**Sand Creek Massacre National Historic Site, National Park Service,**
**Science Status Report, 2008**

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**DRAFT Progress Report of 6/1/08**

Goals:

The objective of the project was to review available natural and cultural resources research reports that have been submitted to the park (list identified below), evaluate the findings, conclusions, and recommendations, determine if any conclusions or recommendations are in conflict with one another, and summarize the findings and recommendations into one set of findings and recommendations for park management.

The park is beginning its first General Management Plan and Comprehensive Interpretive Plan, and it is critically important that the park fully understands its baseline of natural and cultural resources data and resources management objectives to guide the planning process.

This project attempts a synthesis and summarizes the various project reports, and, where possible, provides an analysis of the reports to see where the points of agreement, contradictions, etc. exist. This project attempts to generalize consistent findings from all the research, point out where there are contradictions or questions that require more research, and summarize some key findings.

Reports requested for review:

1 Sand Creek Massacre NHS Vegetation Classification Study and Inventory of Plants at Sand Creek Massacre NHS (Roath report)
2. Pollen Analysis at Sand Creek Massacre NHS
3 A Study of 1864 Environmental Conditions (Environmental History)
4. A Preliminary Assessment of Wetland, Riparian, Geomorphology, and Floodplain Conditions at Sand Creek Massacre NHS
5. Prairie Dog Management Plan and Environmental Assessment
6. Inventory of Rare and Listed Species at Sand Creek Massacre NHS
7 Sand Creek Massacre NHS Bird Inventory
8. Riparian Forest Age Structure and Past Hydroclimatic Variability (Tree Ring Study)
9. Fish Survey at Sand Creek Massacre NHS
8 Geoarcheological Assessment of the Sand Creek Massacre Site
10. An Ethnological and Ethnohistorical Assessment of Ethnobotanical and Cultural Resources of Bent's Old Fort National Historic Site and the Sand Creek National Historic Site
11 Special Soils Survey Report, Sand Creek Massacre NHS

12. Special Resources Study and Environmental Assessment: Site Location Plan (Vol 1)
13. Sand Creek Massacre Project, Special Resources Study, Vol 2.

**Summary**

1. Are there conflicts among these reports?

The most obvious conflict is a conclusion within the pollen analysis study. That study implied that the site's vegetation in 1864 was radically different from a Great Plains grassland. This conflict can be resolved IF the pollen analysis is assumed to be heavily influenced by very small area vegetation inputs, rather than a sample of vegetation at the site. Clearly, the site in 1864 was a native grassland dominated by graminoid plant species, not an area dominated by weedy dicots.

There are conflicts about the landscape configuration of the exact massacre site. The oral accounts that include mention of rocks which are not present at the present site. However, the current morphology of the bluffs and eroded banks of portions of Sand Creek do appear 'rock-like' even though their composition does not include rock in a conventional sense. This apparent conflict is not viewed as a science issue.

There are minor conflicts, mostly plant nomenclature, which are identified below.

2. What are the key consistent findings?

The SCMNPS site is dynamic in terms of its vegetation composition. The relative abundance of vegetation and the fauna that exploit the vegetation as both habitat and food resources have changed annually, due primarily to water availability, and these have varied among years, due to the frequency of fire and intensive (but infrequent) grazing events. Finally, the site has seen the 'rise and fall' of cottonwood groves as these appear and disappear along Sand Creek over century-scaled time intervals.

Since the time of the massacre, what appears to have been intense and chronic grazing mostly by cattle has altered vegetation composition. Areas plowed in past decades for crops have been reseeded with native vegetation, but the composition of this vegetation is altered from what existed pre-plow. The challenge to maintain the site in a form compatible with its mission of historical conservation must find ways to mitigate unacceptable legacies from post-massacre land uses.

More recently, the site has experienced the 'directional drivers' (e.g., climate, $CO_2$ concentrations, N deposition, etc.) associated with global environmental change. The current suite of reports is consistent in NOT addressing these drivers. An analysis of how these drivers may have contributed to the current composition of the site and how these drivers may endanger desired vegetation components clearly is a management concern and research need.

3. What are the major research needs?

The existing vegetation data set needs to be analyzed to 1) provide a summary characterization of the site, and 2) to better understand the extent to which grazing and other disturbances have influenced the composition of the site. While references are made to a generic ('mythical' in my view) historical vegetation composition, vegetation analyses need to be presented in a manner to support forward-

looking management activities that maximize the conservation potential of the site, given the realities of spatial limitations and the vagaries of climate. Specifically, understanding the roles of grazing and fire and using these (or their absence) as management tools is viewed as very important. Further, 'novel' management activities such as mowing, creative revegetation, etc., offer possible opportunities to address conservation issues confronting the site.

A academic exercise could be conducted to integrate vegetation findings with the two soil survey reports, which should provide a baseline assessment of the importance (or lack thereof) the variability in soil conditions in influencing vegetation patterns. Such an analysis might show where current and future management actions are likely to be more or less successful with respect to specific plant species issues.

Achieving desired densities of prairie dogs and use of acceptable methods such as creative vegetation regimes to limit the extent of prairie dog communities remain important research questions.

Scenario planning for a site with a longer growing season (a high probability event) with the same or lower annual precipitation (a likely event) appears warranted. Overall, one might predict a more arid environment and explore mechanisms that increase the resilience of the existing ecosystem to this driver.

Future Desirable conditions.

In 1864, the Sand Creek region was a native grassland containing riparian areas and limited wetlands associated with a perennial spring. Most non-native species such as Kochia (*Kochia scoparia*) were not present, although a subset of non-native species such as Russian thistle (*Salsoli iberica*) may have appeared within the life-times of the survivors of the massacre. The most recent vegetation surveys as well as personal site visits in 2007 and 2008 indicate that no serious threats to native species from the presence of the non-native plant species are evident. However, sage (*Artemisia spp*, mostly *filifolia)* is likely much more abundant than it was in 1864 as a result of concurrent fire suppression and a century of chronic grazing at intensities that likely were in excess to pre-1864 levels. Periodic site use by large numbers of Native American horses undoubtedly had short-term impacts, but grasses of the Great Plains were adapted to high-intensity, short-term grazing. These species are not adapted to chronic, moderate to heavy grazing (and in particular the taller species cannot tolerate chronic late growing season grazing) which can favor a subset of the grasses (mostly buffalo grass and blue grama) and the increase in largely inedible sage species. Chronic grazing also reduced fuel loads such that widespread fire became a much rarer phenomenon. Restoring the dominance of the grassland should employ those techniques that favor the grasses over sagebrush. Both mowing and appropriately-timed fire appear to be management tools that can accomplish this restoration activity.

Project Reviews:

1. **Site Inventory of Plants at Sand Creek Massacre NHS (Roath et al. draft report 2007, as modified by Southern Plain Network, 2008)**

Conceptual issues:

"The Historical Climax Plant Community (HCPC) represents the natural potential plant communities found on relict or relatively undisturbed sites" (NRCS 2003). While the concept recognizes that such areas are determined by the state factors identified by Jenny (1980): climate, biota, topography, parent material, and disturbances such as glacial and drought histories, fire, grazing intensities, etc.. However, the one-to-one correspondence of a generalized community to a small area such as SAND has limitations. For example Roath et al. noted that "some key plant species such as fourwinged saltbush and big bluestem were completely absent from the site." While post 1860s human disturbances have been substantial, it's doubtful that these species (presumably common or dominant under the HCPC model) would have been singled out to be extirpated these from the site. A more reasonable hypothesis is that these species, if present, were initially rare. *Thus, the comparison of community composition with HCPC expectations, while an interesting academic exercise, should not be used as the sole or even major restoration guide.*

A second concern about the HCPC guide is simply that 'the rules that organize the composition of plant communities' have changed over the last few decades (Seastedt et al. 2008); the historical range of natural conditions and natural disturbances that contributed to the composition of this site in the 1860s cannot, in their entirety, be restored. The historical climate, atmospheric chemistry, and disturbance regime no longer exists, and while management activities can enhance or replace some of these, *ultimately the NPS must decide species composition goals and find management activities that advance the site towards those goals.*

The HCPC seems to assume a more mesic climate that has occurred either recently or during much of the documented history of the SAND site (see Mitchell et al. 2007). Periodic droughts, along with periodic fires, clearly influence the composition of the vegetation at this site. As mentioned in the Mitchell et al. (2007) review, both eastward and westward of this region, we know that periodic fires occurred at fairly frequent return intervals (2-4 year fire returns 300 miles to the east, and 7-12 year return intervals at the Colorado Front Range). Reduction of fuels by drought, overgrazing, or both would have reduced fire return intervals in this region during the 1800s, and it is possible that they were below the hypothesized 20-year burn interval for this region. At heavily used areas, such as SAND, this might overestimate the fire return interval. Nonetheless, fire was an organizing factor of the biotic community to a modest degree at this site.

Methodologies. The raw data for this report are apparently available, although this information was not included in the documents I've received by 5/20/08. *It is absolutely critical to have the raw data available for future research and monitoring.* Further, there's a master's thesis ready to be written based upon the first inventory work. Summaries by soil type, by disturbance regime, as well as an overall Park summary would be very useful products. The patterns of plant richness as a function of soils and disturbance regime would also be of major interest.

There are a lot of unidentified plants listed in this report. This will happen due to the limited seasonality of the study, but it's probably important to have well-trained individuals versed in rare species as well as in "early detection and eradication" techniques often walk the site.

The vegetation report lacks a summary. What is the most common plant species on SAND? What are the differences among the major soil types (loam, sand, salt meadow). How does current prairie dog grazing impact respective communities? This emphasizes the need for a more detailed plant community summary.

If I did my analysis of the summary species lists correctly, a total of 207 tentative plant species were identified at SAND. Of the 180 identified species, 167 were native and 13 were introduced.

*Specific comments/edits on the 2007 draft report***:** (Note: if these issues have been addressed in the 2008 edited report this is noted here)

Pg 23 What is scientific name of poison milkweed? *Asclepias subverticillata*?)

Pg 28 change "resistant to change to change…" to "resistant to change…" I question the assertion of "reduced infiltration" without empirical measurements. These slopes are so shallow I've got to believe the sites are very, very stable even under their altered (prairie dog) status. (Issues on Pg 28 were corrected in the 2008 report)

Given the prairie dog status and the assumptions that these animals were likely present in the past, the inferences in Table 1 (potential comp vs. current comp) is a bit of a distortion since the baseline should be "loamy early seral under prairie dog grazing"

And in general…some of these areas are so small that the "expected" is likely based on a much larger sampling area. So when we find a large local assemblage of native species well above "baseline" levels, we shouldn't be surprised and, similarly, when we find the rare species missing, this too is not a surprise?

Pg 46 typo: 7 lines from bottom "dominant". (this typo corrected on pg 49 of 2008 report).

The dominance of sand dropseed in some of the 'loamy' soils makes me think they're not so loamy…esp. with western wheat essentially absent from these. The co-abundance of side-oats grama makes me think the "loamy early-mid serial" stage, is not correct. An analysis of vegetation differences among sites given similar classifications might suggest some microsite soil differences or historical disturbances not discussed in the present effort.

Cover can vary from 35>60% in the Loamy A,B? This emphasizes the importance of grazing and grazing histories?

The loamy R site shows what happens when grazing is excluded: high build-up of western wheatgrass, but also sand dropseed and inland saltgrass are abundant! Again, a more methodical analysis of

vegetation differences seems appropriate. It's strange that this is the only site where western wheat is "within normal" based upon the NRCS classification.

Overflow Mid Seral. Contains some unqualified statement (pg 99) "The…community has lost many tallgrass species, important forbs, and shrubs." A) Possibly, the site never had them, or b) possibly the site was "too small" to have them. Some 'value' statements like "Energy and nutrient cycles have been greatly impaired and infiltration is greatly reduced due to the "root pan" of blue grama. (These statements imply data not in evidence!) (comments now are on pg 59 of 2008 report.)

Overflow B site missing western wheat…which was expected to compose 35-40%!

Overflow D…another grazing exclusion result.

Pg 120. Floodplain "Historically, fires occurred infrequently." Data? (remains on pg 120 of 2008 report).

Pg 120. Grazing destroys prairie cordgrass? I've not seen this. My experience is that cordgrass is only heavily grazed when everything else has been consumed.

Where is the current percent composition defined? Why doesn't this add up to 100% for grasses and forbs? (e.g. pg 130)

These data unchanged in 2008 version. Values exceeding 100% are possible if "hits" include more than one species per point…but this would need to be clarified in methodologies.

You look at the photos and wonder how sagebrush can be such a low % of cover of site N (pg 138)

Salt meadow (pg 152) lowest cover…caused by cottonwood shading? "A grove of cottonwood trees occupy the stratum." (pg 150) The analysis of "out of whack conditions (pg 150) seems to ignore the trees altogether? One might envision this community showing decadal to century-scale patterns as cottonwoods appear and disappear at specific sites.

Table 24: no summaries on % grasses, forbs. (This appears to have been fixed in the 2008 report)

Sands C = water tank disturbance area.

Sands RT: no summaries in table…and subsequent (These appear to have been added in 2008)?

Pg 185 *Amarthanthus retroflexus* identified as "non-native".?

Is the heath aster native to Colorado? Not in the Plant's database map.

Sands G…nice diversity! A function of sample size? This brings up an issue:

Vegetation composition is done with one sample size (e.g., n=80, pg 222) but then cover is done with a larger sample size? (ground cover, n = 360, pg 223)???? What appears to be reported, here, is that 80 plots were sampled with 6 points each, but then we would have 420 points? Is it n=60 on pg 222 or n=420 on page 223???

Sandy bottomland Early-Mid Seral. This site shows high diversity. What is frequently flooded (monthly, yearly…?) (pg 228)

Ref: Jenny, H. 1980. The Soil Resource. Springer Verlag, NY.

2. **Pollen analysis of sediment cores recovered from the Sand Creek Massacre NHS**. (Mensing, Univ. Nevada, Reno.)

Comments upon methodologies: This reviewer lacks the expertise to judge the quality of the methodologies, but these appear to be adequate. Plant species taxonomy needs to match that used by Roath et al. (2007).

Comments upon findings: *The results presented here appear to be localized and/or site specific. While there is no reason to doubt the pollen abundances found here, there are strong reasons to doubt that these findings have generality at sites beyond the sampling areas. A conclusion of the report (pg 1 of discussion, second paragraph) cannot be supported.*

The abundance of *Amaranthus* (probably *Amaranthus retroflexis*, redroot Amaranth or redroot pigweed) as well as the *Chenopodium* spp. appear well in excess of what likely was present in the past, or amounts currently on the site. While this study looks at pollen abundance and not plant abundance, these species occupy only a small percent of the flora now (Roath et al. 2007), and there are no historical accounts that suggest these species were abundant in the past anywhere in this region. Unless one can evoke a massive soil disturbance scenario, (and there appear to be none for SAND around the 1860s), this species was –and remains - at most a limited component of the site.

The only reference I could find to suggest any other scenario was in the SCMS Environmental History document (Mitchell et al. 2006), which included the anecdote, “One night he feasted on lambsquarters” (*Chenopodium album*), “an edible plant that he reported was found only near old Indian camping grounds” (pg 26, line7-8). Thus, the soil core and subsequent analysis may reflect a “local hotspot” of these species.

Given that fact, the relative stability of the pollen counts for these groups might argue that human disturbances have not been excessive since the 1850s? The increase in pollen of *Artemesia* would argue for heavier grazing. The presence of *Pinus* and *Alnus* pollen in the samples collectively demonstrate that pollen has been transferred in from distant locations, yet the dominance by the weeds suggests an overwhelming effect of local pollen deposition.

3.**Sand Creek Massacre Site: An Environmental History** (Mitchell, Langfield, Fiege, 2007)

A modestly edited version of this report could be published as a book. This report reads well, and appears to be very well documented. It's clear the authors have accepted what may currently be mainstream theory about the state of the western prairies in the 1800s. The combination of increased human populations, pre-existing huge herds of bison, and an exponential explosion in the number of horses, accompanied by droughts characteristic of this region, produced what appears to be an 'overgrazed' landscape. Such a landscape, theoretically, could have moved SAND towards the "early to mid seral" vegetation compositions discussed in the Roath et al. (2007) report. Thus, the deviation from the "Historic Climax Plant Communities" may have begun earlier than in the 20th century.

I accept the conclusions of Mitchell et al. regarding the status of the site. Both eastward and westward of this region, we know that periodic fires occurred at fairly frequent return intervals (2-4 year fire returns 300 miles to the east, and 7-12 year return intervals at the Colorado Front Range). Reduction of fuels by drought, overgrazing, or both would have reduced fire return intervals in this region during the 1800s, and it is possible that they were below the hypothesized 20-year burn interval for this region. At heavily used areas, such as SAND, this might overestimate the fire return interval. Nonetheless, fire was an organizing factor of the biotic community to a modest degree at this site.

Comments about the technical accuracy of this document are minor, but include:

Pg 17, line 1. "Tallgrasses" are usually considered warm season grasses and do not green up early. Chances are good these were all "cool season grasses", all of which would be considered mixed grasses. (Prairie sandreed (*Calamovilfa longifolia*) does green up earlier than most tallgrass species, but it's not on the current species list for SAND).

Pg 22, line 7. Buffalo grass is *Buchloe dactyloides,* the synonym listed is no longer valid. A few plant scientific names thereafter also are synonyms or misnomers for plant species used in the Roath (2007) report.

Page 60, first sentence. Actually, there's a large difference in the landscape impacts of bison and cattle grazing IF fences were not involved. Bison were able to travel much farther from water, so the intensity of the grazing impacts was spread over a larger area. Cattle are much more likely to graze at or short distances from water; impacts are more localized.

Page 68. Vegetation list. This should match up with vegetation summaries and nomenclature from Roath (2007). Roath reports no fourwing saltbush (*Atriplex canescens*, not *Chenopodium amaranthus*…there apparently is no such plant). As suggested elsewhere, the findings of the pollen core study cannot be generalized to characterize SAND

4. **A Preliminary Assessment of Wetland, Riparian, Geomorphology, and Floodplain Conditions at Sand Creek Massacre NHS** (Noon et al. 2005)

This report establishes the estimates of the 100 year flood plain and makes appropriate observations based upon that measurement. As noted in the report, the present floodplain appears to have been the consequences of larger flow regimes during a more mesic period and therefore the current floodplain is 'large' relative to anticipated flood runoff. This assumes no unusual upstream developments, but no such developments are anticipated.

Specific comments/observations.
The concern about erosion at this site and potential damage caused by any surface disturbance is real. However, in mitigating vehicle or even foot traffic, effects on surface runoff should also be considered. Vegetation adjacent to trails and roads is 'subsidized' in terms of water and nutrients, and this will select for species unlikely to be those previously adapted to local conditions.

The hydraulic problems associated with County Road W crossing were noted. The wetland at this site appears to have been enhanced during the 20th century to provide a water source for fire control purposes (Tilmant et al. 2006). If restored to more 'natural' conditions, this 'benefit' may be lost. While artificial, there's little doubt the wetland area provides wildlife values not previously present. Among the options for dealing with the obvious flooding issues associated with the current configuration of culverts, a combined culvert and low water crossing design might be added to other options. While as unnatural as the road itself, designing this crossing for higher flows should still consider ways to maintain the wetland.

**5. Prairie Dog Management Plan and Environmental Assessment** (draft). (Sovell 2008)

This report appears to be an adequate synthesis of knowledge, but is missing the arguments for maintaining or even enhancing populations of this species in areas where they have the potential to function as keystone species (Miller et al. 2007). My major concerns with the proactive management suggestions in this report are fourfold. First, as mentioned elsewhere in this report, the assumption that precipitation will return to averages recorded in the 20th century remain uncertain. Accordingly, the analysis of prairie dog-vegetation also contains substantial uncertainty. Second, the prairie dogs appear associated with species of concern at SAND (mountain plover and burrowing owl; Hanni 2007). Third, an assessment of vegetation change associated with current prairie dog colony activity and paired uncolonized areas have not been conducted (although the data are available?). One interpretation of the vegetation inventories of this site conducted by Roath et al. (2007) is that in previous centuries prairie dogs may have occupied a much larger expanse of this area than current populations, and this historical influence is reflected in the very high forb abundance present in the current vegetation composition. Finally, this report concludes (pg 10) that proactive control efforts are likely to stimulate population growth, thereby resulting in rapid recovery of the population. If that's the case, why control in the first place?

In any event, a 'go slow' recommendation for proactive management of these important species seems appropriate. Perhaps meetings with private landowners will dictate some control measures at

boundaries. Would it be appropriate for the Cheyenne and Arapaho peoples to weigh in on the significance of this species at the site?

"We conclude that the available information does not justify holding distribution and numbers of prairie dogs at a level that is too low to perform their keystone ecological function. We further conclude that it is especially important that prairie dogs be sufficiently abundant on public lands to perform this function" (Miller et al. 2007).

Ref: Miller BJ, Reading RP, Biggins DE, Detling, James K.Forrest, Steve C., Hoogland, John L.Javersak, Jody, Miller, Sterling D., Proctor, Jonathan, Truett, Joe, Uresk, Daniel W. Prairie Dogs: An ecological review and current biopolitics. JOURNAL OF WILDLIFE MANAGEMENT **Volume:** 71 2801-2810 NOV 2007

6. **Bird Inventory** (Hanni 2007)

A second opinion should perhaps be sought out to make sure the sampling intensity of this project was adequate (e.g., pg 3), but the species list seems complete to a non-specialist. This report provides a baseline inventory that now can be used and expanded through time. Reference to an "upland sage habitat" (pg 3) presumably refers to the grassland transect. There is no natural "upland sage habitat" at this site.

The presence of 16 species of conservation concern highlights the value of this property for avian conservation. All site management activities need to be evaluated in terms of their potential positive and negative impacts on avifauna.

7. **Rare Species Inventory** (Sovell 2007).

This report provides baseline information on species of conservation concern. The report supports other studies regarding the absence of certain fish and plant species. The report's recommendation regarding a 'go slow' approach to plans for the reestablishment of such species as the lesser prairie chicken appears insightful.

8.**Riparian Forest Age Structure and Past Hydroclimatic Variability**. (Lukas and Woodhouse 2006)

As this report emerged from my own research institution, I must be considered in conflict with the authors and independent evaluation of this effort should be obtained. That said, this report provides information about the age structure and recruitment of cottonwood trees into the Sand Creek floodplain. These findings appear compatible with the historical accounts.

The work also supports the current model that cottonwood population dynamics would show interesting dynamics at both temporal and spatial scales. Along the reach of Sand Creek in SAND, for example,

individual stands of trees would be recruited under similar climate/flood scour conditions at similar times, and such stands would inhibit subsequent regeneration. Die-back and an opening of the canopy would result in conditions favorable for reestablishment. Across the plains one can envision an undulating pattern of regrowth, maturation, and die-back of cottonwoods across the floodplain. At present, a maturing cottonwood forest occupies a substantial portion of SAND, but given the current age structure of the trees, the site may return to its 1864 configuration in the not-too-distant future. Of note is that the last large cohort of cottonwoods were seedlings during what was a hot and dry interval, demonstrating that simple rules about climate and regrowth of riparian forests is more complex that models based upon climate averages. Herbivory, or the absence thereof, could, for example, be a factor in seedling establishment.

Reconstruction of the climate of this region would likely show the period of Native American and European expansion into this region to be one that was perhaps more benign than what existed in the centuries prior to this period. In reconstructing the climate of the Western US, Cook et al. (2004) note that:

> "…this drought (in the early 2000s) pales in comparison to an earlier period of elevated aridity and epic drought in AD 900 to 1300, an interval broadly consistent with the Medieval Warm Period. If elevated aridity in the western United States is a natural response to climate warming, then any trend towards warmer temperatures in the future could lead to a serious long-term increase in aridity…" (pg 1015).

Since those authors penned those words, the prognosis for the western U.S. continues to be one where drought scenarios have higher probabilities than other climate configurations (J. Overpeck, Univ. Ariz., pers. communication to TRS). This expectation of droughts that mimic (at a minimum) the intensities of those observed in the 1930s and 1950s should always be considered in management activities.

Ref: Cook, E.R., C.A. Woodhouse, C.M. Eakin, D.A. Meko, and D.W. Stahle. Long-term aridity changes in the western United States. Science 306: 1015-1018.

9. **Fish Survey at Sand Creek Massacre NHS**, March 14, 2006 (Tilmant et al. 2006)

This report collaborates the rare species inventory, indicating that only the plains killfish has, to date, been positively identified as a resident of Big Sandy Creek. No additional inventories should be necessary until, perhaps, after then next major flow events on the Big Sandy. Species can be expected to be exchanged along that stream during high flow and deposited in permanent sites. However, localized extirpations clearly occur.

10. **An Ethnological and Ethnohistorical Assessment of Ethnobotanical and Cultural Resources of Bent's Old Fort National Historic Site and the Sand Creek National Historic Site** (Campbell 2007)

I do not possess the training to evaluate the dominant social science aspects of this work. Certainly the encyclopedic coverage of this report is acknowledged. The author clearly felt a "big picture" approach was required, and that approach has value. Here, we're provided extensive detail about the culture of the Cheyenne and Arapahoe during the mid to late 1800s, a focus that emphasizes the complexity of the cultures. Regretfully, the amount of time and detail paid to ethnobotanical information specific to SAND was modest at best. If possible, this particular portion of the project should be expanded and continued IF sources for this information are still available.

Among the reports I've read, the number of Cheyenne and Arapahoe killed in the Massacre appears to be "over 150" (Mitchell et al. 2007) to "over 500" (Campbell 2007). Both numbers are appalling; but the best estimate should be reported? It would appear that Campbell chose to use the number reported by Chivington, which I assume is in error.

The scientific name for chokecherries (pg 74) is *Prunus virginiana*. This error is repeated on pg 214, where a reference URL is given that doesn't exist.

Pg 1558. There are some missing numbers that need to be added here.

Possible follow-up projects for the ethnobotany work:

Those species listed within the Campbell (2007) report need to be matched up with the vegetation inventory at SAND. What might be of interest is to note how the Cheyenne and Arapahoe nomenclature for the plants matches up with the concept of 'species', and how these patterns were affected by the use(s) of the plants?

11. Special Soil Survey Report, Sand Creek Massacre National Historic Site, Colorado. Draft July 2006. (NRCS report, survey date 12/19/2005.)

This report provides an update on the information provided by the Soil Survey of Kiowa County conducted by the USDA SCS (Anderson et al.) published in 1981. At the time of this writing I lack a full version of this report, but it provides information similar to that published in 1981.

12, 13. National Park Service. 2000. Sand Creek Massacre project, volume 1: Site location study. Volume 2: Special resource study and environmental assessment. Denver, CO: National Park Service, Intermountain Region. Sand Creek Massacre Project, Special Resources Study, Vol 2

These reports have provided the background research in the general ecological and socio-economic history of the site. As noted by Emily Yost's web posting:

> "The Sand Creek Massacre National Historic Site Study Act of 1998 directed the National Park Service to "identify the location and extent of the massacre area and the suitability and feasibility of designating the site as a unit of the National Park Service system" and prepare alternatives for management, administration, and protection of the area. The National Park Service worked with the State of Colorado, the Northern and Southern Cheyenne tribes, Northern and Southern

> Arapaho tribes to locate the massacre site. The National Park Service Sand Creek Massacre project team used an integrated, multi-disciplinary approach to identify all potential locations of the massacre.
>
> The site location study was completed in 1999 with the cooperation of property owners, Cheyenne and Arapaho descendents, local residents, and scientists. Key features of the massacre lie within the site's mapped boundary: the encampment, sandpit area where the fiercest fighting occurred, and the paths of the military's approach and Indian's flight."

This is an excellent summary. While there will always be uncertainties regarding the exact plant community configuration at the time of the massacre, and there now will also be uncertainties regarding specific details of the massacre itself, all relevant historical information appears to have been retrieved and reviewed. These volumes provided the basis for the subsequent studies evaluated in more detail here, and their science content appears to have been validated and expanded upon in subsequent studies.

**Next Steps for this Science Review**:

NPS personnel will provide feedback to the author. This feedback might include (in addition to other suggestions):

1) what additional materials should be included in the final report
2) what studies need to be evaluated in greater detail