Keeping Landscapes Working

A Newsletter for Managers of Bay Area Rangelands

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A newsletter provided by UC Cooperative Extension Natural Resources Program in the San Francisco Bay Area. This newsletter provides information to managers of both public and private rangelands. RANGELAND, which is land characterized by natural vegetation i.e., grass, forbs and shrubs and managed as a natural ecosystem, is the predominate source of OPEN SPACE in the San Francisco Bay Area.

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In This Issue:

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Global Climate Change: Opportunities and Challenges for Rangeland Managers

Carbon dioxide (CO_2) is one of the major greenhouse gases contributing to global climate change. The burning of fossil fuels is a primary source of CO_2. Because CO_2 from the atmosphere can be captured by plant photosynthesis and trapped in the soil, rangelands can act as organic carbon soil sinks. Research is beginning to shed light on management practices that may improve the carbon sequestering capacity of rangelands. This may be both economically and environmentally important in the future. This issue of "*Keeping Landscapes Working*" explores future economic opportunities as well as management challenges to consider in regards to storing CO_2 in rangeland soils.

Future economic opportunities may include rangeland owners selling carbon credits in the commodity market. For example, carbon credits are purchased by businesses that must either reduce emissions or buy offsetting credits. Future government policies may place limits on the amount of greenhouse gases that are emitted by U.S. industries and increase the value of carbon credits among trade markets in the United States and abroad. Currently, some individuals and communities are purchasing carbon credits to mitigate their own "carbon footprint" (see side bar: Politicians Purchasing Carbon Credits). The Chicago Climate Exchange Specifications included in this newsletter describe the current exchange program and rates.

Management considerations to increase carbon sequestration on rangelands may require us to change our paradigm about "acceptable" management practices and plant species. It is well known that increasing soil organic matter (SOM) is key to improving rangeland's capacity to sequester

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carbon. Many of the same management techniques that have evolved to increase forage production for livestock also have the potential to increase SOM. These management practices may include fertilization, irrigation, introduction of earthworms, intensive grazing management, and sowing of favorable forage grasses and legumes. The article, "*Grassland Management* …" describes how some of these practices improve SOM. Interestingly some of these practices use to be widely promoted by UC Cooperative Extension and the USDA Soil Conservation Service in past decades. For example, seeding legumes, rangeland fertilization and sowing favorable forage species were all once widely promoted range improvement practices. One forage species, Perlagrass (a variety from the same species of Harding Grass, which is considered a "weed," on conservation lands) may have significant carbon sequestration value (see Perlagrass and Carbon Research). Historical information on the introduction of Harding Grass and Perlagrass, rangeland fertilization and seeding with legumes are also included here for your consideration.

Politicians Purchasing Carbon Credits

As reported by CBS 5- SAN FRANCISCO, earlier this year, former Vice President Al Gore purchased more than $14,000 in carbon credits to equal his Tennessee home's power consumption in 2006. Assembly Speaker Fabian Nunez sent in a check for $136 after a recent trip to Davos, Switzerland. Sen. Dianne Feinstein and Gov. Arnold Schwarzenegger are also among those who are buying so-called carbon credits to offset their high fuel habits. Schwarzenegger, who lives in a Los Angeles mansion travels mostly in a motorcade and always flies on a private jet. A one-hour private flight from Los Angeles to Sacramento put out 8,700 pounds of carbon dioxide into the air, about 20 times more carbon dioxide than someone flying on a commercial aircraft on the same trip.

Basic Chicago Climate Exchange (CCX) Specifications for Rangeland Soil Carbon Management

Offsets may be issued to landowners who commit to increase carbon stocks realized on managed rangelands in approved geographic areas. (Alameda, Contra Costa, and Santa Clara Counties are included in the approved geographic area within California).

Eligible projects include:

- Non-degraded rangeland managed to increase carbon sequestration through grazing land management that employs sustainable stocking rates, rotational grazing and seasonal use in eligible locations.
- Restoration of previously degraded rangeland through adoption of sustainable stocking rates, rotational grazing and seasonal use grazing practices initiated on or after January 1, 1999.
- Projects must take place on rangeland in which long-term average precipitation is not less than 14" and not greater than 40".

Offsets are issued at standard rates depending on project type and location. Rates vary from 0.12 to 0.52 metric tons of CO2 per acre per year. The current rate for California rangelands for both improved management and restoration is 0.16 metric tons per acre. Prices have ranged from below $1 to above $5 per metric ton. Carbon credits are expected to sell from $6- $30 per metric ton by 2015.

Offset Projects involving less than 10,000 metric of CO_2 equivalent per year should be registered and sold through an Offset Aggregator. An Offset Aggregator is an entity that serves as the administrative representative, on behalf of

Offset Project owners, of multiple Offset- | generating projects.

Grassland Management for Carbon Sequestration

Carbon sequestration and rangelands: A synthesis of land management and precipitation effects

Derner, J.D., Schuman, G.E. 2007. Carbon sequestration and rangelands: A synthesis of land management and precipitation effects. Journal of Soil and Water Conservation 62(2):77-85.

Interpretive Summary. Proper management of rangelands offers opportunities to partially mitigate the rise in atmospheric carbon dioxide concentrations through sequestration of this additional carbon via storage in biomass and soil organic matter, a process termed carbon sequestration. Carbon sequestration decreases with increasing mean annual precipitation in native rangelands of the North American Great Plains. The general trend for grazing was a decrease in carbon sequestration with longevity of the grazing management practice, whereas carbon sequestration increased with time since interseeding of a nitrogen-fixing legume, illustrating the importance of nitrogen in carbon sequestration. The arena of management-environmental interactions is largely unexplored at this time, but knowledge developed here will increase understanding of nutrient cycling through climate-plant-soil-microbial interactions.

Grassland Management and Conversion into Grassland

Contant, R.T., K. Paustian, and E.T. Elliott. 2001.Grassland Management And Conversion Into Grassland: Effects On Soil Carbon. *Ecological Applications*, 11(2), pp. 343–355.

Abstract. Grasslands are heavily relied upon for food and forage production. A key component for sustaining production in grassland ecosystems is the maintenance of soil organic matter (SOM), which can be strongly

influenced by management. Many management techniques intended to increase forage production may potentially increase SOM, thus sequestering atmospheric carbon (C). Further, conversion from either cultivation or native vegetation into grassland could also sequester atmospheric carbon. We reviewed studies examining the influence of improved grassland management practices and conversion into grasslands on soil C worldwide to assess the potential for C sequestration. Results from 115 studies containing over 300 data points were analyzed. Management improvements included fertilization (39%), improved grazing management (24%), conversion from cultivation (15%) and native vegetation (15%), sowing of legumes (4%) and grasses (2%), earthworm introduction (1%), and irrigation (1%). Soil C content and concentration increased with improved management in 74% of the studies, and mean soil C increased with all types of improvement. Carbon sequestration rates were highest during the first 40 yr after treatments began and tended to be greatest in the top 10 cm of soil. Impacts were greater in woodland and grassland biomes than in forest, desert, rain forest, or shrubland biomes. Conversion from cultivation, the introduction of earthworms, and irrigation resulted in the largest increases. Rates of C sequestration by type of improvement ranged from 0.11 to 3.04 Mg C·ha21 yr21, with a mean of 0.54 Mg C·ha21·yr21, and were highly influenced by biome type and climate. We conclude that grasslands can act as a significant carbon sink with the implementation of improved management.

Discussion and Relevance for California's Grasslands

Contant et al's results suggest that management influences grassland soil carbon in all types of environments. Management improvements and land use conversions intended to increase forage production usually increased soil carbon. Their study demonstrated that climatic variables, native vegetation, depth, time, and original soil C all affect rates of soil C change, but on average, management improvements and conversion into pasture lead to increased soil C content and to net soil C storage. The following is a discussion adapted from Contant et al on specific range improvement practices and their affect on soil C.

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Information on the use of these practices on California's rangelands is also included.

Sowing grasses and legumes:

In addition to increasing forage production, sowing grasses and legumes often results in increased belowground production. This leads to increased belowground C inputs and can result in increased soil carbon. Furthermore, the introduction of legumes can increase soil nitrogen, resulting in superior soil fertility, further increasing aboveground and belowground production. It appears likely that sowing improved species, both grasses and legumes, increases total plant–soil system C, thus sequestering atmospheric carbon.

Sowing in California. Seeding annual legumes, such as rose clover, subterranean clover and lana vetch was a widespread practice across California annual rangelands. Ranchers recognized that annual legumes improved annual rangeland productivity and quality. However, sulfur and/or phosphorus fertilization is required to maintain productivity and an adequate stand of these legumes.

As a result of past range improvement practices, rose clover has successfully colonized large areas of California's foothills. Its hard seed have been spread by livestock into many areas. Rose clover seed in one cow manure pat can produce rose clover plants for more than 20 years.

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Introduced perennial grasses, including Harding Grass and summer dormant orchard grasses, have been seeded into foothill rangelands in many areas in past decades. The potential value of perennials lies in their ability to extend seasonal green forage beyond that supplied by resident annuals (mostly alien annual grasses and forbs). The establishment of these perennial seedlings was often difficult due to competition from annual grasses and forbs. See also: The History of Harding Grass and Perlagrass and Carbon Research.

Grassland fertilization:

Grassland fertilization has been used for centuries to increase forage production. Fertilization results in increased belowground production as well as aboveground production, which can both lead to increased soil carbon. Fertilization resulted in increased production, when it was measured, with increases ranging from 41% to 109%. Soil C increases were generally greater with higher levels of fertilization, though this was not always the case.

Fertilization of California's Rangelands. A range improvement study conducted in the 1960s on California's annual rangelands measured the effect of nitrogen fertilization by weight gains of 7,650 cattle grazing on 16,800 acres. Carrying capacity was increased from 38 to 92 head days per acre, and beef production was increased from 60 to 170 pounds per acre by fertilization. Because most foothill rangelands are either phosphorus and/or sulfur deficient nitrogen and sulfur or nitrogen and phosphorus had greater benefits than nitrogen alone. Increased costs have reduced the application of fertilizer to rangelands.

The addition of manure to soil can also lead to increased production, leading to increased sequestration of atmospheric carbon. However, the direct addition of manure makes it difficult to estimate atmospheric C sequestration since a portion of increased soil C is attributable directly to the addition of manure C to the soil.

Grazing Management:

Under certain conditions, grazing can lead to increased annual net primary production over ungrazed areas, particularly with moderate grazing in areas with a long evolutionary history of grazing and low primary production. Approximately 65% of the articles examining the impacts of grazing on soil C occurred in areas with a long evolutionary history of grazing and relatively low productivity.

Thus, for the majority of the studies reviewed, increased soil C may be the result of increased production, and overall, grazing tended to increase soil C most in warm dry regions, especially those with high potential evapotranspiration. Indeed, average annual rate of soil C content increase was 7.7% for studies with a long history of grazing, but those not meeting the criteria lost an average of 1.8% per year.

Grazing Management in California. Moderate grazing of California's annual grasslands to maximize forage production and species diversity has been promoted by UC Cooperative Extension and the USDA Natural Resources Conservation Service since the 1940s. Currently, an ongoing experiment in the Sierra Foothills suggests that the range of 600 to 1,200 lb/acre of RDM maximizes both forage production and species richness. Both past and current research efforts are clear in noting that neither light nor heavy grazing can achieve the forage production results of moderate grazing.

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Though current studies indicate that improved grassland management can sequester considerable amounts of atmospheric C, emission costs are associated with many types of grassland management. For example, nitrogen fertilizer applied to grasslands also contributes significantly to N_2O emissions. Carbon and nitrogen emission costs associated with improved management must be considered when estimating C sequestration potential of grassland soils with improved management.

The History of Harding Grass in California

Adapted from:
T.E. Adams and B. Kay. 1985. *Perennial Grasses for California Rangelands.* UC Davis Department of Agronomy and Range Science. Range Science Report. No.3.

In 1937, the University of California's Agricultural Extension Service (now Cooperative Extension) in cooperation with the Division of Agronomy at Davis (now Department of Agronomy and Range Science) began testing plants for range Improvement throughout the state. In county trials, nearly 200 species were included in this program. Exotic perennial grasses were included to extend the green-forage season and thereby forage quality. By 1945, it was evident that few perennials were widely adapted. Because of limited adaptation and subsequently low demand for seed, only a few species were recommended for range improvement.

Harding Grass (*Phalaris tuberosa var. stenoptera*) was the most widely planted perennial forage grass for range improvement in California's annual grassland and chaparral shrubland ecosystems. The species is indigenous to northern Africa. It was introduced to Australia from the Union of South Africa; from there it was carried to the United States in 1914 and first planted by the California Agricultural Experiment Station.

Harding Grass is a long-lived, persistent, dryland perennial bunchgrass with short, stout rhizomes originating from the base of a prostrate crown. It provides some winter growth but does not withstand hard frosts. Within California, Harding Grass survives where average annual rainfall is 16 in (400 mm) if the soil has high water-holding capacity. Its ability to do well on light soils with good water holding capacity in the subsoil made Harding Grass useful for seeding brush burns. However, the best stands occur on deep soils with high water-holding ability or where rainfall is ample, well above 16 in.

The most widely used strain of Harding Grass was collected in 1940 from one of the University of California's trial plantings and was put under an Intensive testing program by staff of the Soil Conservation Service Plant Materials Center, Pleasanton, California. Results of this study of the plant's drought resistance, winter growth, perennial character, and palatability led to certification of Harding Grass in 1946 by the California Crop Improvement Association. Certification and large-scale production of seed at reasonable prices encouraged considerable use.

The great value of Harding Grass, for livestock owners, is its long green season, i.e., its ability to break summer dormancy and begin growth before the first fall rains and then to remain green until after seed has matured in early summer. It thus can provide green feed several weeks longer than the resident native and naturalized annual grasses. In this respect, it even surpasses many of the native perennia1 grasses (such as purple needlegrass, *Nassella pulchra* and nodding needlegrass, *Nassella cernua*.

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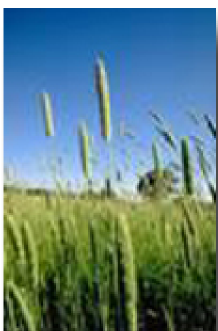
This extended green feed period helps reduce nutritional deficiencies on California's annual-type grasslands. This growth pattern of Harding Grass is due, apparently, to store carbohydrates in bulbs or corms at the base of the culms, hence its specific name tubarosa.

Fortunately or unfortunately, depending on your perspective, establishing Harding Grass has not been easy. The seedlings, like California's native perennial grass seedlings, compete poorly with the more vigorous seedlings of annual grasses. The best stands were obtained by fall seeding on well prepared beds fallowed the previous spring and summer or after a brush burn. Because many seedlings have not met these more ideal conditions, only a limited number of successful stands were ever established.



It is interesting to note that substantial amounts of certified Phalaris seed (mostly Harding Grass) were produced from 1946 to 1970. Assuming a 4 lb/ac seeding rate, 500,000 ac may have been planted with certified Harding Grass between 1946 and 1970. Furthermore, estimates by knowledgeable sources of the amounts of uncertified seed produced in California and imported suggest the total area seeded may have exceeded 750,000 ac. Obviously, most seedlings failed. Field observations indicated one-in-three Harding Grass seedlings failed to establish because of year-to-year extremes in seasonal weather patterns, such as periodic drought or frost. Another third failed because of poor seedbed preparation and competition from annuals during the year of establishment. The remaining one-third largely failed to develop adequate stands for one of three reasons: (1) changing land use patterns (subdivision and farming of rangelands); (2) inability of landowners and managers to incorporate the management needs of perennial grass into their management of annual grasslands, usually season-long grazing; and (3) planting of Harding Grass where rainfall and soil conditions were inappropriate to sustain the plant under recommended grazing management.

Perla Koleagrass

Perla koleagrass, the suggested replacement for Harding Grass, was developed by the USDA 5011 Conservation Service Plant Materials Center, Pleasanton, California, after introduction from Morocco. Similar in appearance to Harding Grass, it is a tall, vigorous bunchgrass with short rhizomes. Three advantages of Perlagrass over Harding Grass are greater seeding vigor, higher winter production, and better survival. Perla has a larger seed, but its distinguishing taxonomic characteristic is its hairy glumes (Adams et al., 1974).

Testing of the new grass began in 1956. Based on cooperative evaluation by the Soil Conservation Service and the University of California Agricultural Experiment Station, Perla was accepted for certification in 1970 by the California Crop Improvement Association. However, Perla koleagrass contributed very little to range improvement in California, because it entered the picture when financial returns from ranching were on a decline, and income from seed production was not competitive with that from other enterprises.

Perlagrass and Carbon Research

One rancher in Red Bluff, California, has not only established and maintained a Perlagrass pasture, but has looked into its benefits as for carbon sequestration. At the Burrows ranch they found that **Perlagrass**, a deep-rooted perennial, similar to Harding Grass produced 3 – 10 times more forage per acre in flat area than annuals growing on the adjacent hill. Rainfall on the ranch is 12 – 72 inches, averaging 34 inches. The Burrows ranch worked with the USDA Natural Resources Conservation Service to study the carbon sequestration capacity of Perlagrass**.** A study conducted by the USDA NRCS found that the annual grassland contained 652 lbs/acre (581 kg/ha) dry root mass, whereas the Perla meadow contained 28,314 lbs/acre (25,271 kg/ha) of dry root mass. Questions left to be answered regarding the potential of Perlagrass for C sequestration include: How does the increase in dry root mass translate into metric tons of C sequestered? Will the commodity markets recognize this increase in valuing C credits from California's grasslands?

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