Central Coast Rangeland Coalition
Indicators of Sustainable Rangeland Stewardship Project

Final Report and Results of Indicator Testing

to the U.S.D.A. Natural Resources Conservation Service
In Fulfillment of Cooperative Agreement #65-9104-5-530

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FINAL: September 17, 2007

Outline

I. INTRODUCTION AND PREVIOUS WORK

The following work, including nine technical reports and 15 individual property test reports prior to this report, has been completed since the start of the project in September 2005:

- Meetings with ranchers (January, February, and April 2006) and agency managers (June 2006)—refer to previous reports submitted (Synthesis of Rancher Meetings, dated May 8, 2006; Summaries of Agency Rangeland Manager Meetings, dated July 14, 2006 and August 2, 2006)

- Synthesis of stewardship concerns and indicator concepts—refer to previous reports submitted (Synthesis of Rancher and Agency Priority Concerns, Indicators, and Recommendations, dated August 4. 2006)

- General meetings (October 12, 2006 and August 29, 2007)—refer to previous reports submitted (Rangeland Health Indicator Monitoring System—Outline, dated October 6, 2006)

- Analytical process—refer to previous reports submitted (Revised Draft Indicator Monitoring System, dated October 18, 2006)

- Summary—refer to previous reports submitted (Latest Draft--Sustainable Rangeland Stewardship Indicators, dated March 1, 2007)

- Scientific review and advice—refer to previous reports submitted (Summary of CCRC Indicators Review, dated March 30, 2007)

- Indicator testing plan—refer to previous reports submitted (Testing Plan, dated April 8, 2007)

- Testing at 15 properties—refer to previous reports submitted (Preliminary Results of Indicator Testing and Recommendations, dated June 20, 2007)

We gratefully acknowledge the collaboration and contributions of the following colleagues in completing this work:

- John Warner, Range Management Specialist, NRCS, Hollister Field Office, CA, for advising on testing design; providing his expert assistance in conducting the field testing in April 2007; providing expert advice on revisions of indicator monitoring methods, including bringing in the expert assistance of his NRCS colleagues; compiling and summarizing soils information and developing the aerial photo maps for the individual property reports; and reviewing and sending the individual property reports to the property owners.

- Dr. Grey Hayes, Elkhorn Slough Coastal Training Program Coordinator, Watsonville, CA, for expert advising on project progress; coordinating and guiding the interviews and correspondence with the panel of scientific advisors; and assessing and preparing most of the summary of that panel's recommendations.

- The CCRC Subcommittee, including Daniel Mountjoy, Rich Morris, Joe Morris, Dan Olstein, Sheila Barry, those mentioned above, and others for technical and organizational

advising and leadership when needed, including reviews of the documents listed above; coordinating with CCRC members to identify and make the arrangements for testing at the 15 properties; and making the CCRC as relevant and important as it is.

II. INDICATOR TEST RESULTS SUMMARY

In the spring of 2007 we visited and tested the indicator system at fifteen properties on the central coast from San Luis Obispo County north to Alameda County. We were able to sample multiple sites at all except one property. The goal was to see how feasible our methods were, how long it took to carry out the monitoring, how useful the resulting information would be, and how we could improve the monitoring methods. The following report shows how the monitoring results can be displayed, how the variables and components of indexes can be used, how results compared within the region, and whether or not such results can meet CCRC goals for monitoring. The results offer a general picture of conditions at each property and site sampled, but in this test, our sampling of the field variables (other than the questionnaires) was not extensive enough or representative enough to make definitive judgments about overall conditions at a property or in the region. The results of the questionnaires are more accurate for each property since these did not involve sampling, assuming accuracy of the answers given by the interviewees. More extensive sampling of the field variables at each property, and monitoring of the "special" management variables, would be necessary to provide a more accurate and comprehensive evaluation of stewardship at each property (refer to the CCRC draft document, "Indicators of Sustainable Rangeland Stewardship," dated March 1, 2007 by Ford and Huntsinger and earlier documents).

To preserve participant confidentiality, the following results summary presents only comparisons of property averages to averages for the sub-regions (corresponding to the three bays) and for the whole CCRC region. We plan to make these overall results public in formal publications, with the exception that all information identifying specific individuals or properties will be excluded. All personal information and records from the test monitoring will remain confidential, and stored securely at the NRCS field office in Hollister, CA according to NRCS confidentiality rules.

Confidential reports of the test monitoring at the fifteen properties were completed and distributed under cover letter by John Warner of the NRCS. The format and contents of the reports were approved by him and Daniel Mountjoy for the NRCS. The reports are full of useful information, including property maps, photos of the transects, graphs of monitoring data (comparing the property to the relevant sub-region and the whole CCRC region), and some interpretation.

II.A. Stewardship Plan (Indicator of Stewardship Planning)

To test the interpretation of results from this complex monitoring variable, we derived a potential index from questionnaire answers by: summing the scores from each of 10 planning elements assessed in five categories of recording and use of the planning information. Note that the score for existence of a comprehensive and up-to-date written plan was given a weight 10 times the score of the other 50 categories. The resulting index could be between 0-300. Refer to Appendix 1 for more details about the components of this variable. The most heavily weighted component was whether all the management planning information was compiled into one written document.

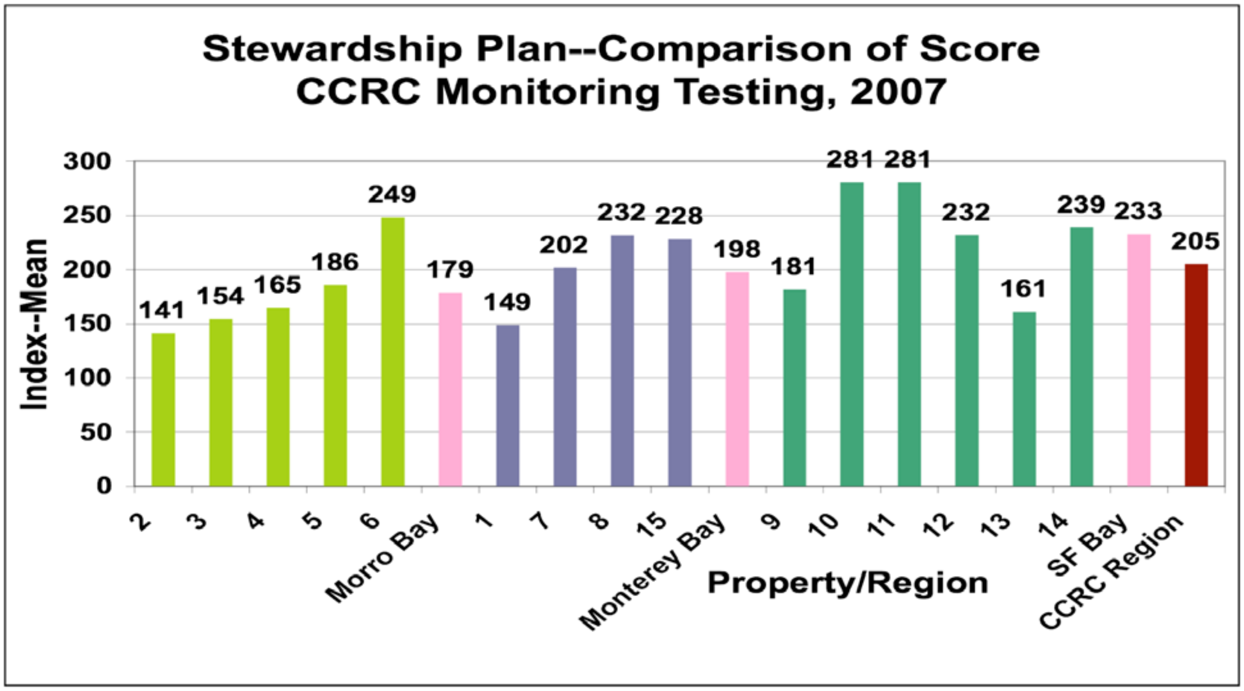

Figure 1. The scores in the stewardship planning index for each property sampled are compared to the average scores for each sub-region (Morro Bay, Monterey Bay, and SF Bay, pink bars) and the average for the combined CCRC region (red bar). A higher number means that the property manager had completed and documented more of the planning components. A lower score may reflect less documentation or planning (Appendix 1 shows the components of the index).

General conclusions:

- Mean index scores across the whole CCRC Region varied substantially from 141 to 281; the average was 205, indicating that most properties would benefit from additional stewardship planning according to the criteria established by the CCRC thus far.
- The Morro Bay Sub-Region average was lower; the Monterey Bay Sub-Region average was about the same; and the San Francisco Bay Sub-Region average was higher than the average for the whole CCRC Region.
- No pattern was discernable for grazed versus ungrazed properties.
- Master plans—3 of 15 properties have written master plans; 6 more have partial written plans; 6 have no written plans.
- Consistently least included in planning—Contingencies (written and supporting information).
- Consistently most included in planning—Site description knowledge; Goals and management objectives knowledge and current on info; Grazing recommendations knowledge and utilization of knowledge.

- Those with written comprehensive master plans included one agency manager (with two properties) and one rancher-owner.

II.B. Bare Ground (Indicator of Watershed Condition, Nutrient Distribution and Recycling, Habitat Diversity, and Public Image)

The following graph shows the percent absolute cover of bare ground found at the participating properties in the sub-regions and the whole CCRC region. Refer to Appendix 1 for more details.

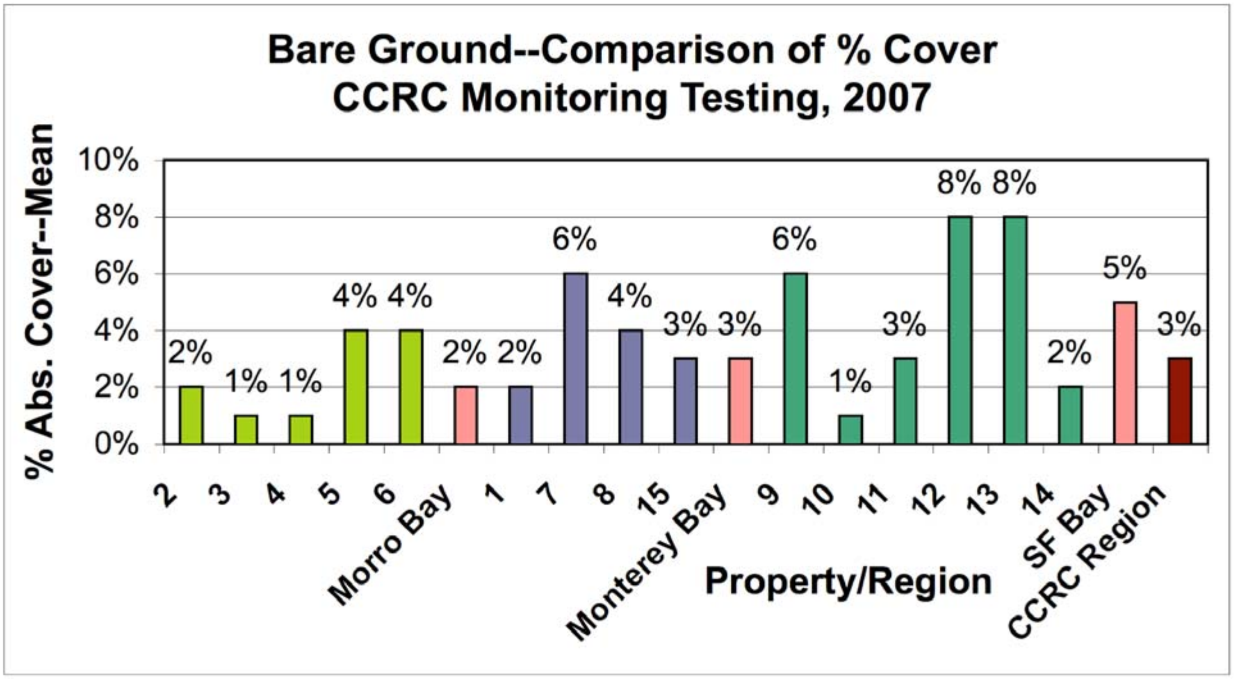

Figure 2: The average percent bare ground cover found at each property sampled is compared to the average for each sub-region (Morro Bay, Monterey Bay, and SF Bay, pink bars) and the average for the combined CCRC region (red bar). A higher number means more bare ground was present; a lower score means less bare ground was present.

General conclusions:

- Mean absolute cover across the whole CCRC Region varied substantially from 1% to 8% (both in the San Francisco Bay Sub-Region); the average was 3%, indicating the bare ground at most properties was well below the maximum (15-25%, depending upon ecological site and weather history) typically recommended by rangeland management professionals for California Non-Native Annual Grassland, and would not necessarily benefit from management attention.
- The Morro Bay Sub-Region average was lower; the Monterey Bay Sub-Region average was about the same; and the San Francisco Bay Sub-Region average was higher than the average for the whole CCRC Region, possibly reflecting a gradient of more to less forbs in the grassland (this was not assessed) from south to north.
- No pattern was discernable for grazed versus ungrazed properties.

- This likely reflects good stewardship as well as abundance of annual forbs during the spring of 2007. Measurement of this variable later in the year would likely have shown far more bare ground due to reduction of those annual forbs (due to drying and decomposition), and thus possibly distinguishing properties, sub-regions, and grazed status. This variable is highly influenced by rainfall and other climatic variables.
- Monitoring of this variable in the spring has not revealed much useful information to affect management.

II.C. Soil Structure (Indicator of Soil Stability and Capability of Infiltration)

We derived a potential index to test the interpretation of results from this important monitoring variable by: (a) assigning a soil structure score of 3 for soil samples displaying least compaction and more infiltration potential (single grain, granular, or blocky), a score of 2 for soil samples displaying medium compaction and infiltration potential (platy), and a score of 1 for soil samples displaying most compaction and least infiltration potential (massive); and (b) multiplying the sum of scores for the 0-4 inch depth by two, adding that product to the sum of scores for the 4-8 inch depth, and dividing by 30 (for 3 x 10 soil test holes, unless the number of test holes was less). Refer to Appendix 1 for more details. The resulting summary score could be between 1-3. A summary index score of at least 2 indicates good structure for infiltration of water into the soil. A score of less than 2 indicates that an improvement of soil structure would be valuable, depending upon the potential of the soil and site.

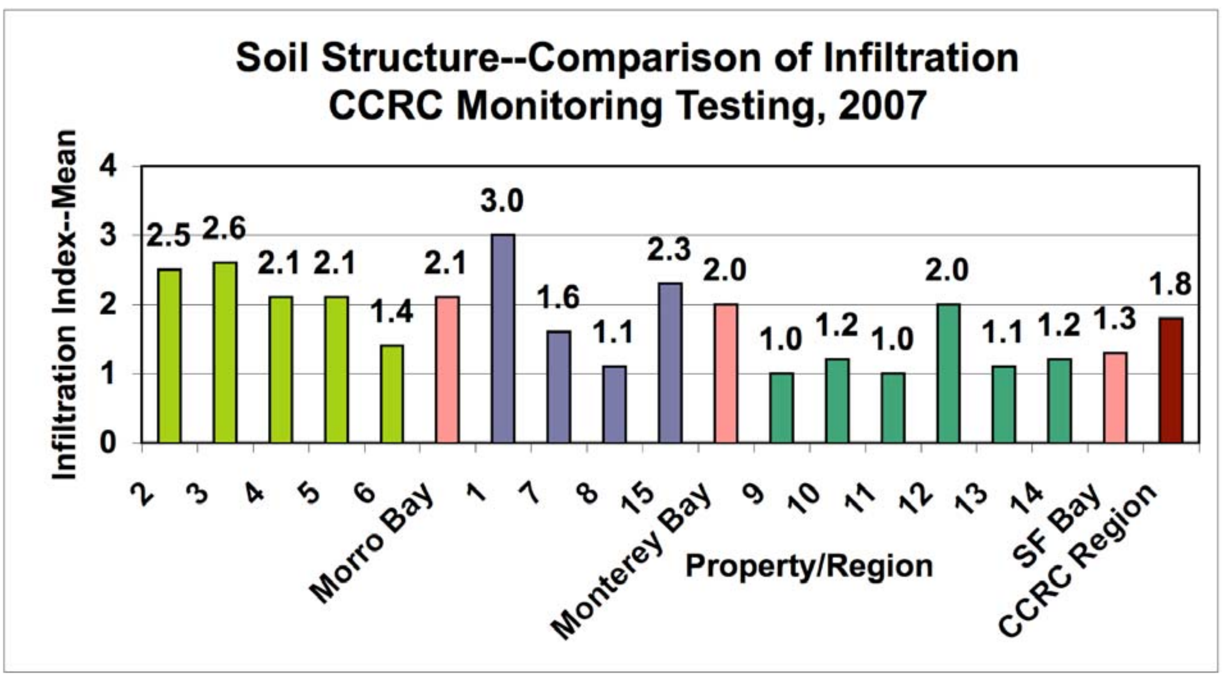

Figure 3. The infiltration capacity measured on sites on each property sampled is compared to an average score for each region (Morro Bay, Monterey Bay, and SF Bay, pink bars) and the average for the combined CCRC region (red bar). A higher number means that the soil has more infiltration capacity. This index represents the range from 0 (least infiltration capacity) - 3 (most infiltration capacity).

General conclusions:

- Mean indexes across the whole CCRC Region varied substantially from the minimum to the maximum (1 to 3); the average was 1.8, indicating the soil structure at most properties was less than optimum, and often less than the apparent potential structure based on NRCS soils surveys.
- The Morro Bay and Monterey Bay Sub-Regional averages were above; and the San Francisco Bay Sub-Regional average was below the average for the whole CCRC Region, possibly reflecting a gradient of less to more farming histories in the grasslands (this was not assessed) from south to north.
- Most properties showed reduced soil stability and capability for infiltration, and therefore increased vulnerability to erosion; slightly less such vulnerability was evident in the upper soil zone than in the lower zone, probably reflecting a history of cultivation (and past damage to soil structure).
- No pattern was discernable for grazed versus ungrazed properties; although two of the three ungrazed properties showed the lowest possible structure index.
- While those properties with the lowest index would benefit from improved soil structure, not all soils have that potential; and where there is potential, such improvement could take decades. More information is needed to determine whether soil structure characteristics on particular ecological sites can be altered through management.

II.D. Aquatic Macro-Invertebrates Occurrence (Indicator of Watershed Water Quality and Stream Habitat Diversity)

We derived a potential summary score to test the interpretation of results from this monitoring variable by: (a) assigning a pollution tolerance score of 1-3 corresponding to group numbers (see below); and (b) adding the tolerance scores of the dominant invertebrates at each sampling station and dividing by the number of sampling stations. Aquatic macro-invertebrates generally fit into three groups related to tolerance of water pollution, and thus indicate water quality. Group 1 invertebrates are generally "sensitive" to pollution, and are found in "good quality water." Group 2 invertebrates are generally "tolerant" of pollution, and are found in "good to fair quality of water." Group 3 invertebrates are generally "tolerant" of pollution, and are found in any quality of water. No suitable streams were found to sample at two properties in the Morro Bay Sub-Region; at one property in the Monterey Bay Sub-Region; and at two properties in the San Francisco Bay Sub-Region. No invertebrates were found in an apparently suitable stream at one property in the Monterey Bay Sub-Region, and is indicted by a score of 4. At another property (in the Morro Bay Sub-Region) only one invertebrate was found in the entire stream segment, and is indicated by a score of 3.9. These are cases with uncertain results that should be investigated further. Refer to Appendix 1 for more details. The scores below represent properties that had streams suitable for sampling, and where aquatic macro-invertebrates were found. Further investigation is needed to determine why some properties with suitable habitat apparently supported no macro-invertebrates, how to improve this indicator, and whether another indicator would be effective at all the properties.

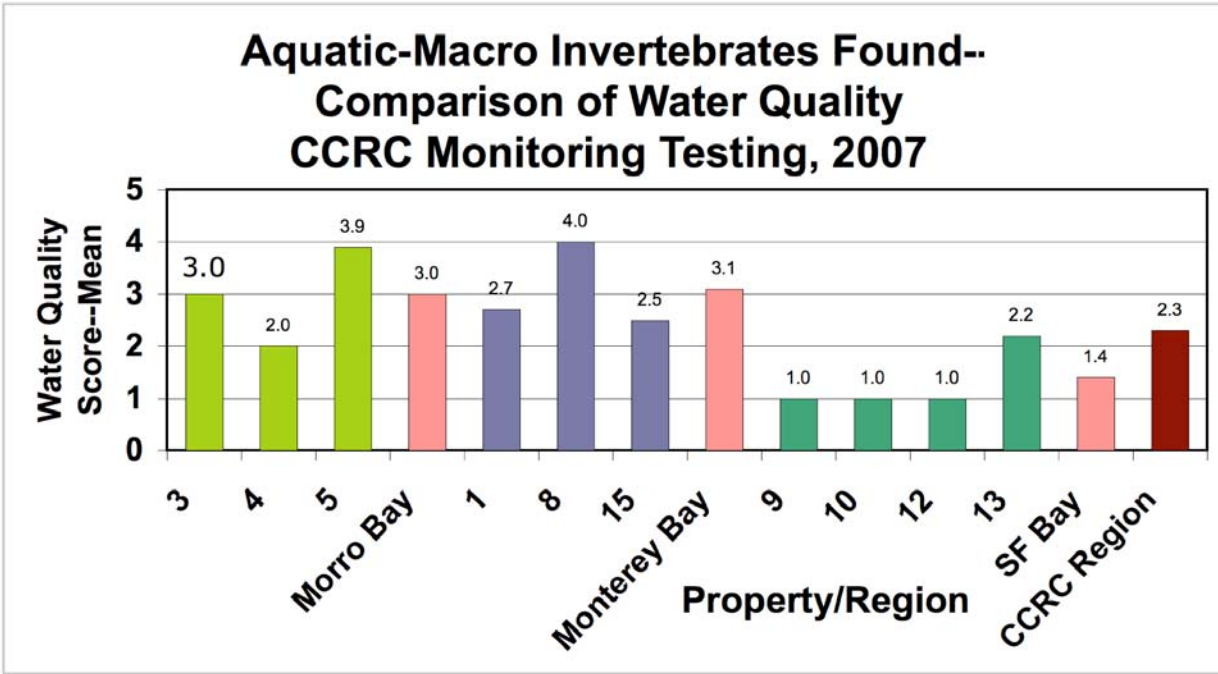

Figure 4. Water quality as indicated by the presence of aquatic invertebrates found during sampling. The indicated water quality is compared to an average score for each sub-region (Morro Bay, Monterey Bay, and SF Bay, pink bars) and the average for the combined CCRC Region (red bar). A higher score (up to 3) means that the aquatic macro-invertebrates found are tolerant to higher levels of pollution, and thus indicated that higher levels of pollution were present. The score 4 means that no macro-invertebrates were found in apparently suitable stream habitat, thus indicating uncertainty and the need for further investigation. A lower score means that the aquatic macro-invertebrates found are intolerant of pollution, and thus indicated that little pollution was present.

General conclusions:

- Average scores across the whole CCRC Region varied substantially from the minimum to the maximum (1.0 to 4.0); the average was 2.3. Further study is needed to determine how to include sites where no macro-invertebrates are found. The results at such sites (two properties had scores higher than 3) were included in the computations of the averages shown, and thus might have skewed our interpretations.
- The Morro Bay and Monterey Bay Sub-Regional averages were more than 2.0 and more (worse) than the average for the whole CCRC Region, possibly reflecting water pollution sources above the sample points. The San Francisco Bay Sub-Regional average was less than 2.0 and less (better) than the average for the whole CCRC Region.
- No pattern was discernable for grazed versus ungrazed properties (but only one ungrazed property had a flowing stream, which is an insufficient sample size to make conclusions).
- Three of the nine properties with an appropriate stream to assess had invertebrates of the class with no tolerance of pollutants (score of 1); six of the nine properties had invertebrates of the classes that indicate presence of pollutants (scores of 2 < 4); one of the nine properties had no invertebrates of any kind (score of 4); five properties did not have an appropriate

stream to assess, and thus no assessment was possible there (no bar, and not included in averages).

- This indicator has revealed useful information. Assuming similar results would be found over the rest of each property with scores above 2.0, management attention to potential sources of water pollution (on and off the property) might be appropriate. At properties with scores less than 2.0, no management attention appears to be needed.

II.E. Residual Dry Matter (Indicator of Watershed Condition, Plant Productivity, Presence of Functioning Recovery Mechanisms, Habitat Diversity, and Fire Hazard)

This indicator was not assessed this spring since it is, by definition, measured in the fall. Nevertheless, some relevant information is available from monitoring of the following indicator.

II.F. Thatch Persistence (Indicator of Nutrient Distribution and Recycling, Plant Productivity, and Habitat Diversity)

This indicator refers to the herbaceous biomass of a grassland that is older than the current year's growth. Refer to Appendix 3 for more details. We measured the current year's biomass and the prior year's biomass (thatch) present in the sampled management unit. Where the management unit was grazed during the previous year, we also estimated ungrazed current (peak crop) biomass and thatch from an adjacent ungrazed site (where available); where an ungrazed comparison was not available, we used the estimate of the property manager. We derived two potential indexes to test the interpretation of results from this monitoring variable. The first index is the proportion of the thatch over the sum of the amount of thatch and the current year's biomass in the management unit. The second index is the proportion of thatch over the sum of the estimated amounts of ungrazed thatch and the current year's estimated peak crop (ungrazed current year's biomass). The resulting indexes could be between 0-100%.

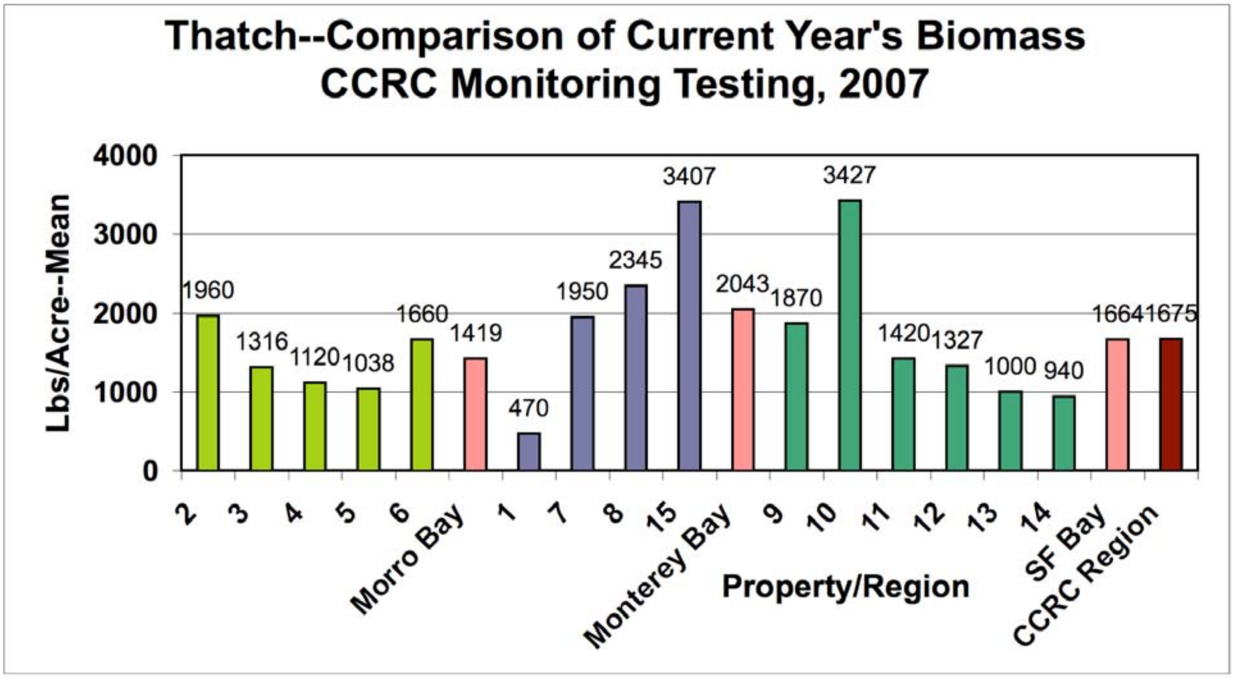

Figure 5. Current year's average biomass compared to the averages for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average for the combined CCRC Region (red bar).

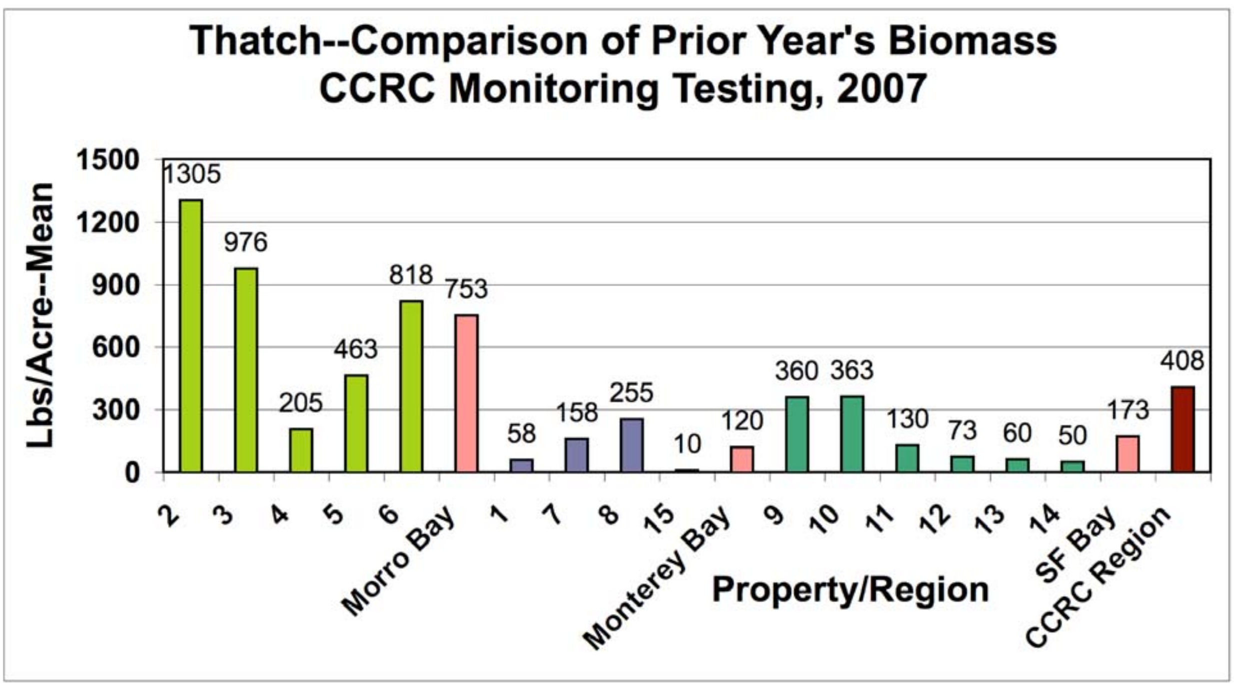

Figure 6. Prior year's average biomass compared to the averages for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average for the combined CCRC Region (red bar).

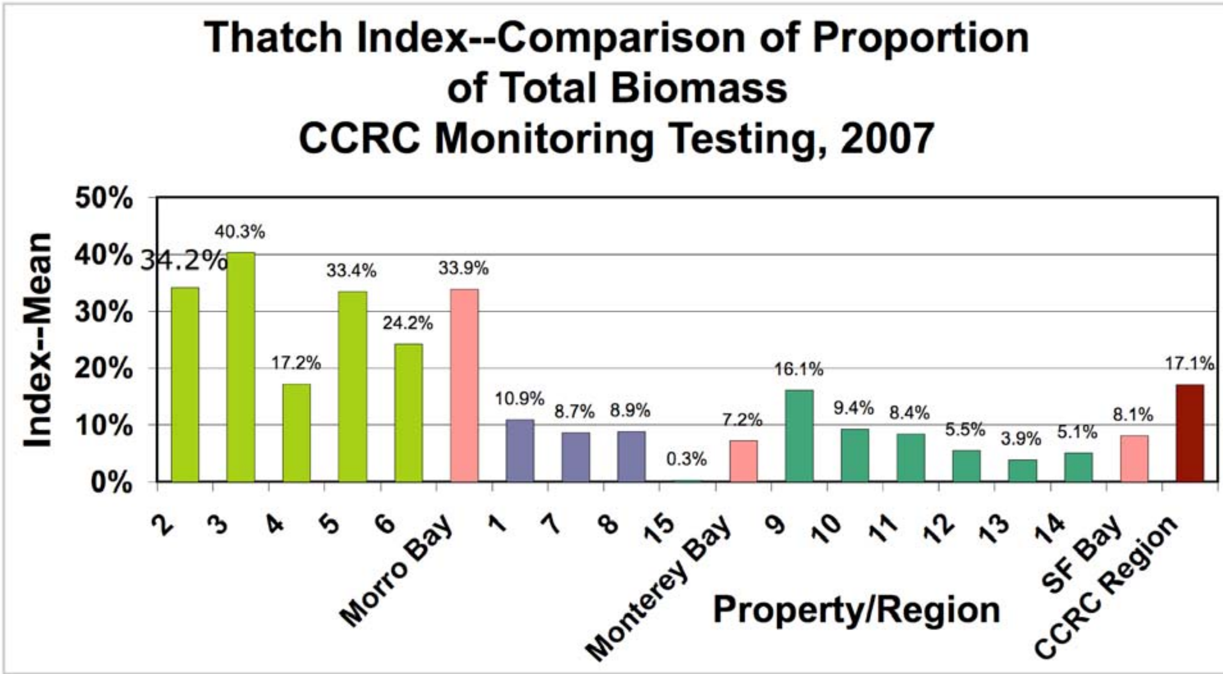

Figure 7. Index of prior year's average biomass as a proportion of total biomass compared to the average indexes for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average index for the combined CCRC Region (red bar).

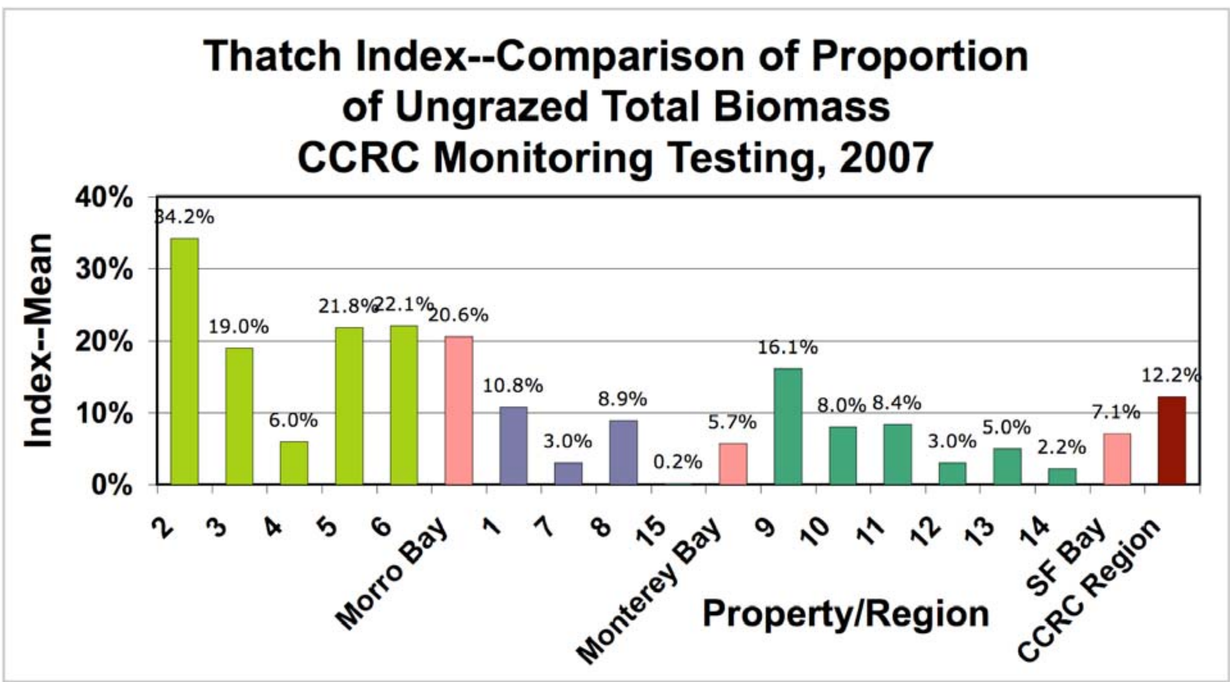

Figure 8. Index of prior year's average biomass as a proportion of ungrazed total biomass compared to the average indexes for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average index for the combined CCRC Region (red bar).

General conclusions:

- Current year's biomass average indexes across the whole CCRC Region varied substantially from 470 to 3427 lbs/acre; the average was 1675 lbs./acre, indicating a fairly high level of herbaceous growth, particularly during a drought year.
- The current year's biomass average for the Morro Bay Sub-Region was below, while the average for the Monterey Bay Sub-Regional was above, and the average for the San Francisco Bay Sub-Regional was about equal to the average for the whole CCRC Region.
- The current year's biomass was relatively high for most properties, and reflected livestock utilization that was not excessive. However, at some properties, the lower biomass level reflects conditions (including drought) where expected livestock utilization and decomposition through the summer might reduce the autumn RDM to below recommended standards.
- The current year's biomass averages for the ungrazed properties were not consistently higher or lower than the sub-regional averages or the regional average.
- Thatch average indexes across the whole CCRC Region varied substantially 10 to 1305 lbs/acre; the average was 408 lbs./acre, indicating a fairly high persistence of thatch at some properties.
- The average thatch for the Morro Bay Sub-Region was above, while the average for the Monterey Bay and San Francisco Bay Sub-Regions was below the average for the whole CCRC Region.
- In the Morro Bay Sub-Region in particular, this likely reflects the above-normal precipitation of the previous year (excess growth) and the below-normal precipitation this year (low decomposition rates).
- The thatch averages for the ungrazed properties were the highest among their sub-regions.
- The indexes of thatch proportion showed results very similar to the thatch levels, except that grazed properties in the Morro Bay Sub-Region were similar. With that exception, little useful information was added by computing the proportion.
- The indexes of current year's biomass and thatch revealed useful information. Assuming similar results would be found over the rest of each property, management attention to potential excess that might be appropriate only in the Morro Bay Sub-Region. At properties in other sub-regions, no management attention appears to be needed.

II.G. Desirable and Undesirable Plant Occurrence (Indicator of Plant Productivity, Presence of Functioning Recovery Mechanisms, and Habitat Diversity)

The results shown in the following graphs are based on the numbers of plant species found at the participating properties in the sub-regions and the whole CCRC Region. Refer to Appendix 1 for more details. Numerous assessments of desirability and undesirability of plant species occurrence are possible with the data collected, including species richness, proportions of native versus non-native species, perennials versus annuals, forage species, and listed non-native invasive species. The plant species found in the monitoring transects are listed below with their native, perennial, forage and invasive statuses.

Note that these results are for numbers of species found in the transects, not percent cover or numbers of plants. Using cover as the measure might have yielded very different results, for example with a single annual grass, such as wild oats, making up 80% of the cover, and 10 other species making up the rest. That would be typical. Also, we did not measure frequency or density of plant species because that would have taken too much time. This measure is the most fundamental; additional or more intensive investigations might be appropriate if a problem is indicated (Tier Two monitoring), or for monitoring the Special Management Indicators, which have not been developed yet.

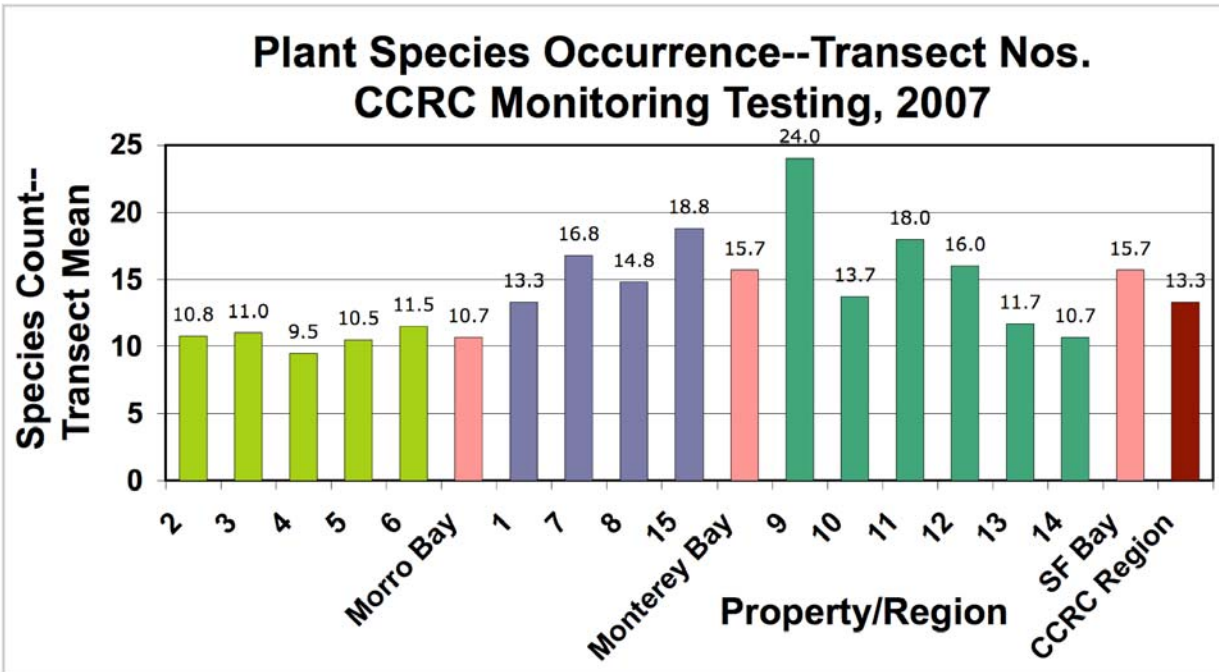

Figure 9. Average number of species found among the sampling transects at each property compared to the averages for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average for the combined CCRC Region (red bar).

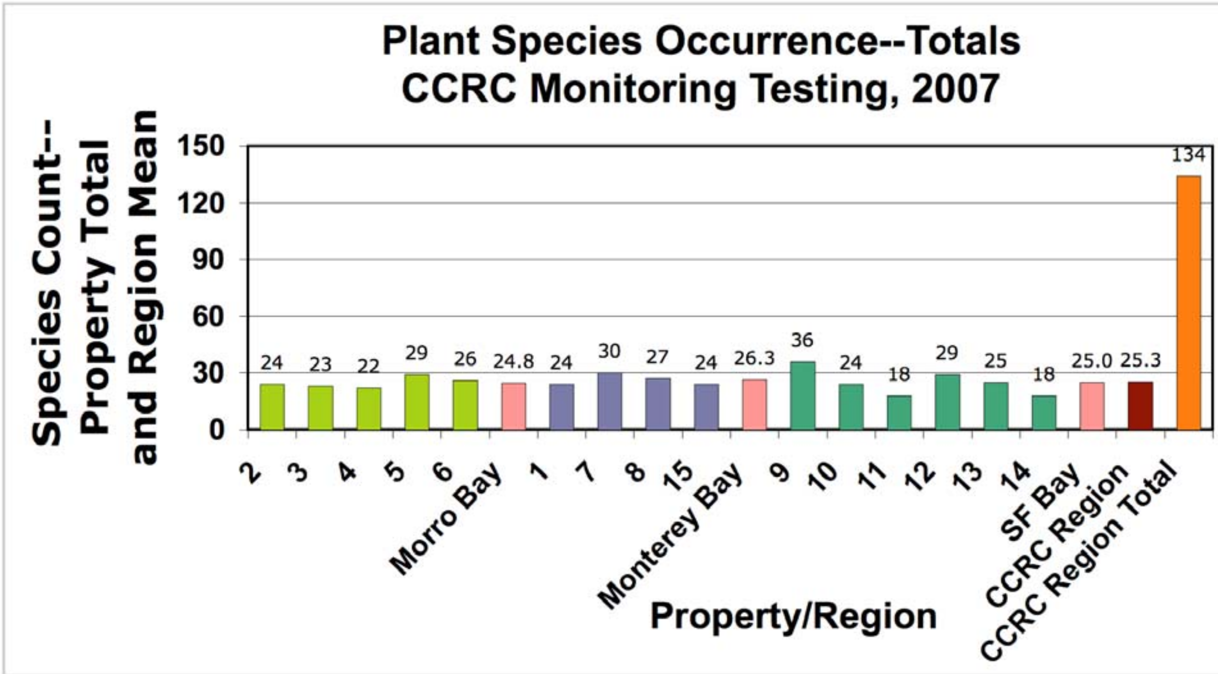

Figure 10. Total number of species found among the transects at each property compared to the average totals for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars), the average (among the properties) for the combined CCRC Region (red bar), and the total for the combined CCRC Region (orange bar).

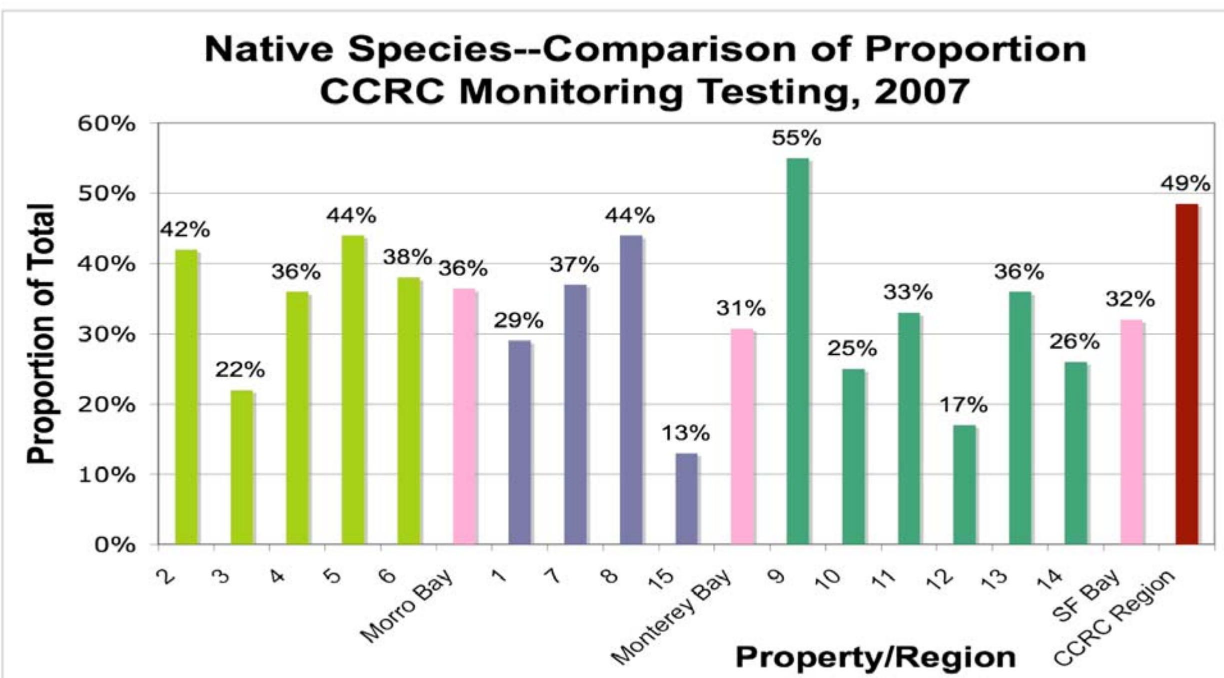

Figure 11. Percentage of natives in the total number of species found among the transects at each property compared to the average percentage of natives for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average percentage of natives for the combined CCRC Region (red bar).

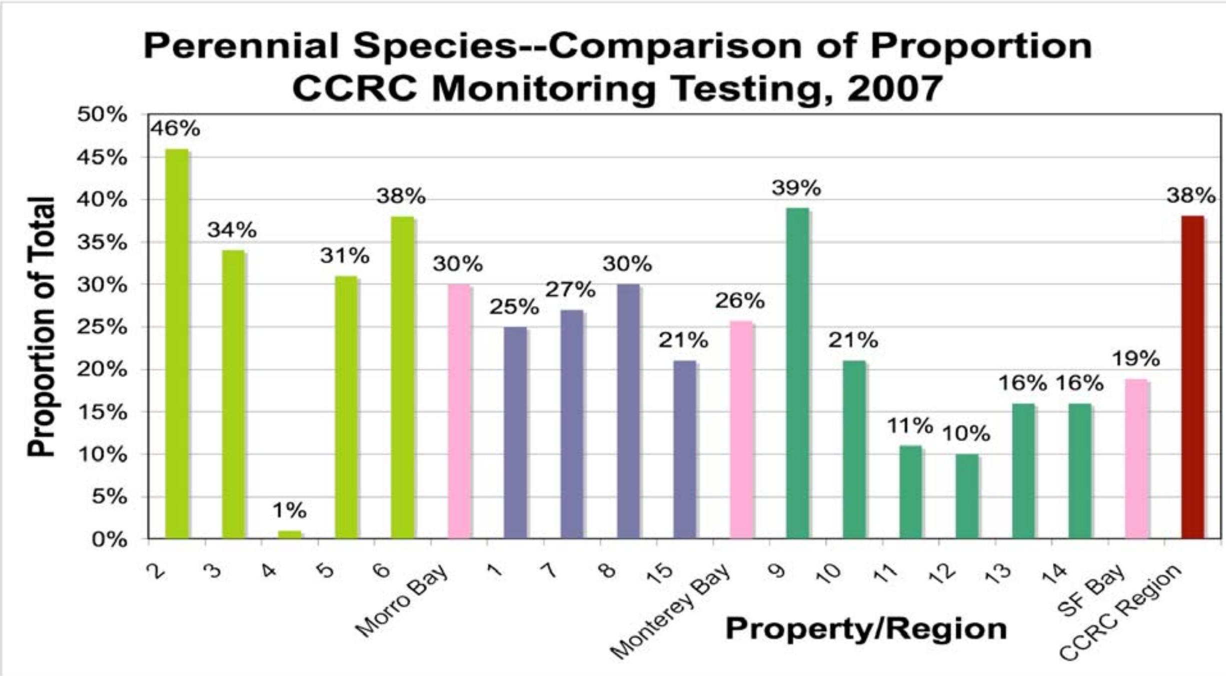

Figure 12. Percentage of perennials in the total number of species found among the transects at each property compared to the average percentage of perennials for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average percentage of perennials for the combined CCRC Region (red bar).

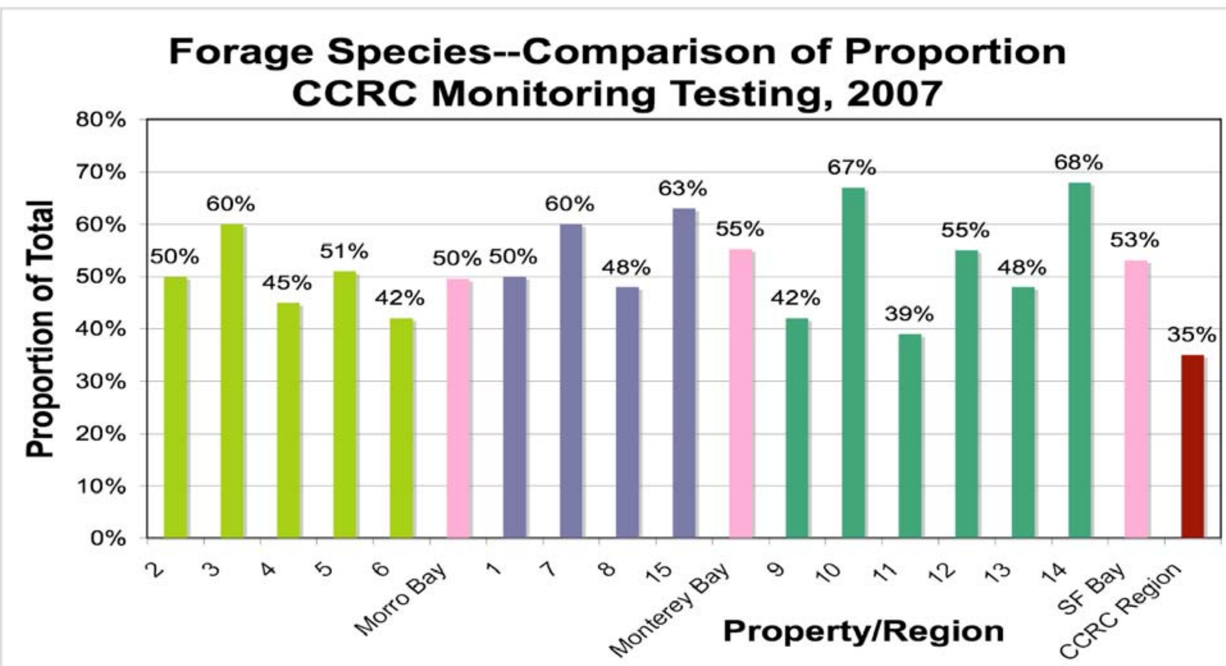

Figure 13. Percentage of forage species in the total number of species found among the transects at each property compared to the average percentage of forage species for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average percentage of forage species for the combined CCRC Region (red bar).

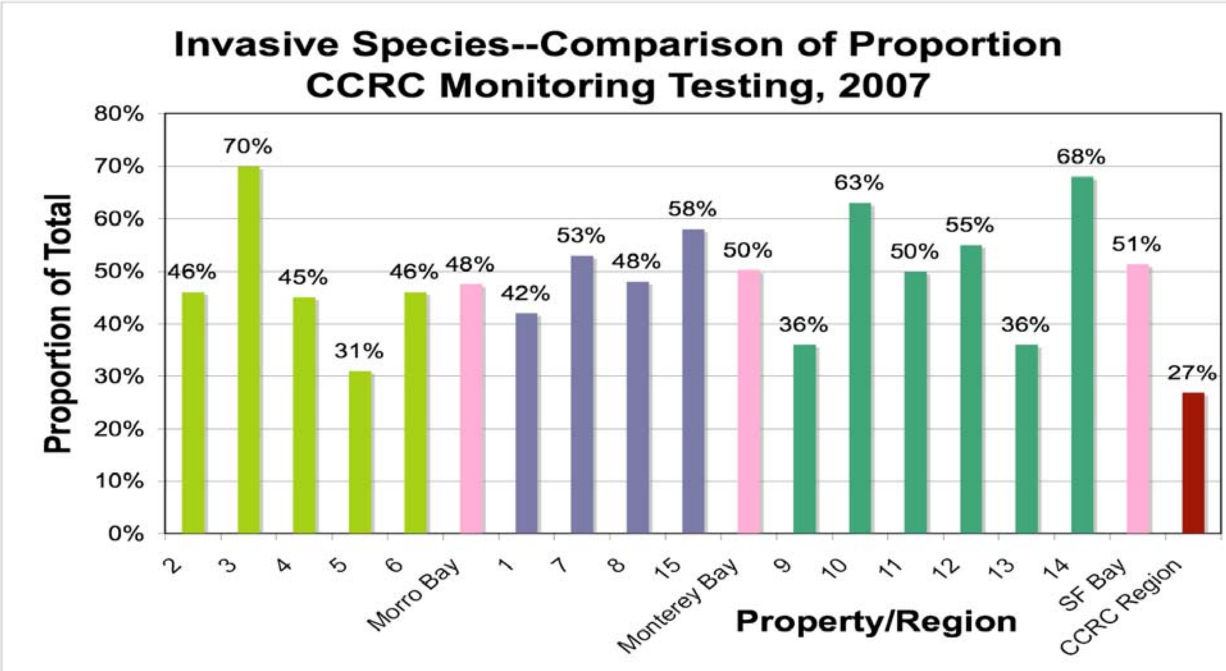

Figure 14. Percentage of invasives in the total number of species found among the transects at each property compared to the average percentage of invasives for each sub-region (Morro Bay, Monterey Bay, and San Francisco Bay, pink bars) and the average percentage of invasives for the combined CCRC Region (red bar).

General conclusions:

- The highest average number of plant species found (average among transects at each property) across the whole CCRC Region varied substantially from 9.5 to 24; the average was 13.3.
- The average number of plant species found (average among transects at each property) for the Morro Bay Sub-Region was below, while the averages for the Monterey Bay and the San Francisco Bay Sub-Regions were above the average for the whole CCRC Region.
- The highest average total number of plant species found (for all transects at a property) across the whole CCRC Region varied substantially from 18 to 36, with both extremes found at ungrazed properties in the San Francisco Bay Sub-Region; the average for the whole CCRC Region was 25.3 species.
- The average total number of plant species found (for all transects at a property) for each sub-region was similar and close to the average for the whole CCRC Region.
- More than 134 plant species were identified for the whole CCRC Region. (Sub-regional totals were not determined.)
- The consistently most common species included wild oats, soft chess, ripgut, morning glory, redstem filaree, barley, Italian ryegrass, burclover, and rattail fescue.
- The highest proportion of native plants in the total at a property (for all transects at a property) across the whole CCRC Region varied substantially from 13% to 55%; the proportion of natives for the whole CCRC Region was 49%.
- The proportion of native plants in the total at a property (for all transects at a property) between the sub-regions was similar, ranging from 31% to 36%. The highest proportion of

natives was found at an ungrazed property in the San Francisco Bay Sub-Region, and probably contributed a disproportionate number of those natives.

- The highest proportion of perennial plants in the total at a property (for all transects at a property) across the whole CCRC Region varied substantially from 1% to 46%, with both extremes found at ungrazed properties in the Morro Bay Sub-Region; the proportion of perennials for the whole CCRC Region was 38%.
- The proportion of perennial plants in the total at a property (for all transects at a property) between the sub-regions represented a gradient from south to north. The proportion of perennials found by property total in the Morro Bay Sub-Region was 30%, while the proportion for the Monterey Bay Sub-Region was 26%, and the proportion for the San Francisco Bay Sub-Region was 19%, all below the proportion for the whole CCRC Region. The highest and second highest proportions of perennials were found at ungrazed properties in the Morro Bay and San Francisco Bay Sub-Regions, and probably contributed a disproportionate number of those perennials.
- The highest proportion of forage plants in the total at a property (for all transects at a property) across the whole CCRC Region varied substantially from 39% to 68%, with both extremes found in the San Francisco Bay Sub-Region, and the least at an ungrazed property; the proportion of forages for the whole CCRC Region was 35%.
- The proportion of forage plants in the total at a property (for all transects at a property) between the sub-regions was similar, ranging from 50% to 55%.
- The highest proportion of non-native invasive plants listed by CalIPC in the total at a property (for all transects at a property) across the whole CCRC Region varied substantially from 31% to 70%, with both extremes found at grazed properties in the Morro Bay Sub-Region; the proportion of invasives for the whole CCRC Region was 27%.
- The proportion of invasives in the total at a property (for all transects at a property) between the sub-regions was similar, ranging from 48% to 51%.
- These numbers revealed useful information. Management attention to each of these issues might require significant resources and long periods of time to improve. In particular, high proportions of invasives appear to be a universal problem, with the highest at grazed properties, but more analysis is required to judge the true costs and benefits of management resources applied to that. Since we cannot expect to be rid of invasives, the more important issue is to manage aggressive invasives. We might be able to manage for the increase in numbers of natives, but to monitor for their abundance, we would need to intensify the sampling by adding frequency or another measure. Such monitoring might be better focused in the Special Management Indicators monitoring (to be developed).

II.H. Infrastructure Function (Indicator of Profitability and Stability and Public Image)

To test the interpretation of results from this complex monitoring variable, we derived a potential summary score from questionnaire answers by: (a) summing the scores from each of 16 questions; then (b) dividing that sum by the maximum score (4). The resulting summary score could be between 0-100%. Refer to Appendix 1 for more details about this variable.

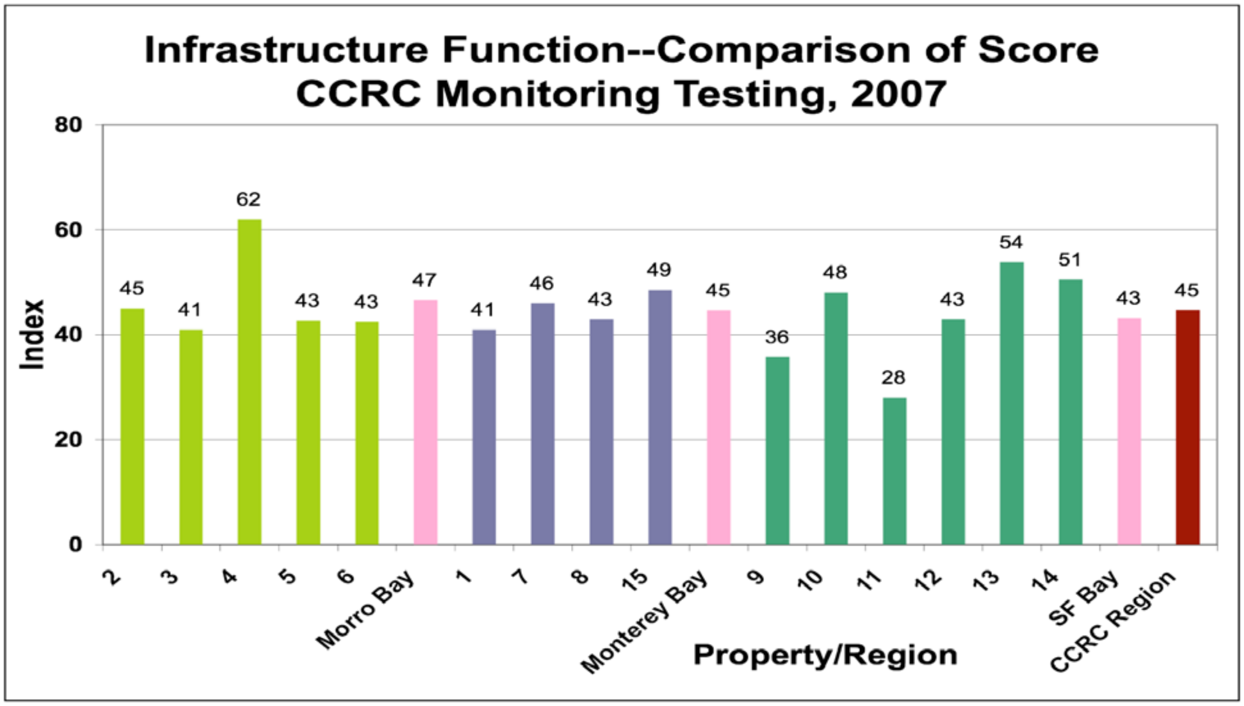

Figure 14. The scores in the Infrastructure Function Index for each property sampled are compared to the average scores for each sub-region (Morro Bay, Monterey Bay, and SF Bay, pink bars) and the average for the combined CCRC region (red bar). A higher number means that the property manager rated the conditions as better. A lower score means the property manager rated the conditions as needing repairs or replacement (Appendix 1 shows the components of the index). This index represents the range from 0 (lowest condition ratings) - 64 (highest condition ratings).

General conclusions:

- Mean index scores across the whole CCRC Region varied substantially from 28 to 62, the lowest at an ungrazed property and the eight highest at grazed properties; the average was 45, indicating that most properties would benefit from management attention to few, if any, infrastructure issues.
- The sub-regional averages were similar, ranging from 43 to 47.
- The facility type of consistently poorest condition was fencing, but barely less than average for all other facilities.
- The facility type of consistently best condition was related to vehicles (access, parking, and the vehicles).
- Some concern remains about self-assessment of infrastructure condition due to obvious biases of pride versus modesty; external evaluation of the same facilities might be more consistent.

II.I. Rangeland Operation Stability and Profitability (Indicator of Profitability and Stability)

To test the interpretation of results from this complex monitoring variable, we derived a potential summary score from questionnaire answers by: (a) summing the scores from each of 18 qualitative questions; then (b) dividing that sum by the maximum score (4). The resulting summary score could be between 0-100%. Refer to Appendix 1 for more details about this variable.

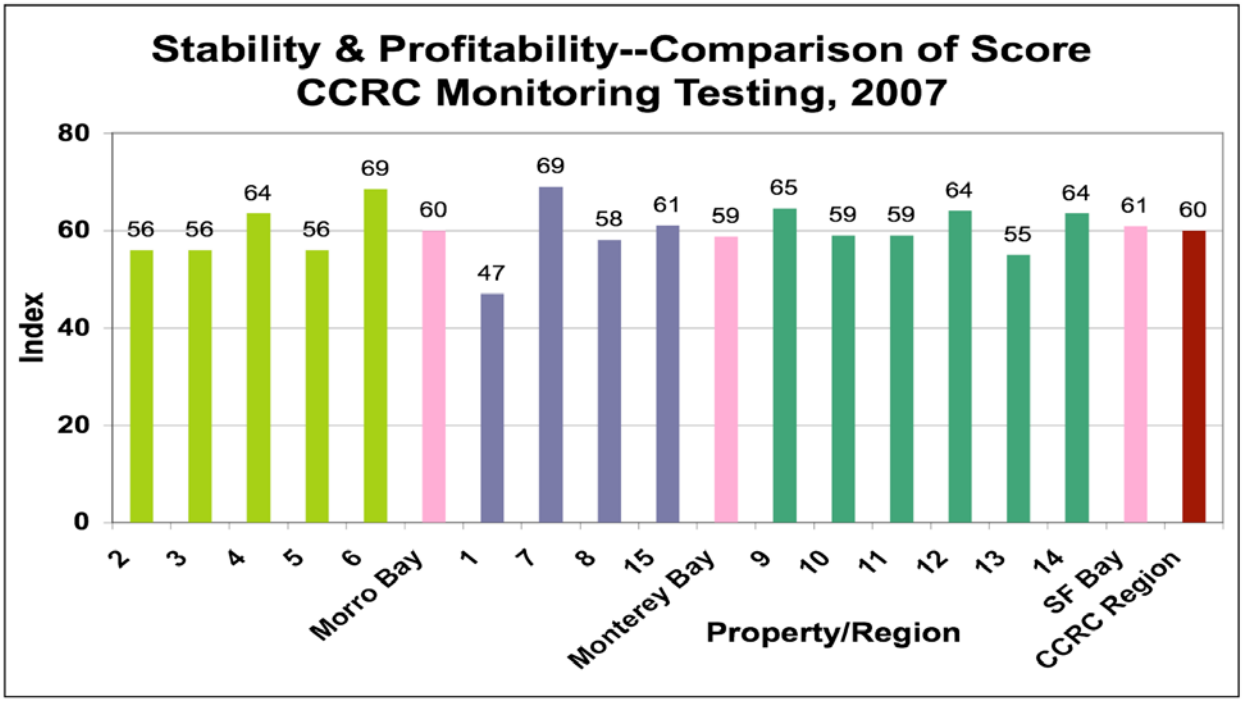

Figure 15. The scores in the Rangeland Operation Stability and Profitability Index for each property sampled are compared to the average scores for each sub-region (Morro Bay, Monterey Bay, and SF Bay, pink bars) and the average for the combined CCRC region (red bar). A higher number means that the property manager rated the stability and profitability as good or better. A lower score means the property manager rated the stability and profitability as less desirable (Appendix 1 shows the components of the index). This index represents the range from 0 (lowest stability and profitability ratings) - 72 (highest stability and profitability ratings).

General conclusions:

- Mean indexes across the whole CCRC Region varied substantially from 69% to 96%, the lowest at a grazed property and the four highest at grazed properties; the average was 86%, indicating that most properties would benefit from management attention to a few issues, if any.
- The sub-regional averages were similar, ranging from 85% to 87%.
- The issues of consistently least agreement were about positive relationships with local government planners; and energy sources from sustainable sources.

- The issues of consistently most agreement were about enjoyment and family support of rangeland management profession, constructive relationships between lessees and lessors; importance of proper management in the future; and present management producing ecological goods and services for the biota as well as humans.
- The gals/acre of fossil fuel use varied from 0.01 to 1.9 (one property represented by each extreme); the other 13 were in the range of 0.2 to 0.65 gals/acre. The average for the whole CCRC Region was 0.5 gals/acre.
- These results represent the perceptions of the manager, and have not as yet been tested against or correlated with other measures of operation stability and persistence, or with other indicators of property condition. A more anonymous format also might yield different results. In general, the results seem too positive, compared to the general view of rangeland operation stability in California. More or different indicators might be needed to obtain a more balanced result, as the goal is to identify areas where stability or profitability can be improved, or where problems can be resolved.

III. INDICATOR EVALUATIONS

Summary:

Indicator Variable:	**Differences Between Properties?**	**Easy Measurement?**	**Useful Results?**	**Accurate Results?**	**Would Managers Monitor It?**	**Feasible to Improve Results?**	**Appropriate Timing of Measurement?**	**Needs Improvement?**
1. Stewardship Plan	Y	N	Y	Y	N	?	Y	N
2. Bare Ground	Y	Y	?	Y	Y	?	N	Y
3. Soil Structure	Y	N	Y	?	?	N	Y	Y
4. Aquatic Macro-Invertebrates Occurrence	Y	Y	Y	Y	Y	?	?	Y
5. Residual Dry Matter (NO TEST)								
6. Thatch Persistence	Y	Y	N	Y	?	N	Y	Y
7. Desirable and Undesirable Plant Occurrence	Y	N	?	Y	?	?	Y	Y
8. Infrastructure Function	Y	Y	Y	Y	Y	Y	Y	N
9. Rangeland Operation Stability and Profitability	Y	Y	Y	Y	Y	Y	Y	?

III.A. Stewardship Plan

- The spread of summary scores was wide, indicating great differences in planning among the property managers.
- This questionnaire was accepted, and provided much valuable ancillary information; however it took the most time of all indicators.
- Clarification is needed to more precisely assess each element and what is needed in the written comprehensive master plan.

- Most managers, even highly-trained, did not recognize enough value in written planning to conduct the analyses, collect the reference materials, or produce the documents.
- Moving scores for this indicator higher would probably require a concerted technical assistance program.

III.B. Bare Ground

- This variable is subject to gopher and ground squirrel effects, which should be added as an element to assess bare ground sources.
- With more sampling rigor, this variable would be reliable and display more differences related to site conditions and manageable effects.
- Expect less bare ground during the spring growing season, except during drought, and more later in the summer; probably most highly correlated with annual weather.
- Better to measure this variable in summer or fall—to see more variation and effects of site and management differences.

III.C. Soil Structure

- This indicator required more technical training than the others, and would be subject to assessment error without technical training.
- Digging the holes to 8 inches depth with a shovel was easy enough (and usually performed by our hosts); use of the mattock was required at less than half the sites.
- This indicator reveals a lot about site history, and trends in improved structure since cultivation (differences in soil depth and changes between sampling events reflecting changes).
- Improve this indicator by dividing into three depth zones—0-2in, 2-6in, and 8-12in, to better reflect surface and subsurface conditions, including effect of past cultivation.
- Add a root density element to this indicator, to reflect ability of roots to reach moisture and to stabilize soils.
- With more sampling rigor, this variable would be reliable and display more differences related to site conditions and manageable effects.

III.D. Aquatic Macro-Invertebrates Occurrence

- A flowing stream with flat stones was found at only 10 of 15 properties; thus this variable is limited in universality.
- A more concerted effort to find a downstream location could have been attempted with more time, but that would have required permissions from downstream owners and complicates the problem of determining pollutant source if a low score is found.
- We need to look for a more universal alternative indicator.
- With more sampling rigor, this variable would be reliable and display more differences related to site conditions and manageable effects.

III.E. Residual Dry Matter (RDM)

- This indicator could be measured at the same time (fall) as the thatch indicator, with combined measurements.

III.F. Thatch Persistence

- That thatch was found at most properties this year probably reflects the above normal precipitation of the previous year.
- This indicator did reflect the expected increase at some of the ungrazed sites.
- Separating the linked effects of prior and present weather from management would be difficult.
- With more sampling rigor, this variable might be reliable and display more differences related to site conditions and manageable effects.
- The indexes of thatch proportion showed results very similar to the thatch levels, so little useful information was added by computing the proportions.

III.G. Desirable and Undesirable Plant Occurrence

- Numerous assessments of desirability and undesirability of the species found were possible, and produced interesting results that might not be feasible to improve.
- With more sampling rigor, this variable would be reliable and display more differences related to site conditions and manageable effects.

III.H. Infrastructure Function

- The spread of scores indicated slightly less variation than for planning, but still significant differences between the properties.
- This questionnaire was accepted, and provided much valuable ancillary information.
- Where poorer condition infrastructure was admitted, the manager was aware and knew that improvements were needed.
- Correlations to other indicators would tell whether this is a useful indicator of other stewardship.
- Without verification by external monitoris, it is difficult to determine whether the ratings are accurate.

III.I. Rangeland Operation Stability and Profitability

- The spread of scores indicated slightly less variation than for planning, but still significant differences among the properties.
- Deviation from the mean gals/acre fossil fuel use could be assessed simply, and would reflect cases of exceptionally high fossil fuel use.

- This questionnaire was accepted, and provided much valuable ancillary information.
- Correlations to other indicators would tell whether this is a useful indicator of other stewardship.
- Without verification by external monitors, it is difficult to determine whether the ratings are accurate.
- Questions that were better at identifying potential problems would be desirable. An anonymous format is not feasible for this process, and neither are questions that are too intrusive.

IV. OTHER CONCLUSIONS

- Reduced reliability of results due to insufficient sampling.
- Incorporation of the Scientific Review Panel recommendations would require a lot of time and analysis.
- To produce defensible results, far more sampling (and therefore technical efficiency and time) will be required, which will increase the monitoring costs.
- To conduct Tier 1 monitoring for both universal and special indicators, far more technical efficiency and time will be required.

V. RECOMMENDATIONS

- Continue to include the Scientific Review Panelists in communications, and seek their advice about development of the monitoring system.

- To judge "stewardship" several additional parts of the monitoring system need to be developed. Develop the appropriate scoring methods for each indicator, and the weighting methods among the indicators. To make the indicators more useful when a low score is found, examine the remedial issues, and define the Tier 2 monitoring or causal investigations needed and potential improved practices to improve the poor condition.

- Expand the monitoring system to include the Special Management indicators, protocols for their measurement, and related scoring and weighting.

- Develop an appropriate protocol for sampling using either enhanced professional judgment or more rigorous methods that would allow statistical analyses.

- Expand sampling to include related vegetation types that are affected by management, including oak savanna, shrub-savanna, upland woodlands, and riparian zones.

- Future testing will be needed. Plan for a 2008 test period, using the improved indicators and protocols, plus appropriate scoring and weighting methods, and the Tier 2 and remedial program. Put the monitoring program together into a working draft handbook that can be tested by the cooperating property managers.

- Further examine the differences and compatibility of the CCRC monitoring methodology from that espoused by the UC Cooperative Extension and the USDA NRCS in order to make use of those compatibilities in expanding CCRC monitoring and understanding, better serve CCRC members, and serve broader monitoring goals.

- Plan for a means to conduct the planning, baseline assessments, and monitoring for those properties that do not have or want the capabilities to do it themselves, or where external verification is required. The goal of a half-day of monitoring that includes both the universal and the special indicators is not feasible.

- Examine and determine the extent of technical competence and level of assistance will be required to efficiently and effectively conduct the monitoring. Consider raising grant funding to support a CCRC technical team for training of self-monitors and for conduct of the monitoring. If verification will be required for a CCRC certification, then a certified in-house technical capability will needed. It seems possible that a cooperative arrangement could be forged with the UC Cooperative Extension or the USDA NRCS to provide such technical services, especially if the protocols for monitoring and analysis were relatively easy to complete.

- Plan to expand the role of the Scientific Review Panel to test the effectiveness of the CCRC monitoring methods and results.

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APPENDIX 1. MONITORING VARIABLES AND METHODS USED

<table>
<tr><th>Indicator</th><th>Measurement Procedure</th></tr>
<tr><td>1. Stewardship Plan</td><td>A questionnaire posed these questions: Does the existing plan meet or exceed these standards?
1. Available in writing in a comprehensive document (score weighted 10x the 50 other scores) and/or by component (below)
2. Demonstrated knowledge
3. Up-to-date
4. Utilized by the designated managers
5. Includes appropriate supporting information and materials

Plan components:
1. Site Description and Environmental Setting
2. Current Conditions and Resource Inventories, including resource baselines (flora, fauna, pests, erosion, hydrology), maps, grazing capacity, infrastructure
3. Land Use History
4. Site-Specific Goals and Management Objectives—economic, ecological, social (including legal and non-grazing); distinguishes strategic goals, tactical objectives, and operational practices
5. Predicted Effects and Desired Conditions
6. Grazing Recommendations and Prescriptions
7. Contingencies
8. Monitoring, including evaluation standards, adaptation, analysis, and reporting
9. Implementation Schedule and Responsibilities
10. Analysis and Reporting</td></tr>
<tr><td>2. Bare Ground</td><td>Line-Point Intercept Transect (measuring tape, end stakes, intercept pointer, data form). Cover of bare mineral soil (not covered by herbaceous or woody vegetative foliage, standing dead plants, rock, litter, lichen, or moss) will be estimated. All areas of livestock use and environmental conditions will be included, except for “service areas.” Since this indicator will vary seasonally and annually due to weather and impacts on vegetation, it should be measured during the autumn at the end of the dry seasons and before the start of the growing season.

Monitoring plots (transects) will be located with the starting point identified by GPS coordinates and a compass bearing for the length of the transect. Each transect will be 100-feet long. The appropriate number of transects will be located within each Sampling Unit by random selection or to represent the apparent variation (also used for Indicators #3,5,6,7).

Estimate the percent absolute cover of bare ground along the transect by recording the number of “hits” at 1 foot intervals along the transect, with 100</td></tr>
</table>

Indicator	Measurement Procedure
	points measured (hits/100 = % bare ground). The result will be average cover of bare ground for each transect. Ref: Herrick et al. 2005
3. Soil Structure	Line Transect (measuring tape, end stakes, shovel, trowel, data form). Soil structure, as a measure of water infiltration and stability will be estimated. All areas of livestock use and environmental conditions will be included, except for "service areas." Monitoring plots (transects) will be located with the starting point identified by GPS coordinates and a compass bearing for the length of the transect. Each transect will be 100-feet long. The appropriate number of transects will be located within each Sampling Unit by random selection or to represent the apparent variation (also used for Indicator #2,5,6,7). Estimate the soil structure in eight inch deep holes (or less if too firm) dug with a shovel at a distance of 6 feet from the tape measure at each 10-feet interval on the transect (avoid digging holes where previously dug or where the soil has been churned by rodents or other extreme disturbance), with 10 points measured. Record the type of soil structure (one of five types—*massive, single grain, granular, blocky, or platy*) at two depth increments (0-4 inches and 4-8 inches). The result will be a range and average soil structure at two depths for each transect. Refs: K. Oster, personal communications; NRCS 1999 and 2002
4. Aquatic Macro-Invertebrates Occurrence	Observation under rocks and other submerged objects within the stream (water shoes). The relative occurrence of three classes of macro-invertebrate animals indicates the habitat quality, pollution, and biological diversity of streams. The classes are identified in the illustrated reference, "Stream Visual Assessment Protocol" (Newton, Pringle, and Bjorkland 1998)—intolerant, facultative, and tolerant species. Since this indicator will vary seasonally due to invertebrate lifecycles, and is dependent upon presence of adequate surface flows and stones, it should be measured during the spring. If streams are flowing, Monitoring Plots will be selected at the top, middle and, bottom of the watersheds represented by the Sampling Units; if not flowing in these watersheds, then sampling will occur in the nearest downstream segments of flowing streams draining the watersheds, even if outside the property boundaries (assuming permission can be given by the owner). Monitoring Plots (stream segments) will be located with the downstream point identified by GPS coordinates, photo, and compass bearing for the general direction of the stream segment upstream. Each segment will be

Indicator	Measurement Procedure
	100-feet long, and sampled by turning over stones and submerged objects and looking for the invertebrates. Observe which class of macro-invertebrates is dominant in each segment. The result will be a class of invertebrates (I, II, or III) or none found. Refs: Ward, Tate, and Atwill 2003; Newton, Pringle, and Bjorkland 1998
5. Residual Dry Matter (Autumn) NO TEST (wrong season)	Line Transect (measuring tape, end stakes, frame or loop, [clippers, sample bags, and scale], and data form). The autumn herbaceous biomass of a grassland or associated savanna or woodland will be compared to the standards developed by Bartolome, Frost, and McDougald (2006) for similar sites of woody cover, topography, and grassland type. RDM includes all herbaceous matter, except summer annual plants (e.g., noxious weeds) and tree leaves. All areas of livestock use and environmental conditions will be included, except for "service areas." Since biomass varies seasonally and annually due to weather and impacts on vegetation, this variable should be measured once per year during the autumn--at the end of the dry seasons and before the start of the growing season (usually early October). During years of drought, measurements of this indicator would likely be below-standards, and will be incorporated with the recognition of drought effects. Significant proportions of the landscape with excess or insufficient RDM will indicate the need for adjustments of livestock distribution practices. Monitoring plots (transects) will be located with the starting point identified by GPS coordinates and a compass bearing for the length of the transect. Each transect will be 100-feet long. The appropriate number of transects will be located within each Sampling Unit by random selection or to represent the apparent variation (also used for Indicators #2,3,6,7). Estimate the biomass following the visual method described by Guenther (1998) at 20-feet intervals along the transect, with five measurements taken. Calibrate the visual estimates with clipping, and converting the field weight to estimated dry weight using the NRCS National Range and Pasture Handbook estimates. (Clip a 1.92 square foot area, collect and weigh it in a bag, then later collect a sub-sample and air-dry it to determine a dry/field weight percentage, then compute and record air-dry weights.) The result will be a range and average biomass (pounds) per acre for each transect. Refs: Bartolome, Frost, and McDougald 2006; Guenther 1998
6. Thatch Persistence	Line Transect (measuring tape, end stakes, frame or loop, [clippers, sample bags, and scale], and data form). The herbaceous biomass of a grassland or associated savanna or woodland older than the current year's growth is measured using the same visual estimation method (or clipping, drying, and

Indicator	Measurement Procedure
	weighing) as RDM (Indicator #5), but is measured in the late spring (at the time of peak standing crop), and separates the current year's biomass. Thatch persistence will be assessed using the standards developed by Bartolome, Frost, and McDougald (2006) for similar sites of woody cover, topography, and grassland type. Following wet seasons with high precipitation and above-normal growing conditions, measurements of this indicator would likely be above-standards, and will be incorporated with the recognition of such effects. Significant proportions of the landscape with excess thatch will indicate the need for adjustments of livestock distribution practices. Monitoring plots (transects) will be located with the starting point identified by GPS coordinates and a compass bearing for the length of the transect. Each transect will be 100-feet long. The appropriate number of transects will be located within each Sampling Unit by random selection or to represent the apparent variation (also used for Indicators #2,3,5,7). Estimate the biomass following the visual method described by Guenther (1998) at 20-feet intervals along the transect, with five measurements taken. Calibrate the visual estimates with clipping at one station, and converting the field weight to estimated dry weight using the NRCS National Range and Pasture Handbook estimates. (Clip a 1.92 square foot area, collect and weigh it in a bag, estimate the air-dry weight based on NRCS standards, then compute and record air-dry weights.) The result will be a range and average biomass (pounds) per acre for the two biomass components for each transect. Refs: Bartolome, Frost, and McDougald 2006; Guenther 1998
7. Desirable and Undesirable Plant Occurrence	Belt Transect (measuring tape, yard stick, data form). All plant species will be recorded. Species that are not recognized will be collected and labeled with a code, then identified later. Since this indicator will vary seasonally and annually due to weather and impacts on vegetation, it should be sampled twice, once during the late spring and once in early summer to assure that the species can be identified. Monitoring plots (transects) will be located with the starting point identified by GPS coordinates and a compass bearing for the length of the transect. Each belt transect will be 100-feet long and three feet wide. The appropriate number of transects will be located within each Sampling Unit by random selection or to represent the apparent variation (also used for Indicators #2,3,5,6). Occurrence will be recorded within the 100-feet long by 3-feet wide belt transect. Also record whether each species is relatively common or rare within the transect. The result will be a list of species and their relative

Indicator	Measurement Procedure
	commonness for each transect. Refs: Herrick et al. 2005; Bonham 1989
8. Infrastructure Function	A questionnaire posed these questions: Which condition category does the existing infrastructure fit (not serviceable and needs rebuilding, needs major repairs, good and needs minor repairs, excellent, not appropriate for goals, or absent? 1. Fencing at property perimeter. 2. Fencing of internal pastures. 3. Gates and cattle-guards. 4. Corrals, chutes, shade shelters, and feeders. 5. Watering sources and supplies—developed springs, streams, other natural drainage (reliable and sustainable) 6. Watering mechanisms—wells, pumps, tanks, plumbing, and troughs. 7. Stock ponds (soundness of berms and drains, effectiveness of water collection, siltation). 8. Internal roads for vehicles. 9. Public access trails, staging areas. 10. Property access—for equipment, livestock, and supplemental feed delivery. 11. Vehicle parking areas. 12. Drainage and erosion control associated with roads and parking. 13. Maintenance, storage, and supplementary enterprise barns and buildings. 14. Vehicles, ATVs, machinery, etc. 15. Working horses and related facilities. 16. Public educational structures and signage.
9. Rangeland Operation Stability and Profitability	A questionnaire posed these questions: Do you strongly disagree, disagree, agree, or strongly agree with the following statements? 1. Ranching/rangeland management is something I enjoy and that adds to my quality of life. 2. My family supports my efforts in ranching/rangeland management. 3. The local community in the vicinity of the ranch/rangeland property generally supports ranching/rangeland management. 4. Local government planners work with the ranching/rangeland management community in a positive way. 5. I have the ability to work with the regulatory agencies that influence this ranch/rangeland property (including leased rangeland) to resolve problems. 6. If these rangelands are leased, can the lessor and lessee work together constructively to resolve problems and set goals. 7. It is important to me that this rangeland is managed well even after I stop

Indicator	Measurement Procedure
	managing or using it. 8. It is feasible for this ranch/rangeland property to remain an ecologically or economically viable ranch/rangeland property for the next 100 years. 9. If there are no significant economic or family changes, I would be agreeable to continuing to ranch/manage rangeland here at my current anticipated income for at least 10 years. 10. The gross profits from rangeland enterprises at this property are meeting my expectations (gross profits are income minus direct costs). 11. The net ecological, social, and economic benefits from stewardship at this property are meeting my expectations. 12. I feel good about what is being accomplished on this rangeland. 13. If we continue with our present management practices at this property, we will be contributing to achieving our goals for the future landscape, economy, and community. 14. The financial resources available for rangeland management at this property are adequate to maintain the resource base. 15. The energy sources (fuels, utilities, chemicals) used for rangeland management at this property comes from sustainable sources as much as possible. 16. (Approximately how many gallons of fossil fuel per acre are used in the management of these rangelands?) 17. The water supply available is adequate for sustainable rangeland management. 18. The tools being used by management are generally the most cost and energy effective means to achieve management objectives. 19. Present management practices are producing ecological goods and services for the biological communities sharing the rangeland as well as human communities surrounding the rangelands we manage.