end of the season for processing.

The long-term meadow vegetation repeat photography collection represents a valuable source of information on gross changes in meadow vegetation and morphology. The formal collection consists of 320 scenes, dating from 1929 through 1992, that have been formally documented in a database. At least 202 of these have one contemporary shot documented in the database; 34 have been re-taken three times and documented, and seven have been photographed four times. Black and white prints of each original scene and subsequent revisit have been made and reside in park files. Subsets of the photographs have been re-taken as time and resources allowed. These images provide a tool with which to document the establishment of lodgepole pine (*Pinus contorta*) saplings into meadows, a dynamic that has been the subject of much research and discussion. Recovery from past heavy grazing by cattle and sheep, and the efficacy of the efforts of the Soil and Moisture Crews (1948-1980) to halt erosion and restore proper hydrologic functioning through the installation of check dams could also be assessed using this resource. The Soil and Moisture Crews also removed ‘invasions’ of *Pinus contorta* and *Veratrum californicum* from within selected meadows. These restoration efforts were well-documented in reports and photographs that remain in park files, and thus there are potentially useful ancillary data on management actions to correlate with any changes in condition captured by the photographic record.

Photographic documentation would continue to be included in each component of the monitoring program, although images would be acquired using contemporary high resolution color digital photography. Photographs would be taken during site visits made by field staff, during assessment of opening date conditions, as part of species composition and residual biomass monitoring, and whenever concerns or questions arise regarding meadow, camp, or trail conditions. Digital images would continue to be processed and archived on the park network for access by managers and subject matter experts.

Site Visits and Condition Assessments

Site visits to grazed meadows would continue to be made with the goal of surveying for stock impacts and describing and documenting these impacts. Site visits will serve as early detection efforts and to identify where additional management action or monitoring or may be needed.

A typical site visit would include a survey of stock camps, preferred forage areas, maintained and informal trails, stream banks, seeps, and springs, and any other sensitive features in the meadow area. In the course of each site visit, staff would describe stock impacts and other factors influencing meadow vegetation and hydrology. Stock impacts which will be evaluated would include the extent and severity of deep hoof prints, trampled vegetation, closely cropped vegetation, stream bank shearing, erosion, and extent of the area subject to preferential grazing.

Documentation would consist of categorical assessments, narrative, and photographs. The date and extent of each survey would be documented. Observations would be linked to the timing and amount of stock use which has occurred at the time of the survey. The efficacy of existing management (opening dates, capacities, head and night limits, education and outreach) for meeting goals would be evaluated. The need for additional monitoring (residual biomass, bare ground, repeat photography, stream bank stability) would be assessed. Parameters used to estimate grazing capacity would be verified. When non-native species, rare species, or other sensitive resource features are encountered, staff would document and distribute this information to appropriate specialists.

Meadow monitoring staff would continue to train others working in wilderness (wilderness rangers, other technicians, packers) in data collection protocols and collate and summarize field reports.

INTEGRATION OF MONITORING RESULTS INTO MANAGEMENT ACTIONS

Monitoring data would continue to be summarized annually and provided to the Stock Use and Meadow Management Committee. This committee would continue to meet once each year mid-winter to discuss issues pertaining to stock use and meadow management in the wilderness of the two parks. The interdisciplinary committee would continue to be composed of representatives from most divisions of the park, including wilderness managers, trails staff, and resource specialists. The annual meeting would serve two purposes: to share results from the stock use and meadow monitoring program, and to provide a forum for the discussion of stock use management issues. Results from the previous years' monitoring program would be presented, and where conditions indicate a need for action, alternatives proposed and discussed. If a need for imposing or lifting formal restrictions on stock use should arise, recommendations would be made to the Superintendent for final approval. A notice of temporary restrictions for the upcoming season would be distributed to users by March 1, and submitted to the law enforcement specialist for inclusion in the Superintendents compendium at the same time. Area specific management actions that do not require formal restrictions—such as encouraging use of one meadow over another, or modifying administrative grazing plans—would continue to be discussed at subsequent district-level operations meetings held each spring, and communicated to field staff during early season training and orientation sessions.

Table D-5 provides a summary of monitoring measures and activities and proposed thresholds for triggering management actions.

Table D-5: Meadow Monitoring Data, Measures, Thresholds for Action, and Actions

Monitoring Data, Measure	Threshold	Actions
Stock use, percentage of estimated grazing capacity	Current year's use is greater than 100% of capacity.	Site visit during current year (if possible) or following year; consider establishing RB or bare ground monitoring. Temporary reduction in the following year's capacity if conditions indicate.
	Previous five years' average use is 80-100% of capacity.	Annual site visits to determine the need for management changes. Consider establishing RB or bare ground monitoring.

Monitoring Data, Measure	Threshold	Actions
	Previous five years' average use is 50-80% of capacity.	Site visits at least every 2 years to determine the need for management changes.
	Previous five years' average use is less than 50% of capacity.	Site visits at least every 5 years to determine the need for management changes.
Site visits, qualitative evaluations	Stock impacts to vegetation cover or soil stability in springs, seeps, or stream banks observed.	Consider a midseason grazing closure. Document and establish monitoring (secondary assessment, repeat photographs, or quantitative method as appropriate). Reevaluate opening date. Reevaluate grazing capacity.
	Stock impacts to vegetation cover or soil stability in springs, seeps, or stream banks result in accelerated erosion or instability.	Consider a midseason grazing closure. Consider temporary grazing closure until vegetation and soils have stabilized. Document and establish monitoring (repeat visits, repeat photographs, or quantitative method as appropriate). Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity.
	Deep hoof prints observed in a sensitive area (spring, seep, steep area, rare plant population, amphibian habitat, etc.) or over a significant portion of the meadow area.	Consider a midseason grazing closure. Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity.
	Closely cropped or trampled vegetation observed in a sensitive area (spring, seep, steep area, rare plant population, amphibian habitat, etc.) or over a significant portion of the meadow area.	Consider a midseason grazing closure. Reduce stock impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate grazing capacity.
	Introduced species with the potential for spread detected.	Document extent and abundance. Provide to vegetation management program. Control immediately if feasible. Refer to vegetation management program if not feasible. Modify stock use to prevent spread, if necessary.

Monitoring Data, Measure	Threshold	Actions
Residual biomass, percentage of annual production	Less than 55% in -moist lower montane meadows with high logistical value.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
	Less than 65% in - dry or wet lower montane meadows with high logistical value - moist lower montane meadows with low logistical value - upper montane and subalpine meadows with high logistical value.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
	Less than 75% in -dry or wet lower montane meadows with low logistical value -upper montane and subalpine meadows with low logistical value.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
Bare ground, percentage of soil surface	Bare soil cover value within range for low ecological condition (values to be determined).	Site visit to assess meadow condition and contributing factors.
	Bare soil cover value within range for low ecological condition (values to be determined) for two successive monitoring periods and site visit indicates stock use is a contributing stressor for both monitoring periods.	Reduce impacts (increase education, change stock handling, erect barriers, establish head or night limits). Reevaluate opening date. Reevaluate grazing capacity. Consider temporary grazing closure until bare soil cover value improves. Monitor annually for 3-5 years or until bare soil cover value falls within range for moderate or high ecological condition (values to be determined).
	Bare soil cover value double the value for low ecological condition (values to be determined), or previous management actions have been ineffective, or monitoring for 3-5 years has not shown improvement in bare ground.	Discontinue grazing until bare soil cover value falls within range for moderate or high ecological condition (values to be determined).
Species composition, percent change	Greater than 15 percent change in the dominant species as recorded by the frequency plots.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.
	Greater than 15 percent increase in the proportion of bare ground and with observed erosion.	Temporary reduction in the following year's capacity if conditions indicate. Reevaluate grazing capacity.

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Attachment 1: Grazing Capacities for Recreational Pack and Saddle Stock – Background and Use in Sequoia and Kings Canyon National Parks

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GRAZING CAPACITIES FOR RECREATIONAL PACK AND SADDLE STOCK – BACKGROUND AND USE IN SEQUOIA AND KINGS CANYON NATIONAL PARKS

LIMITING IMPACTS FROM STOCK GRAZING

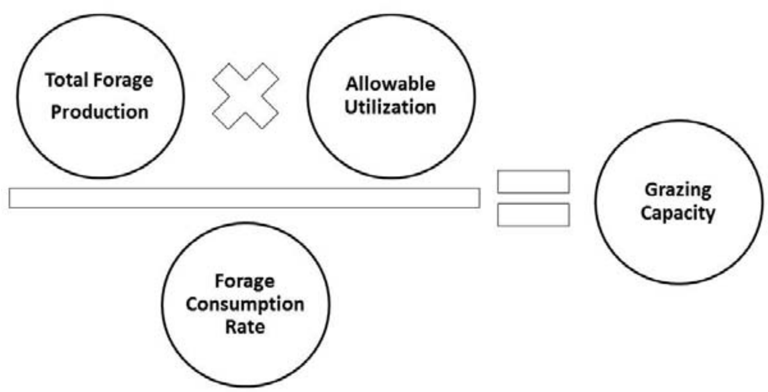
There are several ways that grazing stock can impact natural resources and other wilderness users. Setting a limit on the total amount of grazing allowed within one growing season is one management tool that can be used to keep impacts within standards.

Depending on the meadow characteristics, any one kind of impact could be a limiting factor for the amount of grazing that can take place. For example, stream bank shearing could reach unacceptable levels before the amount of trampling, social conflicts, species composition changes, or defoliation reaches an unacceptable level. Because defoliation has the closest relationship to grazing (defoliation being a necessary impact for grazing to occur rather than an undesirable side effect which can be mitigated) it is the starting place for developing capacities. The methodology used to estimate capacities for grazing in park meadows is described below.

GRAZING CAPACITY MODEL

Ratliff et al. (1987) present a grazing capacity model based on the ability of Sierra Nevada meadows to produce foliage palatable to stock while leaving enough plant biomass for maintenance or improvement of meadow condition and for meeting other management goals, such as wildlife habitat protection. This model was first applied to park meadows grazed by pack stock in 1992 (Neuman 1994). With modification for wilderness management, this basic model provides a framework for defining and establishing grazing capacity.

The model includes total forage production, allowable utilization (the proportion of forage production which can be grazed), and a forage consumption rate by pack and saddle stock.



FORAGE PRODUCTION

Net primary productivity (hereafter, “productivity”) is the amount of solar energy captured by plants minus the amount of energy used by the plant for respiration; it is expressed per unit area. Measurements of aboveground biomass (the dry weight of plant material per unit area present at one point in time) at the end of the growing season are used to estimate productivity for herbaceous species in temperate environments. Productivity varies across the landscape due to many abiotic and biotic factors (Barbour et al. 1998). In the Sierra Nevada, the factors that are most relevant are elevation, moisture availability, and condition; these are the factors used to predict productivity. The total amount of forage produced will be a product of the area and productivity.

Productivity

Elevation: All else being equal, meadow productivity decreases as elevation increases (Ratliff 1985, Ratliff et al. 1987). The model assumes a linear decline with elevation.

Moisture: Moisture availability influences both species composition and productivity (Ratliff 1985, Ratliff et al. 1987). The productivity model assumes that meadows can be assigned to one of three moisture classes (Ratliff et al. 1987). Moist meadows with shorthair grass (*Calamagrostis muiriana*), tufted hairgrass (*Deschampsia cespitosa*), or Nebraska sedge (*Carex nebrascensis*) as dominant species are the most productive. Wet meadows with beaked sedge (*Carex utriculata*, C. *vesicaria*) or spikerush (*Eleocharis acicularis*, *E. pauciflora*) as dominant species are intermediate in productivity. Dry sites with shorthair sedge (*Carex filifolia*) as the dominant species are the least productive. In comparing published information, different authors may assign a given species to different moisture categories.

Within any given meadow, a range of moisture conditions and several dominant species will exist. Because horses and mules are selective grazers and do not graze evenly across the meadow, the moisture category (wet, moist, or dry) of the vegetation favored by stock in a given forage area is used to estimate productivity.

Condition: Productivity may vary with species composition and plant vigor, and how intact litter and soils are. Taken together these factors can be considered as “range condition” and included as a factor in the productivity model. Ratliff et al. (1987) assume a decline in the productivity of forage species related to condition based on data presented in Crane (1950).

The decline in productivity is assumed to be the same at all elevations and moisture types. Meadows in excellent condition are assumed to have the maximum productivity. Productivity for other condition levels is given in reference to maximum productivity: good condition produces 65%, fair condition 44%, and poor condition 25%. No reduction was presented for very poor condition meadows.

The missing litter and humus, broken sods, and erosion that characterize fair, poor, and very poor condition meadows are rare in park meadows, and where they occur, are limited to very small portions of the meadow (although before effective grazing controls were implemented, these impacts were more widespread; see Sumner 1941, Sharsmith 1959, and others). The meadows classified as “excellent” condition by Crane (1950) were largely cultivated and irrigated pastures, while natural meadows generally fit the criteria for “good” condition. Ratliff applied contemporary condition class concepts (USFS 1969) to 90 non-randomly selected Sierra Nevada meadows and found 27% to be in excellent condition and 26% in good condition (Ratliff 1985). Therefore, we assume that 65% of maximum productivity is a conservative, reasonable value to use in estimating the forage productivity of park meadows.

Given these assumptions, the productivity of dry, moist, and wet meadows can be estimated by the following equations where productivity is in units of pounds per acre, and elevation is in units of feet.

- Dry: Productivity = 2275 - 0.175 * Elevation
- Moist: Productivity = 4725 - 0.325 * Elevation
- Wet: Productivity = 4705 - 0.36 * Elevation

Productivity for other condition classes can be calculated using the coefficients in table D-12Table . Predicted forage productivity values calculated from data in Ratliff et al. (1987) are illustrated in Figure D-1Figure.

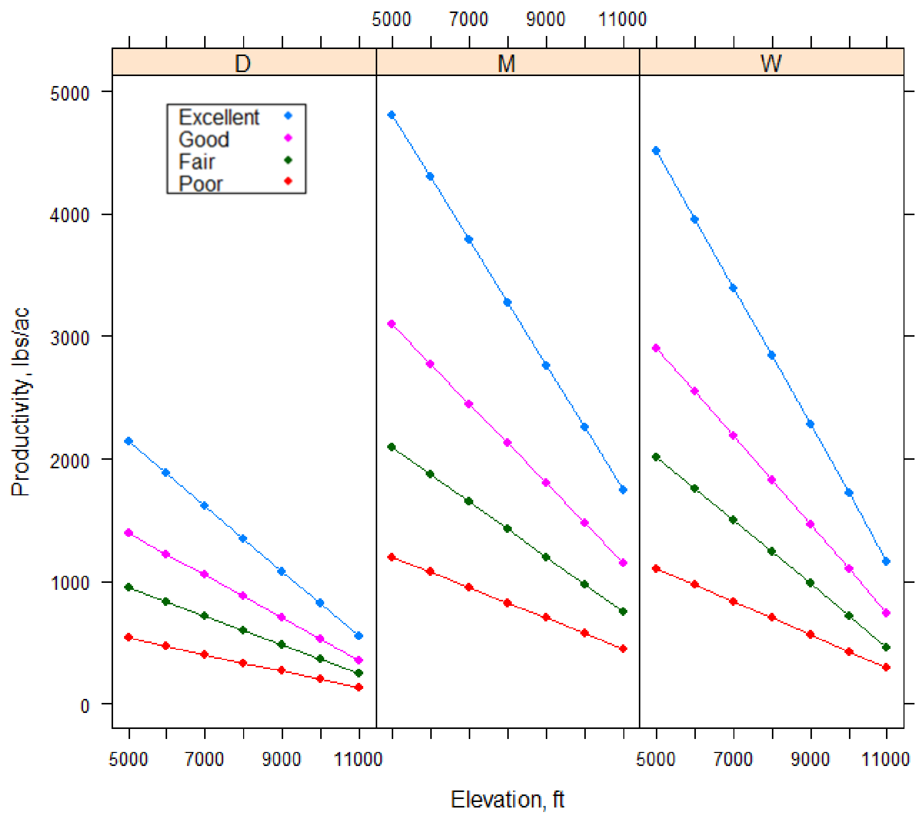


Figure D-1: Predicted productivity (lbs/acre) by elevation (ft) for three moisture classes (D = dry, M = moist, W = wet), and four condition classes (excellent, good, fair, poor)

Area

Calculating capacities for management units of interest requires determining how much grazing area is available. Forage areas are defined as the primary meadows and their associated forested or upland grasslands, which are commonly used by stock for grazing. Therefore, the forage area is the scale at which grazing capacities are calculated.

Total area: The total amount of meadow area in each forage area was calculated from vegetation maps (NPS 2007).

Preferred proportion: For each forage area, a preferred proportion (1-100%) has been assigned. The preferred proportion gives the area of vegetation types favored for grazing by horses and mules. Because horses and mules are selective grazers and overall grazing pressure is light, grazing impacts are generally concentrated in one vegetation type. Initial estimates of the proportion of the preferred meadow vegetation were assigned to park forage areas by Neuman (1994); these estimates have been periodically revised as new information is obtained about stock grazing patterns. The preferred proportion for all forage areas in the parks was reviewed and revised between 2012 and 2014. The review ensured that the preferred proportion did not include any peat accumulating area within the forage area.

ALLOWABLE UTILIZATION

The amount of biomass that should be left ungrazed for the purposes of maintaining a litter and humus layer on the soil, for wildlife habitat, for maintaining the health of vegetation, and for other purposes will vary with the management goals for individual meadows. In perennial grasslands such as mountain meadows, the amount of biomass to leave at the end of the growing season has generally been defined as a percentage of total biomass production. The proportion of total biomass production which can be grazed while meeting management goals is “allowable utilization”. The amount of vegetation remaining ungrazed at the end of the season is referred to as “residual biomass”.

Existing utilization guidelines

Guidelines for appropriate utilization rates for Sierra Nevada meadows have evolved over time.

Consistent with range standards at the time, Crane (1950) suggested that utilization guidelines of 60-70% were appropriate for Sierra Nevada meadows used for livestock production.

Ratliff (1976, 1980) measured decomposition rates of filter paper and natural herbage to estimate how much biomass decomposed annually; these were proposed this as the minimum that should be retained as residual to maintain a meadow at a given condition, and that more could be retained to increase the condition of meadows in degraded condition (Ratliff et al. 1987, table D-6). Ratliff found that decomposition rates were highest at intermediate moisture levels, and suggested that utilization guidelines of 20-45% would be appropriate to either maintain or improve condition of Sierra Nevada meadows (Ratliff 1985).

Neuman (1994) proposed reducing the utilization limits in Ratliff (1985, 1987) by 10 percentage points to reflect more conservative grazing levels in a National Park wilderness area.

Table D-6: Ratliff et al. (1987) Utilization Recommendations by Moisture and Condition

Moisture	Condition	Allowable utilization, Ratliff et al. (1987)
Moist	Excellent	45
	Good	40
	Fair	35
	Poor	30
Dry or Wet	Excellent	35
	Good	30
	Fair	25
	Poor	20

The USFS (2001) adopted utilization limits of 30-40% for montane and subalpine meadows and 10-20% for alpine meadows in the Ansel Adams, John Muir and Dinkey Lakes Wildernesses (table D-7). The higher number is for meadows in high-seral ecological condition and the lower is for meadows in mid- to low-seral ecological condition. High seral status would roughly correspond to Crane's (1950) excellent condition, and mid to low seral state would roughly correspond to good or lower conditions although the two condition classifications differ (David Weixelman, pers. comm. 2014).

Table D-7: Utilization Standards for Herbaceous Perennial Vegetation in Wilderness Meadows of the Sierra and Inyo National Forests

Landscape Zone	Seral Ecological State	Allowable use
Montane and Subalpine	High	40
	Mid to Low	30
Alpine	High	20
	Mid to Low	10

Source: USFS 2001

A study which evaluated the impacts of a range of utilization rates on three upper montane and subalpine meadow vegetation types in Yosemite National Park described the relationship between utilization rates and impacts to meadow attributes (Cole et al. 2004). The authors fit linear models for the relationships between utilization and productivity, basal vegetation cover, and relative graminoid cover, with variation by vegetation type and number of years of grazing. In dry *Carex filifolia* vegetation, statistically significant relationships for productivity and basal vegetation cover were reported. In mesic *Calamagrostis muiriana* vegetation, statistically significant relationships for productivity, basal vegetation cover, and relative graminoid cover were reported; the relationship with bare ground was statistically significant, but had poor predictive ability. In mesic to hydric *Deschampsia cespitosa* vegetation, only the relationship for productivity was statistically significant.

The relationships presented by Cole et al. (2004) can be used to estimate the level of utilization which would, on average, result in a given level of change for a combination of vegetation type and meadow attribute (table D-8). Assuming that all three vegetation types are present in most upper montane and subalpine forage areas, one of the combinations of attribute and vegetation type will be the limiting factor, where the level of acceptable change would be reached first. This may be thought of as a limiting utilization value.

Table D-8: Utilization Values for Different Levels of Acceptable Change in Attributes for Three Upper Montane and Subalpine Meadow Vegetation Types

Attribute	Vegetation type	Acceptable change in attribute				
		0%	-5%	-10%	-15%	-20%
Productivity (from peak standing crop)	*Carex filifolia*	27%	31%	35%	39%	43%
	Calamagrostis muiriana	5%	15%	24%	34%	43%
	Deschampsia cespitosa	10%	17%	24%	31%	38%
Basal vegetation cover	*Carex filifolia*	28%	30%	32%	34%	37%
	Calamagrostis muiriana	39%	41%	43%	45%	47%
Relative graminoid cover	*Calamagrostis muiriana*	12%	22%	31%	41%	50%
Limiting utilization value		**5%**	**15%**	**24%**	**31%**	**37%**

Values were calculated from results in Cole et al. (2004). Values for *Calamagrostis muiriana* productivity and basal vegetation are averages across treatment years

Proposed Utilization Rates for Action Alternatives Allowing Grazing

Utilization rates for all forage areas would limit stock induced changes to plant composition, density, cover and/or vigor, and productivity to acceptable levels. These rates would prevent adverse effects to soils and associated sod that may lead to accelerated erosion, prevent changes to springs, seeps and water courses that could alter hydrologic processes, and promote recovery from past overuse where necessary. Allowable utilization rates would vary by vegetation zones and the logistical value of the forage area.

Vegetation zones: Each forage area is classified as either "lower montane/woodland" or "upper montane/subalpine". The upper montane/subalpine/ forage areas are generally located at higher elevations, but overlap in elevation range with lower montane/woodland forage areas.

Lower montane/woodland zones are below approximately 8,500 feet in elevation. Research results from Ratliff (1976, 1980) are used to set utilization rates for these forage areas.

Upper montane/subalpine zones are above approximately 7,500 feet in elevation. The research results from Cole et al. (2004) are used to set utilization rates in these forage areas by selecting a limit for the amount of change in meadow attributes to accept.

Logistical value: Some forage areas have high logistical value to groups travelling with stock. The characteristics used to designate forage areas as having high value are:

- resource concerns other than defoliation do not limit grazing capacity
- closest forage area to a high pass
- first forage area beyond round-trip distance from trailhead
- fires allowed at forage area but not in nearby forage areas
- lack of other forage areas open to grazing nearby
- traditional stock camp
- strategic location for administrative use

Lower utilization rates are proposed in forage areas with low logistical value; this provides a greater level of conservation without unduly reducing recreational opportunities for stock travelers. Forage areas would not be designated as high logistical value if grazing demand could be met by these lower utilization rates. 55 forage areas met these criteria: 14 in the lower montane and woodland zones, and 40 in the upper montane and subalpine zones. A list of the named forage areas assigned a high logistical value is provided in table D-13.

Utilization rates: Proposed utilization standards which would be used to estimate grazing capacities under the preferred alternative range from 25% to 45% (table D-9).

Table D-9: Utilization Rates Proposed as Standards and Used to Estimate Grazing Capacities

Vegetation Zone	Moisture Class	Logistical Value	Utilization Limit
Subalpine / Upper Montane	All	High	35%
		Low	25%
Lower Montane / Woodland	Moist	High	45%
		Low	35%
	Dry or Wet	High	35%
		Low	25%

These utilization rates would, on average, result in changes to the most heavily grazed portions of meadows relative to comparable ungrazed vegetation (tables D-10 and D-11). In lower montane meadows, maximum utilization would be equal to or less than the amount needed to leave residual biomass equal to that which decomposed annually. In upper montane and subalpine meadows, maximum utilization rates would be set to limit decreases in productivity, basal vegetation cover, and relative graminoid cover to 18% or less.

Table D-10: Predicted Response of Meadow Attributes for Lower Montane and Woodland Vegetation Types to 25%, 35%, and 45% Utilization*

Attribute	Utilization Moist <35% Dry or Wet <25%	Utilization Moist 35-45% Dry or Wet 25-35%
Residual biomass	greater than annual decomposition	greater than or equal to annual decomposition
Productivity	similar to comparable ungrazed meadow vegetation	similar to comparable ungrazed meadow vegetation

*** Based on Ratliff (1976, 1980, 1985); responses for productivity would be expected to occur after more than one growing season**

Table D-11: Predicted Mean Response of Meadow Attributes for Three Upper Montane and Subalpine Vegetation Types to 25% and 35% Utilization*

Attribute	Vegetation type	25% utilization, percentage change relative to ungrazed conditions	35% utilization, percentage change relative to ungrazed conditions
Productivity	*Carex filifolia*	+2%	-10%
	Deschampsia cespitosa	-11%	-18%
	Calamagrostis muiriana	-10%	-16%
Basal vegetation cover	*Carex filifolia*	+7%	-16%
	Calamagrostis muiriana	+41%	+14%
Relative graminoid cover	*Calamagrostis muiriana*	-6%	-12%

* Based on Cole et al. (2004); predicted response for *Calamagrostis muiriana* is average across treatment years as reported for two, three and four years of grazing in the original study.

In subalpine and upper montane forage areas having higher logistical value, utilization rates would be limited to 35%. If grazed to capacity regularly, this level of utilization in dry *Carex filifolia* vegetation would, on average, reduce productivity by 10% and reduce basal vegetation cover by 16% relative to ungrazed vegetation. In moist to wet *Deschampsia cespitosa* vegetation, this level of utilization would, on average, reduce productivity by 18% relative to ungrazed vegetation. This level of utilization in moist *Calamagrostis muiriana* vegetation would, on average, reduce productivity by 16%, increase basal vegetation cover by 14%, and decrease relative graminoid cover by 12% relative to ungrazed vegetation.

In subalpine and upper montane forage areas having lower logistical value, utilization would be limited to no more than 25%. If grazed to capacity regularly, this level of utilization in dry *Carex filifolia* vegetation would, on average, increase productivity by 2% and increase basal vegetation cover by 7% relative to ungrazed vegetation. In moist to wet *Deschampsia cespitosa* vegetation, this level of utilization would, on average, decrease productivity by 11% relative to ungrazed vegetation. This level of utilization in moist *Calamagrostis muiriana* vegetation would, on average, reduce productivity by 10%, increase basal vegetation cover by 41%, and decrease relative graminoid cover by 6% relative to ungrazed vegetation.

In lower montane forage areas with higher logistical value, utilization would be limited to no more than 45% in moist meadows and 35% in dry or wet meadows. The amount of foliage left ungrazed at these levels would be approximately equal to the amount of herbage which would be expected to decompose annually; if grazed to capacity regularly, productivity would be expected to remain near current levels.

In lower montane forage areas with lower logistical value, utilization would be limited to no more than 35% in moist meadows and 25% in dry or wet meadows. The amount of foliage left ungrazed at these levels would be more than the amount of herbage which would be expected to decompose annually; if grazed to capacity regularly, productivity would be expected to trend towards or be similar to comparable ungrazed meadow vegetation.

BIOMASS CONSUMPTION RATES

Rates of biomass consumption are expressed as an amount of biomass grazed over a given period of time. As most grazing occurs during overnight stays (saddle and pack animals generally work during the day), the time period of interest is one night.

The amount of biomass grazed by pack and saddle animal are related to the size of the animal. 94% of all stock use in the parks' is by horses and mules (Frenzel and Haultain 2013). Ratliff et al. (1987) provide consumption rates for horses of 1.25 animal units (AU) which equates to 1000 lbs of dry biomass consumed per month. Burro consumption rates are assumed to be 0.5 AU, and llama consumption rates are assumed to be 0.35 AU. Some sources give consumption rates of 1.8 AU for horses, in part because they consume more biomass for their size than ruminants (Holechek 1988).

Capacities provided to stock users and managers are expressed as "stock nights" which is defined as an overnight stay by any horse, mule, burro, or llama. Biomass consumption per stock night is assumed to be 1.25 animal unit nights (AUN), or 32 lbs of dry biomass per night. This represents an approximate average based on the various sizes of stock grazed in the parks, which includes horses, mules, burros and llamas. Capacities reported as stock nights (as opposed to animal unit nights) are simple for stock users and managers to understand, track, and report. Information about animal type is included in stock use reports and available to inform management decisions in the few places where burros and llamas make up a significant portion of the total grazing.

CAPACITY CALCULATION

Grazing capacities for park forage areas are calculated as:

$$\frac{\text{area} * \text{preferred proportion} * \text{productivity} * \text{allowable utilization}}{\text{nightly forage consumption}} = \text{capacity in stock nights}$$

Model capacities are provided in table D-14.

VALIDATING AND REFINING THE MODEL OUTPUT

Several factors will be taken into account when evaluating model capacities against actual impacts, standards, and goals for each meadow and forage area.

IMPACTS OTHER THAN DEFOLIATION

Where grazing at model capacities results in impacts outside of standards, impacts other than defoliation can be the factor limiting grazing capacity. In these areas, previous use levels can be compared to observed impacts to lower capacity values. Use levels will be evaluated for their impacts in the following areas:

- Trampling
- Impacts to soils and hydrology
- Defecation
- Plant species composition
- Social conflicts

For example, concerns over mechanical impacts such as shearing, trampling in peat accumulating meadows and fens have been partially addressed by ensuring that these areas are not included in the preferred acreage of a meadow. Limiting capacity to the amount of forage available outside of fen areas may reduce the likelihood that stock will seek forage within the fen. As an example, this approach has proven successful in Big Pete Meadow, where stock avoid the wettest, peat accumulating portions of the forage area at low stocking rates, but begin to trespass into sensitive areas when use numbers increase and easily accessible forage is depleted. Continuing to document the grazing level at which impacts other than grazing occur will improve the park's ability to refine capacities.

ASSOCIATED NON-MEADOW FORAGE

Where past grazing above modeled capacities has resulted in acceptable meadow condition, vegetation other than meadows (such as the understory of forests and woodlands) is often an important source of additional forage for stock. Therefore, the model may underestimate grazing capacity in these forage areas. The amount of grazing capacity in areas adjacent to meadows can be added to meadow capacities in these cases. This has been done for some meadows based on evaluation of stock grazing patterns and impact levels from past use.

INTERANNUAL WEATHER VARIABILITY

Productivity estimates are averages. Annual weather fluctuations are not explicitly included in the model, although they are known to influence productivity. In high snowfall years, productivity can be reduced by cold wet soils and shorter growing seasons (Moore et al. 2013). In very low snowfall years, lack of soil moisture may limit productivity.

Residual biomass data collected from ungrazed reference sites in the parks can be used to estimate the magnitude of interannual variation. Twenty-seven meadows had at least three years of reference residual biomass data. The coefficient of variation (ratio of the sample standard deviation to sample mean with small-sample correction, (Sokal and Rohlf 1995)), for these meadows averaged 0.36.

In years where very high or very low precipitation is an important factor, public information provided to stock users is used to warn them of reduced capacities. Monitoring of conditions throughout the season can indicate when a mid-season grazing closure is appropriate due to reduced productivity.

TIMING AND INTENSITY OF USE

Managing grazing by livestock in the traditional sense differs from the management of recreational grazing in wilderness in that in the latter, the timing and intensity of grazing in any given location can be highly variable and is often unpredictable. The arrival and departure of animals at a given site can result in periods of rest for the meadow, during which vegetative growth may occur and thus result in increased capacity. Conversely, periods of intense grazing without recovery periods may lead to depletion of the allowable biomass before the estimated capacity is reached. On site monitoring allows for mid-season adjustments in use levels that reflect these conditions.

SHORT TERM MANAGEMENT GOALS

Modified capacities can be used to respond to observed conditions. For example, if use in one year results in impacts which are out of standard, lower capacities may be set in following years to allow a relative decrease in grazing and allow recovery.

MODEL EVALUATION

The capacities calculated from the model are a starting point for estimating what amount of grazing will meet management goals for park meadows.

If monitoring data indicates that levels of use below the calculated values result in impacts outside of standards for erosion, creek bank impacts, productivity, basal plant cover, bare ground, species composition, or that these impacts would lead to unacceptable or irreversible changes, management changes (including reducing capacities) will be made. Conversely, if observed impacts are well below standards at the calculated capacities, capacities could be increased.

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Table D-12: Regression Coefficients for Each Combination of Moisture Level and Condition*

Moisture	Condition	B_0	B_E
D	Excellent	3470	-0.265
D	Good	2275	-0.175
D	Fair	1520	-0.115
D	Poor	878	-0.0675
M	Excellent	7355	-0.51
M	Good	4725	-0.325
M	Fair	3225	-0.225
M	Poor	1825	-0.125
W	Excellent	7297	-0.5575
W	Good	4705	-0.36
W	Fair	3297	-0.2575
W	Poor	1780	-0.135

* Productivity for a given moisture and condition is given by B_0 + B_E*Elevation.

Table D-13: Forage Areas Designated as Having High Logistical Value

Forage Area Number	Forage Area Name
28-3	Cony Camp
28-4	Franklin-Montgomery
33-1	Evolution
39-2	Big Pete
39-4	Ladder Camp
39-8	Deer
46-2	South Fork Kings River
51-1	Simpson
53-4.2	Glacier Valley
53-5	Fallen Moon
53-7	Shorty's
58-1	Castle Domes
58-2	Woods Creek Crossing
58-3	Baxter Creek Drift Fence
63-1	Charlotte Creek
65-3	Upper Vidette
65-4	Upper Bubbs Creek
66-3	Junction (Bubbs Creek)
67-1	East Lake
69-2.2	Upper West Side Roaring River

Forage Area Number	Forage Area Name
69-3	JR Past; Allen Camp
69-4	Lackey Pasture
69-5.1	Scaffold Tourist Pasture
69-5.2	Grasshopper
70-4	Cement Table
70-5	Big Wet
70-6	Grand Palace Hotel
71-1	Austin Camp
71-2	Grave
71-3	Ranger
77-7	Pinto Lake
79-1	Cold Springs Camp Area
79-5	Gallats Lake
80-3	Tyndall Cr
81-2.1	Wallace Cr/JMT Junction
83-4	Upper Crabtree
83-7	Lower Whitney Creek
83-8	Sandy
84-2	Lower Rock Creek Crossing
85-4	Penned-up
85-10	Nathan's
86-1	Kern Bridge Camp
86-2	Upper Funston
86-5	Lower Funston
86-7	Lewis Camp Large Pasture
87-3	Big Arroyo Patrol Cabin
89-3	Lower Lost Canyon
89-9	Middle Rattlesnake Canyon
89-10	Cow Camp (Rattlesnake Creek)
90-5.1	Hockett
90-5.2	Hockett Pasture
90-9	Lower South Fork
90-10	South Fork Meadow
90-11	South Fork Pasture
90-13	Slim's

Table D-14: Estimated Grazing Capacities for 225 Forage Areas Open to Grazing under the NPS Preferred Alternative

Forage Area Number	Forage Area Name	Elevation, ft	Moisture	Vegetation Zone	Logistical Value	Area, ac	Preferred vegetation	Productivity, lbs/ac	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights
28-1	Piute Cr	8050	D	U	L	0.8	100%	866	25%	5		5
28-2	Aspen	8200	M	L	L	0.5	100%	2060	35%	11		11
28-3	Cony Cmp	8420	M	L	H	1.8	100%	1989	45%	50		50
28-4	Franklin-Montgomery	8720	W	U	H	7.7	50%	1566	35%	66		66
28-5	Pig Chute	9160	M	U	L	0.8	100%	1748	25%	11		11
28-6	Hell-For-Sure Jct Area	10000	M	U	L	32.8	50%	1475	25%	189		189
33-1	Evolution	9230	M	U	H	13.4	80%	1725	35%	202		202
33-2	McClure	9630	W	U	L	21.3	50%	1238	25%	103		103
33-3	Colby	9700	W	U	L	9.6	75%	1213	25%	68		68
33-4.1	Upr Colby (Upr Colby #1)	9850	W	U	L	3.6	30%	1159	25%	10		10
33-4.2	Darwin Pockets (Upr Colby #2)	9850	W	U	L	4.5	30%	1159	25%	12		12
34-1	Evolution Lk	10860	W	U	L	60.4	25%	795	25%	94		94
34-2	Sapphire Lk	10970	W	U	L	36.8	35%	756	25%	76		76
34-3	Huxley Lk	11300	D	U	L	34.2	35%	298	25%	28		28
34-4	Wanda Lk	11400	D	U	L	100.9	15%	280	25%	33		33
38-2	Blue Cyn	8410	W	U	L	28.9	30%	1677	25%	114		114
38-3	Lwr Blue Cyn	8000	D	L	L	0.9	100%	875	25%	6		6
39-2	Big Pete	9230	W	U	H	3.2	75%	1382	35%	36	50	50
39-3	Little Pete	8860	W	U	L	10.3	60%	1515	25%	73		73
39-4	Ladder Cmp	8310	D	L	H	3.5	50%	821	35%	16	50	50
39-6	Palisade Cr Jct	8020	D	L	L	1.4	50%	872	25%	5		5
39-7	Stillwater; Lwr Deer	8430	M	L	L	5.8	60%	1985	35%	76		76
39-8	Deer	8840	W	U	H	15.4	25%	1523	35%	64	100	100

Forage Area Number	Forage Area Name	Elevation, ft	Moisture	Vegetation Zone	Logistical Value	Area, ac	Preferred vegetation	Productivity, lbs/ac	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights
42-1	Dusy Cr	9500	M	L	L	1.2	50%	1638	35%	11		11
45-1	Palisade Lks	10650	M	U	L	26.7	40%	1264	25%	105		105
46-1	Upr Basin	11200	M	U	L	204	25%	1085	25%	432		432
46-2	South Fk Kings River	9900	M	U	H	51.3	30%	1508	35%	254		254
46-3	Bench Lk/John Muir Trail Jct	10900	W	U	L	50.6	80%	781	25%	247		247
46-4	Bench Lk	10550	M	U	L	4.6	60%	1296	25%	28		28
46-6	Lk Marjorie	11150	M	U	L	14.9	20%	1101	25%	26		26
51-1	Simpson	5930	M	L	H	22.8	25%	2798	45%	224		224
51-2	Tehipite Vly	4100	D	L	L	13	10%	1558	25%	16		16
51-3	Gnat	7850	M	L	L	5.5	25%	2174	35%	33		33
51-4	Hay	7320	M	L	L	5	50%	2346	35%	64		64
52-1	Volcanic Lks Basin	10000	M	U	L	46.5	10%	1475	25%	54		54
52-2	Kennedy Cyn	9300	M	U	L	32.4	60%	1703	25%	259		259
52-3	Upr Kennedy Cyn	9540	M	U	L	15.3	30%	1625	25%	58		58
52-4	Kennedy Pass	10400	M	U	L	19.1	25%	1345	25%	50		50
52-5	West Kennedy Lk	9963	M	U	L	4.3	25%	1487	25%	12		12
52-6	Frypan	7800	M	L	L	5.8	50%	2190	35%	69		69
52-8	Jug	9860	D	U	L	6.8	25%	550	25%	7		7
52-9	Big Cmp	9900	M	U	L	14.7	25%	1508	25%	43		43
53-1	Horseshoe	10200	M	U	L	25.1	20%	1410	25%	55		55
53-2	Horseshoe Lks Turnoff	10500	M	U	L	12.9	40%	1313	25%	53		53
53-3	State Lks Area	10400	M	U	L	39.6	30%	1345	25%	125		125
53-4.1	Dougherty	9500	M	U	L	7.1	50%	1638	25%	45		45
53-4.2	Glacier Vly	9950	M	U	H	25.7	40%	1491	35%	168		168

Forage Area Number	Forage Area Name	Elevation, ft	Moisture	Vegetation Zone	Logistical Value	Area, ac	Preferred vegetation	Productivity, lbs/ac	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights
53-5	Fallen Moon	9540	W	U	H	18.8	25%	1271	35%	65		65
53-6	Volcanic Trail Jct	9420	W	U	L	2.3	50%	1314	25%	12		12
53-7	Shorty's	10070	W	U	H	7.8	50%	1080	35%	46		46
53-8	Granite Pass	10300	W	U	L	9.3	45%	997	25%	33		33
54-2	Granite Basin	10000	M	U	L	109.5	30%	1475	25%	379		379
54-3	Grouse Lk	10473	M	U	L	11.4	20%	1321	25%	24		24
54-4	Halfmoon	10260	M	U	L	6.1	75%	1391	25%	50		50
54-5.1	Upr Tent	8200	D	L	L	2.9	25%	840	25%	5		5
54-5.2	Lwr Tent	8200	D	L	L	2.3	25%	840	25%	4		4
56-1	High south of Pinchot Pass	11200	M	U	L	157.1	20%	1085	25%	266		266
56-2	Twin Lks Area (Woods Cr)	10600	M	U	L	89.7	20%	1280	25%	179		179
56-3	White Fk Cmp/Ghost Forest Cmp	9780	W	U	L	1	50%	1184	25%	5		5
58-1	Castle Domes	8130	M	L	H	4.4	70%	2083	45%	90		90
58-2	Woods Cr Xing	8500	M	L	H	3	100%	1963	45%	83	75	75
58-3	Baxter Cr Drift Fence	9450	W	U	H	2.3	100%	1303	35%	33	40	40
63-1	Charlotte Cr	10000	W	U	H	30.1	25%	1105	35%	91		91
65-3	Upr Vidette	10680	W	U	H	5.7	50%	860	35%	27		27
65-4	Upr Bubbs Cr	10400	M	U	H	39.3	25%	1345	35%	145		145
66-1.1	Sphinx Cr Conf	6240	D	L	L	2.5	75%	1183	25%	17		17
66-1.2	Angleworm	6840	D	L	L	0.2	75%	1078	25%	1		1
66-2	Charlotte Cr Conf	7300	W	L	L	18.5	10%	2077	25%	30		30
66-3	Junction (Bubbs Cr)	8130	D	L	H	7	25%	852	35%	16	50	50
67-1	East Lk	9550	W	U	H	4.8	50%	1267	35%	33	50	50

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67-2	Ouzel	9580	M	U	L	1.8	70%	1612	25%	16		16
68-1	Screwball	8550	W	L	L	2.4	50%	1627	25%	15		15
69-1	The Big Hole	7600	M	L	L	0.6	100%	2255	35%	15		15
69-2.1	Lwr West Side Roaring River	7200	D	L	L	2.4	100%	1015	25%	19		19
69-2.2	Upr West Side Roaring River	7600	D	L	H	1.5	100%	945	35%	16	75	75
69-3	JR Past; Allen Cmp	7380	M	L	H	0.9	100%	2327	45%	29	50	50
69-4	Lackey Past; Scaffold	7370	M	L	H	1.9	75%	2330	45%	47	55	55
69-5.1	Scaffold Tourist Past	7360	M	L	H	9.5	60%	2333	45%	187		187
69-5.2	Grasshopper	7700	M	U	H	3.1	60%	2223	35%	45		45
69-6.1	Moraine	8160	W	U	L	6	80%	1767	25%	66		66
69-6.2	Moraine Stringers	8800	W	U	L	10.4	80%	1537	25%	100		100
69-6.3	Metroyhoy	9500	W	U	L	11.3	80%	1285	25%	91		91
70-1.1	Grasshopper Cmp; Brewer Cr Conf	7980	M	L	L	1.4	50%	2132	35%	16		16
70-1.2	Brewer Stringers	10400	M	U	L	4.2	50%	1345	25%	22		22
70-2	Barton Stringers	9400	M	U	L	8.8	50%	1670	25%	57		57
70-3	False Cement Table	8430	M	U	L	3.6	60%	1985	25%	34		34
70-4	Cement Table	8540	W	U	H	5.9	75%	1631	35%	79		79
70-5	Big Wet	8740	W	U	H	29.4	35%	1559	35%	175		175
70-6	Grand Palace Hotel	9040	M	U	H	5.7	45%	1787	35%	50		50
70-7	Colby Lk	10620	D	U	L	4.4	20%	417	25%	3		3
71-1	Austin Cmp (all)	7950	M	U	H	5	60%	2141	35%	70		70
71-2	Grave	8400	M	U	H	5.1	50%	1995	35%	56		56
71-3	Ranger (all)	8780	W	U	H	49.5	35%	1544	35%	293		293

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71-4	Upr Ranger	9230	M	U	L	11.7	30%	1725	25%	47		47
71-5	Upr Deadman Cyn	9400	M	U	L	35.4	5%	1670	25%	23		23
72-1	Pond	8500	W	L	L	2.5	50%	1645	25%	16		16
72-2	Catch'em	8900	W	L	L	2.9	50%	1501	25%	17		17
72-3	Willow (Sugarloaf Cr)	9200	W	L	L	9.9	50%	1393	25%	54		54
72-4	Mitchell (Sheep Cr)	9600	W	U	L	25.6	50%	1249	25%	125		125
72-5	Quartz	8920	M	U	L	5.4	20%	1826	25%	15		15
72-6	Williams	8020	M	L	L	31.8	20%	2119	35%	147		147
72-7	Comanche	7820	W	L	L	4.3	20%	1890	25%	13		13
72-8	Sugarloaf	7300	M	L	L	23.2	50%	2353	35%	298		298
72-9	Little Sugarloaf	7200	M	L	L	3.6	50%	2385	35%	47		47
72-10	Sugarloaf Cr Cmp	6960	D	L	L	0.7	50%	1057	25%	3		3
72-11	Tom Sears; Honeymoon	7100	W	L	L	2.3	10%	2149	25%	4		4
72-12	Boggy	7240	M	L	L	2.1	50%	2372	35%	27		27
72-13.1	Cabbage	7760	D	L	L	2.9	50%	917	25%	10		10
72-13.2	Crowley Cyn	8000	D	L	L	1.1	50%	875	25%	4		4
72-13.3	Upr Crowley Cyn Pockets	8940	M	U	L	20.5	25%	1820	25%	73		73
72-14.1	Lwr Box Cyn	8200	W	U	L	1.6	25%	1753	25%	5		5
72-14.2	Suez Canal	9140	W	U	L	5	25%	1415	25%	14		14
72-14.3	Upr Box Cyn	9750	W	U	L	16.2	25%	1195	25%	38		38
72-16.1	Lwr Paradise	8980	M	U	L	5.6	40%	1807	25%	32		32
72-16.2	Upr Paradise	9150	M	U	L	14.3	40%	1751	25%	78		78
72-17.1	Lwr Log	8780	M	U	L	2.6	25%	1872	25%	10		10
72-17.2	Upr Log	8900	M	U	L	6	25%	1833	25%	21		21

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72-17.3	Salt Log	8940	M	U	L	0.6	25%	1820	25%	2		2
72-17.4	Ditch	8980	W	U	L	1.3	25%	1472	25%	4		4
72-17.5	Sheep Pen Meadow	9020	W	U	L	8.5	25%	1458	25%	24		24
72-18	Ferguson	8637	M	U	L	9.4	50%	1918	25%	70		70
72-19	Long (Ferguson Cr)	9590	W	U	L	66.1	40%	1253	25%	259		259
72-20.1	Lwr Lewistall	8580	W	U	L	4.5	50%	1616	25%	28		28
72-20.2	Upr Lewistall	8820	W	U	L	2.6	50%	1530	25%	16		16
72-21	Little Jack	9380	W	U	L	1.3	50%	1328	25%	7		7
72-22	Scenic	9780	M	U	L	32.7	35%	1547	25%	138		138
73-1	Sheep Cmp (Sugarloaf Cr)	8270	M	U	L	2.4	60%	2037	25%	23		23
73-3	Lovelace Cabin	8740	M	U	L	2.8	80%	1885	25%	33		33
73-4	Lost Lk	9130	W	U	L	0.8	60%	1418	25%	5		5
73-5	Ranger & Beville Lks	9142	W	U	L	4	50%	1414	25%	22		22
74-1	Twin Lks (Clover Cr)	9430	M	U	L	5.7	50%	1660	25%	37		37
74-2	Pattee	9260	M	U	L	9.4	50%	1716	25%	63		63
74-3	Clover Cr	8434	M	U	L	33.9	50%	1984	25%	263		263
75-1	Lone Pine	8800	M	U	L	9.4	25%	1865	25%	34		34
75-2	Tamarack Lk	9215	M	U	L	4.1	15%	1730	25%	8		8
77-1	Bearpaw	7460	M	L	L	1.3	75%	2301	35%	25		25
77-2	Lwr Bearpaw	6860	M	L	L	9.1	60%	2496	35%	149		149
77-3	River Vly	6480	D	L	L	0.7	100%	1141	25%	6		6
77-5	Redwood	6040	M	L	L	10	40%	2762	35%	121		121
77-6	Cliff Cr	7400	M	L	L	4.6	40%	2320	35%	47		47
77-7	Pinto Lk	8700	M	U	H	5.6	50%	1898	35%	58		58

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79-1	Cold Springs Cmp Area	9180	W	U	H	16	50%	1400	35%	123		123
79-3	Rockslide Lk	9050	M	U	L	12.1	25%	1784	25%	42		42
79-4	Lwr Kern-Kaweah River	9700	M	U	L	12.2	35%	1573	25%	52		52
79-5	Gallats Lk	10030	M	U	H	33.2	25%	1465	35%	133		133
79-6	Upr Kern-Kaweah River	10350	M	U	L	146.9	9%	1361	25%	141		141
80-2	Tyndall Cr/JMT Frog Ponds	11050	M	U	L	29.3	40%	1134	25%	104		104
80-3	Tyndall Cr	10600	M	U	H	14.6	50%	1280	35%	102		102
80-4	Sheep Cmp (Tyndall Cr)	11400	M	U	L	796.4	20%	1020	25%	1269		1269
81-1	Wright Cr Drainage	10900	M	U	L	507	25%	1183	25%	1171		1171
81-2.1	Wallace Cr/JMT Jct	10400	M	U	H	3.2	30%	1345	35%	14		14
81-2.2	Wallace Cr	10500	M	U	L	7.3	50%	1313	25%	37		37
81-2.3	Wallace Cr Waterfall	10860	W	U	L	9.8	40%	795	25%	24		24
81-2.4	Marshy	11100	W	U	L	5.4	40%	709	25%	12		12
82-1	Junction (Kern)	8050	W	L	L	1.7	65%	1807	25%	16		16
82-2	One mi below Junction	8000	D	L	L	0.3	100%	875	25%	2		2
82-3	Three mi below Junction	7700	D	L	L	1.4	100%	928	25%	10		10
83-4	Upr Crabtree	10460	W	U	H	38.9	30%	939	35%	120		120
83-6	Crabtree Lks	10900	M	U	L	9.2	70%	1183	25%	59		59
83-7	Lwr Whitney Cr; Strawberry	9950	M	U	H	5.9	30%	1491	35%	29		29
83-8	Sandy	10600	M	U	H	47.9	30%	1280	35%	201	300	300
84-2	Lwr Rock Cr Xing	9500	M	U	H	47.1	25%	1638	35%	211		211
84-6	Siberian Outpost	10780	D	U	L	270.6	40%	389	25%	329		329
85-4	Penned-up	10650	W	U	H	10.8	50%	871	35%	51		51
85-6	Lwr Soldier Lk	10800	W	U	L	25	20%	817	25%	32		32

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85-7	New Army Pass Jct	10920	M	U	L	50.1	25%	1176	25%	115		115
85-8	Rock Cr Lk (all)	10430	W	U	L	32.5	40%	950	25%	97		97
85-10	Nathan's	10020	M	U	H	15.7	50%	1469	35%	126	75	75
86-1	Kern Bridge Cmp	6800	W	L	H	6.1	75%	2257	35%	113	150	150
86-2	Upr Funston	6700	M	L	H	10.3	30%	2548	45%	111		111
86-3	Big Arroyo Conf	6640	D	L	L	1.6	40%	1113	25%	6		6
86-4	21-inch Cmp	6580	M	L	L	3.1	30%	2587	35%	26		26
86-5	Lwr Funston	6480	W	L	H	4.4	50%	2372	35%	57		57
86-6	Rattlesnake Cmp; River Past	6390	M	L	L	1.1	50%	2648	35%	16		16
86-7	Lewis Cmp Large Past	6400	M	L	H	9	60%	2645	45%	201	220	220
86-8	Kern Station Small Past	6440	M	L	L	1.5	50%	2632	35%	22		22
87-1	Upr Big Arroyo	9960	D	U	L	84.9	85%	532	25%	300		300
87-2	Little Upr Big Arroyo	9780	M	U	L	6.6	40%	1547	25%	32		32
87-3	Big Arroyo Patrol Cabin	9510	W	U	H	5.3	95%	1281	35%	71		71
87-4	Lwr Big Arroyo	9200	M	U	L	26.2	80%	1735	25%	284		284
87-5	Chagoopa Plateau #1	10460	W	U	L	10.1	40%	939	25%	30		30
87-6	Chagoopa Plateau #2	10430	W	U	L	8.7	75%	950	25%	48		48
87-8	Chagoopa Plateau #4	9960	W	U	L	14.3	75%	1119	25%	94		94
87-9	Chagoopa Plateau Treehouse	10380	M	U	L	14.1	66%	1352	25%	98		98
87-10	Sky Parlor	9150	D	U	L	66.2	60%	674	25%	209		209
88-1	Lwr Little Five Lks	10420	M	U	L	54	10%	1339	25%	56		56
88-2	Upr Little Five Lks	10520	W	U	L	14.8	50%	918	25%	53		53
88-3	Big Five Lks Lwr	9900	W	U	L	5.4	50%	1141	25%	24		24
88-4	Big Five Lks Upr	10220	W	U	L	22.2	35%	1026	25%	62		62

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89-2	Upr Lost Cyn (all)	10100	M	U	L	31	40%	1443	25%	140		140
89-3	Lower Lost Cyn (all)	9650	M	U	H	20.2	30%	1589	35%	105		105
89-4	Soda Cr Cyn	9200	M	U	L	23.8	50%	1735	25%	161		161
89-5.1	Forester Lk Bench	10760	M	U	L	29.4	75%	1228	25%	212		212
89-5.3	Forester Lk Pocket	10710	M	U	L	6.3	50%	1244	25%	31		31
89-6	Upr Rattlesnake Cyn	10440	M	U	L	6.4	50%	1332	25%	33		33
89-7	Shotgun Pass	10585	M	U	L	20.5	50%	1285	25%	103		103
89-8	South Rattlesnake Cyn	10320	W	U	L	20.9	30%	990	25%	48		48
89-9	Middle Rattlesnake Cyn	9500	W	U	H	7.2	60%	1285	35%	61		61
89-10	Cow Cmp (Rattlesnake Cr)	8720	M	U	H	14.4	25%	1891	35%	74		74
89-11	Laurel Cr Basin	10400	M	U	L	77	25%	1345	25%	202		202
89-12	Crytes Cr	10650	M	U	L	26	35%	1264	25%	90		90
89-13	Coyote Cr	9400	M	U	L	36.6	50%	1670	25%	239		239
90-1	Horse Cr	8580	M	U	L	1.8	75%	1937	25%	20		20
90-2	Ansel Lk	10540	M	U	L	19.9	10%	1300	25%	20		20
90-3	Evelyn Lk	8700	M	U	L	0.8	50%	1898	25%	6		6
90-4	Cow Cmp (Hockett)	8470	M	U	L	5.3	30%	1972	25%	24		24
90-5.1	Hockett	8500	M	U	H	42.1	35%	1963	35%	316		316
90-5.2	Hockett Past	8500	M	U	H	8.3	65%	1963	35%	116	100	100
90-6	Sand	8540	W	U	L	43.8	50%	1631	25%	279		279
90-8	Tuohy Cr Jct	8275	D	U	L	3.2	50%	827	25%	10		10
90-9	Lwr South Fk	8500	D	U	H	18.2	50%	788	35%	78		78
90-10	South Fk Mdw	8515	M	U	H	13.2	50%	1958	35%	141		141
90-11	South Fk Past	8560	M	U	H	9.3	50%	1943	35%	99		99

Forage Area Number	Forage Area Name	Elevation, ft	Moisture	Vegetation Zone	Logistical Value	Area, ac	Preferred vegetation	Productivity, lbs/ac	Utilization	Model capacity, stock nights	Evaluated capacity, stock nights	Proposed capacity, stock nights
90-12	Blossom Lk	10200	M	U	L	5.9	30%	1410	25%	19		19
90-13	Slim's	8860	M	U	H	8	50%	1846	35%	81		81
90-14	Green; Cabin	9350	M	U	L	44.1	20%	1686	25%	116		116
90-15	Tuohy	8350	M	U	L	5.8	50%	2011	25%	46		46
90-16	Summit	8980	M	U	L	13.5	50%	1807	25%	95		95
90-17	Cyclone	9290	W	U	L	31.4	40%	1361	25%	134		134
90-18	Summit Lk	9340	W	U	L	3.9	35%	1343	25%	14		14
90-19	Quinn	8340	M	U	L	23.8	50%	2015	25%	187		187
91-1	Ladybug Cmp	4280	D	L	L	0.4	100%	1526	25%	5		5
91-2	Whiskey Log Cmp	5300	D	L	L	0.4	100%	1348	25%	4		4
91-3	Cahoon (Hockett)	7340	M	L	L	18.5	50%	2340	35%	237		237
96-1	North Fk Kaweah River	1900	D	L	L	9.7	90%	1943	25%	132		132

Notes: Forage area number is "travel zone - number"
Moisture is D = dry, M = moist, W = wet
Vegetation zone is U = upper montane and subalpine, L = lower montane and woodland
Logistical value is H = higher, L = lower
Preferred vegetation is the percentage of the meadow area which is preferentially grazed by stock.
Productivity is 65% of the maximum productivity from Ratliff et al. (1987).
Utilization is the maximum percentage of annual plant production that may be grazed.
Model capacity is total production divided by consumption rate.
Evaluated capacity is capacity developed through an evaluation of past use and impacts.
Proposed capacity is the evaluated capacity (if listed) or model capacity.

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