

Lehmann lovegrass live component biomass and chemical composition

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Abstract

Lehmann lovegrass (*Eragrostis lehmanniana* Nees), a perennial bunchgrass from southern Africa, is replacing native grasses in Arizona. After the invasion, biomass production and quality may change. This study was conducted to determine the production and chemical composition of live Lehmann lovegrass leaves, culms, and seedheads during wet and dry years. During 3 years, green leaf biomass peaked at $78 \pm 14 \text{ g m}^{-2}$ ($\bar{X} \pm \text{SE}$) in early August, green culms peaked at $103 \pm 21 \text{ g m}^{-2}$ in mid October, and green seedheads peaked at $18 \pm 12 \text{ g m}^{-2}$ in mid August. Leaf and culm growth peaks correspond with low crude protein (2.5%) and moderate phosphorus (0.23–0.25%) levels while seedhead growth peaks correspond with high crude protein (7–10%) and moderate phosphorus (0.19–0.29%) levels. There were no crude protein and phosphorus peaks in green culms. In Lehmann lovegrass forage, crude protein should meet animal requirements for about half the year while phosphorus should be adequate throughout the year. In native forages, crude protein is adequate throughout the year because animals selectively graze forbs, grasses, and shrubs but phosphorus does not meet animal requirements except in mid-summer.

Key Words: crude protein, *Eragrostis lehmanniana* Nees, green culms, green leaves, green seedheads, phosphorus

Between 1880 and 1900, southern Arizona and southern New Mexico rangelands were overgrazed by domestic livestock and grassland productivity declined. Griffith (1901) documented the deterioration, and in 1900 studies were initiated to restore productivity. Native grasses failed to persist at southwestern revegetation sites, and numerous forage species were introduced between 1920 and 1950 (Herbel et al. 1973, Jordan 1981).

In 1930, Lehmann lovegrass (*Eragrostis lehmanniana* Nees), a subclimax, perennial, warm-season bunchgrass from semiarid southern Africa, was introduced to the southwestern United States (Crider 1945). In the following 50 years Lehmann lovegrass was seeded extensively and in the 1940's the species began to appear on areas which had not been artificially seeded. The species is well adapted in southeastern Arizona, where it has been sown on over 69,000 ha and has spread by seed to an additional 76,000 ha (Cox and Ruyle 1986).

Green perennial grass forage is usually higher in crude protein and phosphorus than that of mature or dry forage (Holechek et al. 1989), and during summer the protein content of green Lehmann lovegrass forage is 1.2 to 1.9 times that of dry forage (Cable and Shumway 1966). Lehmann lovegrass either produces or retains

green biomass throughout the year (Cox et al. 1990) and observations indicate that cattle selectively graze green leaves in spring and summer, green seed stalks (culms) in winter, and green seedheads in fall.

Researchers have determined the annual relationships between Lehmann lovegrass total live biomass and cattle weight gains (Ward 1975), and total live biomass and crude protein content (Cable and Shumway 1966), but have not attempted to determine the quantity and quality of individual live biomass components. My objective was to examine the quantity and quality of live Lehmann lovegrass leaves, culms, and seedheads in wet and dry years, and generally assess the importance of quantity and quality on animal performance.

Methods and Materials

The study site is located 40 km south of Tucson in southeastern Arizona ($31^{\circ}41' \text{N. lat.}$, $100^{\circ}37' \text{W. long.}$) on the Santa Rita Experimental Range. Elevation is 1,075 m, slope is 2–5% and soil is a Comoro sandy loam (thermic Typic Torrifluent). Soils are recent alluvium, weathered from granitic rocks, moderately acid ($\text{pH} = 6.2 - 6.9$); depths range from 0.2 to 2.5 m (Hendricks 1985). Average annual precipitation is 450 mm, and it has varied from 175 to 700 mm in the past 80 years (Cox et al. 1990). Precipitation is bimodally distributed: about 60% comes as rain between July and September, and about 40% comes as rain or snow between October and April. Daytime temperatures average 30°C in summer and nighttime temperatures average 5°C in winter, but daytime maximums frequently exceed 38°C in June and July, and nighttime minimums are below 0°C in January and February.

A 6-ha dense, shrub-free Lehmann lovegrass stand was fenced to exclude livestock. Nine 15- by 15-m plots were established; there were 3 plots in each of the 3 blocks. One plot in each block was randomly selected for sampling at 2-week intervals between 18 July 1984 and 2 July 1985. Three additional plots were sampled between 18 July 1985 and 2 July 1986, and 3 more plots were sampled between 18 July 1986 and 2 July 1987. Experimental design was a randomized, complete block with 3 replications each year and sampling over 3 years.

On every sampling date, 3 previously unsampled 0.25- by 0.25-m quadrats were selected at random in each plot. Lehmann lovegrass plants were clipped at the soil surface, and forage separated into live (green) and dead components. Green forage was separated into leaves, culms, and seedheads, dried in a forced-draft oven at 40°C for 72 hours and weighed. The same plant part from the 3 quadrats were pooled for each plot and ground over a 40-mesh screen. Samples were thoroughly mixed and 3 sub-samples digested and analyzed for total nitrogen and total phosphorus using a micro-digester and a continuous flow auto-analyzer (Schuman et al. 1973). Total nitrogen and phosphorus concentrations ($\mu\text{g/g}$) were converted to dry matter % crude protein and % phosphorus and values compared to general maintenance and lactation requirements of cows and ewes (Holechek et al. 1989).

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Precipitation and surface soil temperatures were measured daily (Cox et al. 1990). Daily precipitation was accumulated for all dates between harvests.

The year effect was evaluated for each green forage component and for crude protein and phosphorus within each component at every sampling date using analysis of variance. When F-values were significant ($P \leq 0.05$), Least Significant Difference tests (Steel and Torrie 1960) were used to separate means.

Results and Discussion

Green Leaves

Green leaf production differed ($P \leq 0.05$) among years on 5 consecutive sampling dates in fall and winter, and was similar at remaining dates during the 3 years (Fig. 1-A). Fall precipitation was common in 1984 and 1985, and leaves produced in spring remained green during fall. Precipitation was light and widely distributed in 1986, and leaves died in September. As a result, leaf biomass was 2 to 3 times greater in fall 1984 ($20 \pm 12 \text{ g m}^{-2}$) ($\bar{X} \pm \text{SE}$) and fall 1985 ($14 \pm 7 \text{ g m}^{-2}$) as compared to fall 1986 ($3 \pm 2 \text{ g m}^{-2}$).

Green leaf production followed a pronounced seasonal trend during the 3 years (Fig. 1-A). In January and February tiller initiation occurred when mean minimum soil surface temperatures ranged from 2–4° C, and in March leaf numbers and leaf lengths gradually increased when mean minimums ranged from 5–10° C. In April, existing leaves rapidly elongated and by 4 June leaf biomass doubled, when mean minimum soil surface temperatures ranged from 10–15° C.

As surface soil (0–90 cm) dried in early summer (unpublished

data, USDA-ARS), a decline in green leaf biomass was expected. This assumption was incorrect and leaf biomass was unchanged during the summer drought. Leaves retained their color and rolled into tight cylinders when peak mid-day temperatures were recorded and partially opened at sunrise and sunset. Roots were apparently extracting soil water at depths below 90 cm, because moisture in the soil profile was depleted by 7 May.

When soil water conditions improved in midsummer, leaves unrolled and continued to elongate. Peak green leaf biomass was measured in mid July 1984 ($74 \pm 18 \text{ g m}^{-2}$) in early August 1985 ($87 \pm 17 \text{ g m}^{-2}$) and 1986 ($84 \pm 20 \text{ g m}^{-2}$). Summer (June–August) precipitation was above the long-term average (196 mm) in 1984 (390 mm), about equal to the average in 1986 (190 mm) and below average in 1985 (130 mm). Lehmann lovegrass predominates where summer precipitation ranges from 150 to 220 mm in 30–40 days (Cox et al. 1989). In summers of above-average precipitation, above-ground energy resources may be diverted from leaf production and allocated to culm and seedhead production (Cox et al. 1992).

In the southwestern United States, crude protein and phosphorus accumulate in native perennial grasses when green growth peaks in spring (March–April) and summer (July–August) (Nelson et al. 1970). The same trends were expected when Lehmann lovegrass green leaves accumulated in spring and elongated in summer. Crude protein and phosphorus accumulated in newly forming tillers (29 January–26 February), peaked when leaves initially elongated (9 April–21 May), slightly increased in the summer growing season, and either gradually increased or decreased in fall (Fig. 1-B and 1-C). Failure to detect a crude protein or phosphorus

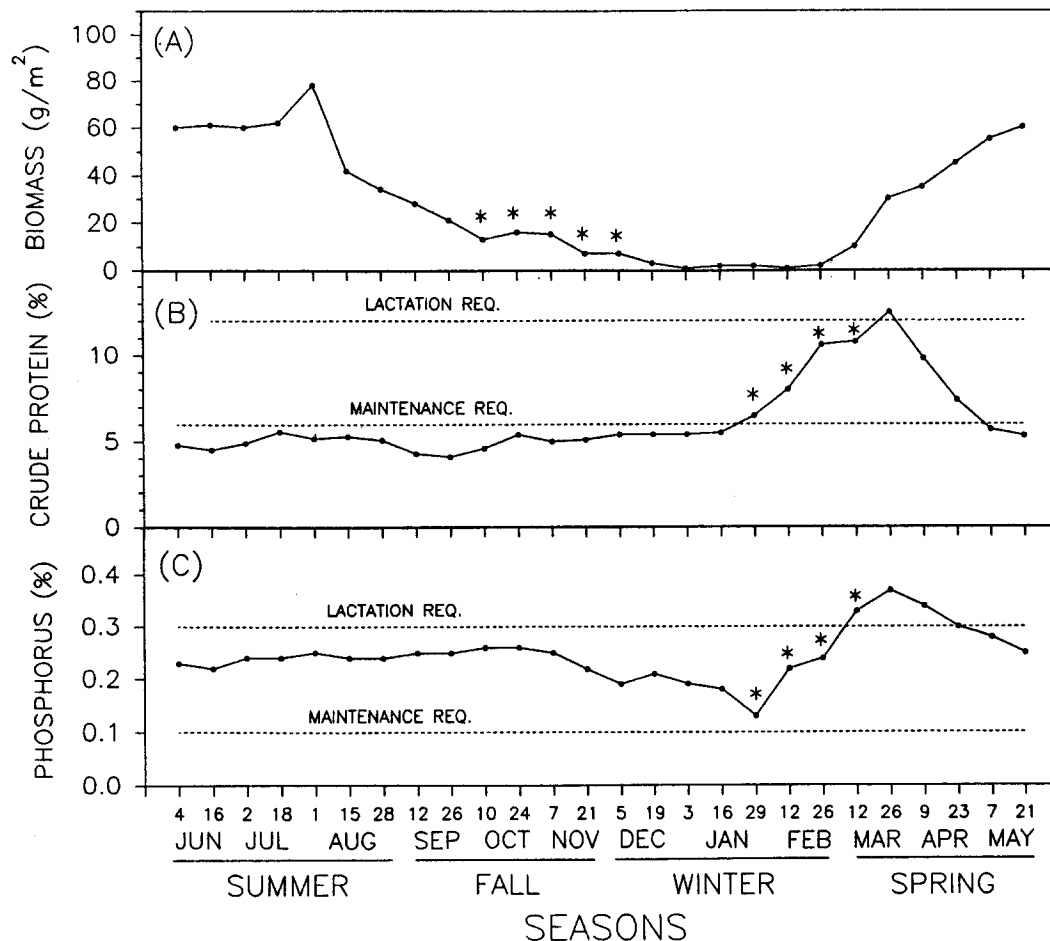


Fig. 1. Three year means (1984–86) for biomass (A), crude protein (B), and phosphorus (C) of Lehmann lovegrass green leaves at a site in southeastern Arizona. An asterisk (*) indicates a significant difference ($P \leq 0.05$) among years at the same sampling date, and broken lines denote differences between maintenance and lactation requirements of cows and ewes.

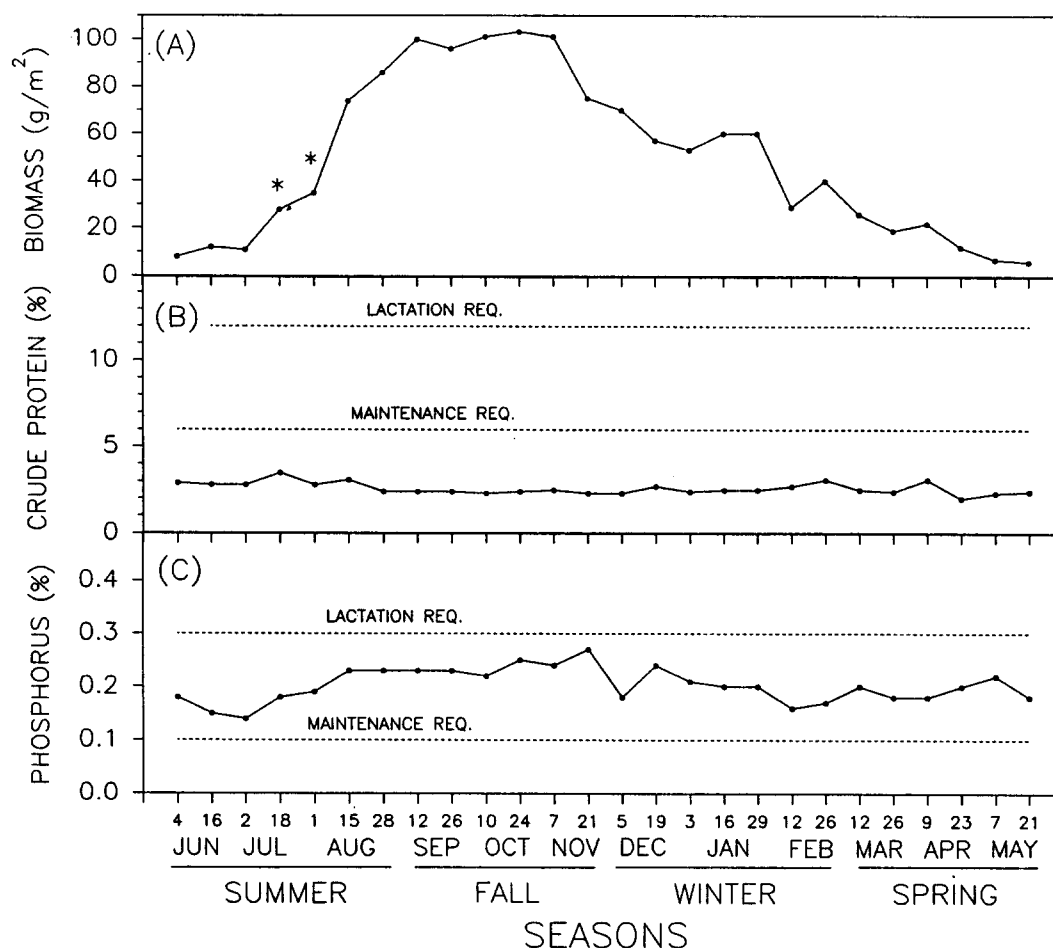


Fig. 2. Three year means (1984-86) for biomass (A), crude protein (B), and phosphorus (C) of Lehmann lovegrass green culms at a site in southeastern Arizona. An asterisk (*) indicates a significant difference ($P \leq 0.05$) among years at the same sampling date, and broken lines denote differences between maintenance and lactation requirements of cows and ewes.

increase in the summer growing season was expected because summer growth is the result of elongation of existing leaves rather than formation of new leaves.

Crude protein levels in green leaves were sufficient to meet dry cow and dry ewe maintenance requirements (Holechek et al. 1989) on 7 of 26 sampling dates (Fig. 1-B), whereas, phosphorus levels exceeded maintenance requirements on all sampling dates (Fig. 1-C). In contrast, crude protein levels were sufficient to meet lactation requirement on 1 of 26 sampling dates and phosphorus levels were sufficient on 4 of 26 dates. Green leaf nitrogen and phosphorus levels were high in late winter and early spring when leaf biomass was low (Fig. 1-A). In ungrazed and lightly grazed Lehmann lovegrass stands, leaves grow up-right and limited biomass quantities are available to cattle. In heavily grazed stands, however, leaves grow prostrate and beneath a coarse stubble, and leaves are unavailable.

Green Culms

Culm biomass differed ($P \leq 0.05$) among years at 2 summer sampling dates and was similar at the remaining dates during the 3 years (Fig. 2-A). When summer rains began, leaves elongated and within 10 days, culms from tillers initiated the previous winter (6-7 months of age) rapidly elongated. During summer 1984, rains began in June and tiller elongation occurred in the first week of July, while summer rains in 1985 and 1986 began in mid July and tiller elongation occurred in late July and August.

Green culm biomass peaked between September and November, and gradually declined between December and June (Fig. 2-A).

During winter, green culms from tillers produced in the previous January and February senesce slowly from top to bottom and all green disappears by June when daytime temperatures peak (Cox et al. 1990).

Lehmann lovegrass culms are photosynthetically active in summer, and activity may remain in autumn, winter, and spring (Cox et al. 1992). Extended culm photosynthetic activity may reduce the plants dependence on stored crown and root carbohydrates during rapid growth in either spring or summer (Laude 1972).

Crude protein and phosphorus in green culms was similar among sampling dates during the 3 years (Figs. 2-B and 2-C) and there was little change among sampling dates. Crude protein levels were insufficient to meet dry cow and dry ewe maintenance requirements (Holechek et al. 1989) at any time of the year, while phosphorus levels exceeded maintenance requirements on all sampling dates.

Initially, it was expected that green culm chemical composition would be influenced by variability among seasons and years. The assumption that chemical composition in Lehmann lovegrass green culms would vary among seasons and years was incorrect. Similar adaptive strategies have been reported in annual species (Etherington 1975), but not in perennial grasses.

Green Seedheads

Green seedheads were present on 12 of 26 sampling dates, and biomass differed ($P \leq 0.05$) among years at 6 summer and 1 fall sampling dates (Fig. 3-A). Peak seedhead production was greatest

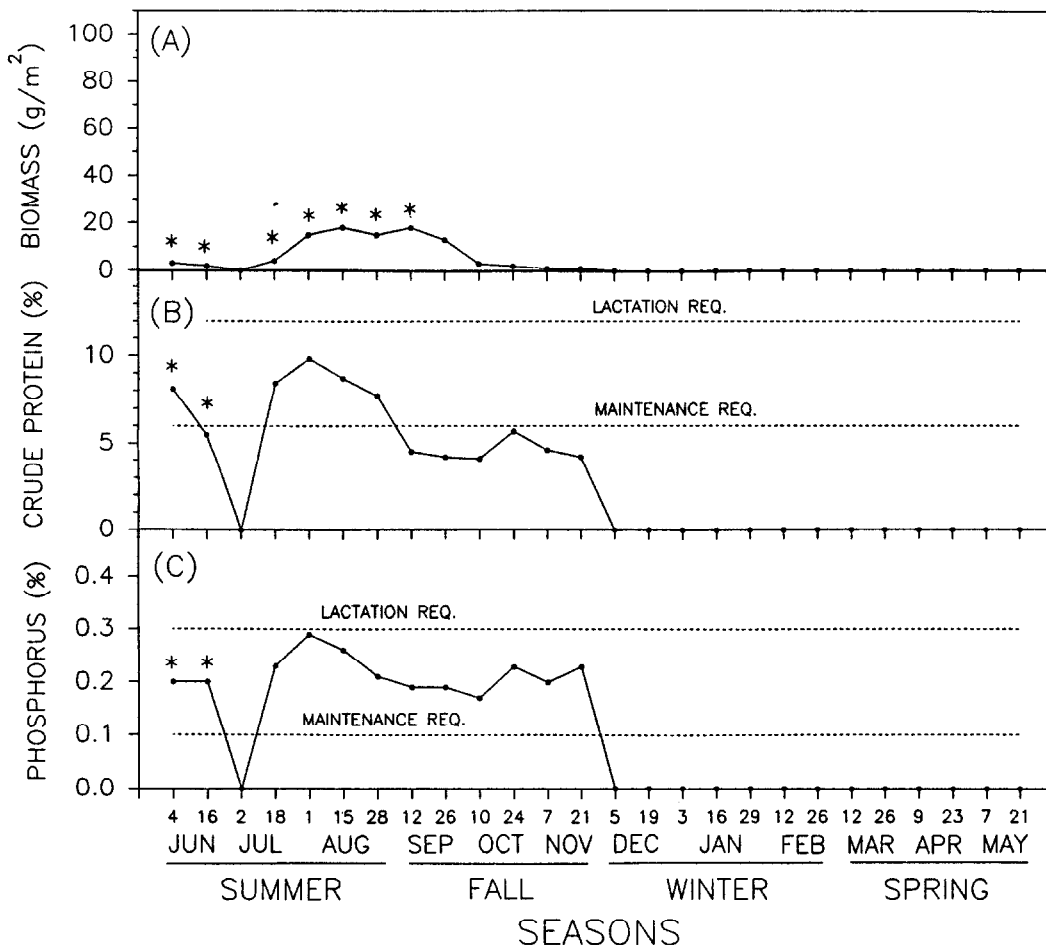


Fig. 3. Three year means (1984-86) for biomass (A), crude protein (B), and phosphorus (C) of Lehmann lovegrass green seedheads at a site in southeastern Arizona. As astrisk (*) indicates a significant difference ($P \leq 0.05$) among years at the same sampling date, and a broken line denotes differences between maintenance and lactation requirements of cows and ewes.

($40 \pm 14 \text{ g m}^{-2}$) in the summer of above-average precipitation (1984), intermediate ($32 \pm 12 \text{ g m}^{-2}$) in the summer of average precipitation (1986), and least ($12 \pm 6 \text{ g m}^{-2}$) in the summer of below average precipitation (1985).

Cable and Shumway (1966) observed many seedheads during May and June in 4 consecutive years. Spring precipitation was widely distributed in 1986 and only a few seedheads ($1 \pm 1 \text{ g m}^{-2}$) were present in early summer. In contrast, spring precipitation was above the long-term average in 1985 and seedhead production was $9 \pm 3 \text{ g m}^{-2}$ in early summer (Fig. 3-A); this amount was 25% of that measured when summer precipitation was above the long-term average, 30% of that measured when summer precipitation was equal to the long-term average, and about equal to that measured when summer precipitation was below average.

Lehmann lovegrass seed produced in early summer fail to germinate (unpublished data, USDA-ARS) because soils dry in late spring and early summer before seed mature (Cox et al. 1990). In southern Africa, where the grass occurs naturally, seed produced in early summer germinate more frequently than those produced in late summer.

Precipitation is distributed in spring, summer, and fall (September–April) and winters are dry in southern Africa while precipitation is distributed in summer and winter, and spring and fall are usually dry in Arizona (Cox et al. 1989). Spring and winter temperatures are warmer in southern Africa while summer and fall temperatures are warmer in Arizona.

When either spring or summer precipitation ranges from 150 to

220 mm, thunderstorms in both southern Africa and Arizona occur at 1–4 day intervals (Cox et al. 1989). Under these conditions Lehmann lovegrass seed germinates in 4–5 days, seedlings emerge in 9–12 days, and seedlings produce viable seed in 30–40 days (Crider 1945). When either spring or summer precipitation is less than 150 mm and thunderstorm activity is irregular, Lehmann lovegrass seedlings either fail to produce viable seed or die.

Crude protein and phosphorus in green seedheads peaked on 1 August (Figs. 3-B and 3-C), and levels between 18 July–28 August exceeded cow and ewe maintenance requirements (Holechek et al. 1989). In August and September cattle, mule deer (*Odocoileus hemionus*), and white-tail deer (*Odocoileus virginianus*) were observed feeding on Lehmann lovegrass seedheads. Observations at 6 locations in southeastern Arizona indicate that cattle and wildlife may remove seedheads before 1 October. Selective seedhead grazing by cattle may explain why crude protein in rumen samples during late summer is 5–12% greater than in corresponding hand-harvested green leaf and green culm samples (Cable and Shumway 1966).

Seedhead foraging by cattle may explain the rapid spread of Lehmann lovegrass between 1960 and 1980 (Cox and Ruyle 1986). In a preliminary study, 5 kg of dry feces from cattle observed feeding on Lehmann lovegrass seedheads was dried, passed through a grinder, sown over sand, covered with fine mulch, and subirrigated for 21 days. From this nonreplicated observation study more than 1,680 Lehmann lovegrass seedlings were counted in 21 days.

Implications

On ranges where native forbs, grasses, and shrubs predominate, grazers utilize green grass growth during spring and summer, and high protein forb and browse forage in fall and winter (Cable and Shumway 1966, Galt et al. 1969, Nelson et al. 1970). Selective grazing insures that crude protein levels remain above cow and ewe maintenance requirements. However, phosphorus levels exceed maintenance requirements only when plants actively grow in spring and summer (Holechek et al. 1989).

Native grasses, forbs and browse are usually more palatable than Lehmann lovegrass (Obo 1986), and cattle selectively graze native plants in summer and Lehmann lovegrass in fall, winter, and early spring (Martin 1983). Selective seasonal grazing reduces the vigor of native forages because plants are repeatedly grazed while actively growing in summer. The reduction or elimination of native canopy reduces soil shading. The increased light stimulates Lehmann lovegrass seed germination (Sumrall et al. 1991), thus densities of Lehmann lovegrass increase (Cox and Ruyle 1986).

Once Lehmann lovegrass predominates, green biomass production of the grass component increases by a factor of 4 (Cox et al. 1990), crude protein levels drop below maintenance requirements for 6 months of the year, and phosphorus levels exceed maintenance requirements during the entire year. Lehmann lovegrass does not fit into existing grazing management strategies because its growth and nutrient patterns differ from those of native perennial grasses (Cable and Shumway 1966, Galt et al. 1969, Nelson et al. 1970, Figs. 1, 2, and 3). Hence the need to consider new options. Managers should consider grazing Lehmann lovegrass in late spring and summer because live biomass, crude protein, phosphorus, and organic matter digestibility peak in those seasons (Fourie and Roberts 1976, Obo 1986). Pastures with native forbs and native perennial grasses should be rested in spring and summer, and moderately grazed in fall and winter.

Because this study was conducted in a 6-ha enclosure, I cannot conclusively state that herbage production and quality changed after Lehmann lovegrass replaced native perennial grasses on Arizona rangelands. Neither can I recommend that managers discontinue the common practice of supplementing phosphorus. However, this study and others (Cox et al. 1990 and 1992, Fourie and Roberts 1977, Galt et al. 1969) suggest that plant productivity and nutrient patterns do change after Lehmann lovegrass invades. Hence, my recommendation that grazing studies in Lehmann lovegrass and perennial native grass communities be conducted to verify the importance of this laboratory data.

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