By Matt Germino

Browsing the Literature

This edition of *Browsing the Literature* covers several new papers and a special issue on drought effects in rangelands or grasslands, along with metanalyses of grazing effects on plant communities and soil nutrients. As always, I emphasize papers that are either just accepted, are in online "early view", or were published in the month or so prior to writing of this column.

- Matt Germino, 9 October 2020
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New insights on a key but not well-studies plant nutrient, silicon

Plant silicon as a factor in medusahead (*Taeniatherum caput-medusae*) invasion
Spackman, C.N., Monaco, T.A., Stonecipher, C.A., and Villalba, J.J. 2020. *Invasive Plant Science and Management*. pp. 1–12. doi:10.1017/inp.2020.20

This paper is highly recommended reading for anyone interested in exotic annual grasses in rangelands. The authors provide a comprehensive review of the geochemistry, physiology, and ecological effects of silicon uptake in rangeland grasses with a focus on how phytolith accumulation is a major factor in the accumulation of wildfire fuels in medusahead, and probably other exotic annual grasses (Fig. 1). The authors also provide thoughftful speculation on how the silica hyperaccumulation in medusahead impacts common tools used to manage it, such as mowing or herbicide.

Plants sustain the terrestrial silicon cycle during ecosystem retrogression
de Tombeur, F., Turner, B.L., Laliberté, E., Lambers, H., Mahy, G., Faucon, M.P., Zemunik, G. and Cornelis, J.T., 2020. *Science*. 369(6508), pp. 1245–1248. doi:10.1126/science.abc0393

Silicon affects palatability and decomposition of rangeland grasses but is rarely measured and poorly understood. These authors discovered that control of the silicon nutrient cycle shifts from geochemical to biological control as ecosystems age across a 2,000,000-year chronosequence of coastal dune age in Western Australia.

Drought effects in grass and rangelands

Drought in South African savannas (Special Issue)
Bond, W. du Toit, J., and Malherbe, J. 2020. *African Journal of Range & Forage Science*. 37(1), iii–v. doi:10.2989/10220119.2020.1739197

Eight papers and an introductory/synthesis article address how rangelands in the southern half of Africa, predominately Kruger National Park and south, have responded to drought

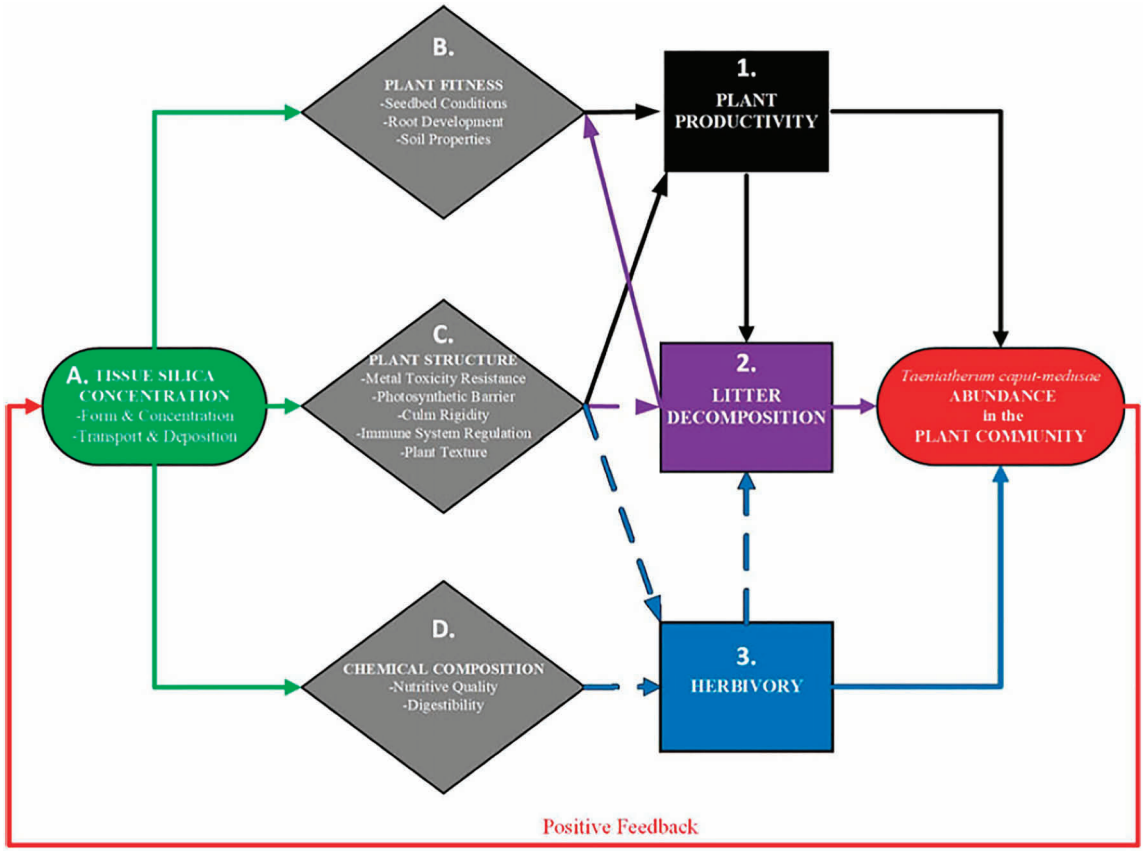

Figure 1. A model explaining the self-reinforcing positive cycle feedback of *Taeniatherum caput-medusae* invasion in relation to silicon (Si). Rhomboids represent plant characteristics; rectangles represent invasion processes; solid lines represent net positive effects and dashed lines net negative effects.

cycles that have been notoriously impactful in recent years. The articles address drought indices, plant community and tree dieback response, and impacts to native and domestic ungulates including the megafauna that the continent uniquely still maintains. While some may think of African savanna as a benchmark of naturally functioning rangelands, fragmentation including fencing have altered plant movement and ability of herds to adapt to drought.

Resolving the Dust Bowl paradox of grassland responses to extreme drought

Knapp, A.K., Chen, A., Griffin-Nolan, R.J., Baur, L.A., Carrol, C.J.W., Gray, J.E., Hoffman, A.M., Li, X., Post, A. K., Slette, I.J., Collins, S.L., Luo, Y., and Smith, M.D. 2020. *Proceedings of the National Academy of Sciences*. 117(36): 22249–22255. doi:10.1073/pnas.1922030117

One of the most basic effects of water deficits that are strong enough to be labeled drought is that they cause long-lasting impacts to plant communities, typically shifts in the species assemblages. The drought of the 1930's Dust Bowl in the USA caused a shift among the relative abundances of water-efficient C4 grasses compared to cool-season C3 grasses, paradoxically increasing the latter over the former. Using data on the climate, weather, and vegetation change in the 1930's combined with contemporary experimental rain-out experiments, these authors discovered that shifts towards cool-season moisture dominance explain the rise in dominance of C3 grasses during the droughts. The figure below shows the spatial scope of the study and extent of meteoric drought (reproduced with permission, Copyright 2020 National Academy of Sciences).

Global syntheses of grazing effects

A global meta-analysis of grazing effects on plant richness

Gao, J., and Carmel, Y., 2020. *Agriculture, Ecosystems & Environment*. 302:107072. doi:https://doi.org/10.1016/j.agee.2020.107072

For 259 comparisons of past studies done around the globe, species richness was greater on grazed compared to ungrazed conditions. Nearly half of the variation in species richness among studies could be explained by aridity, vegetation type, and stocking rates. However, the evolutionary history of sites (i.e. whether the plant community evolved with large ungulates) and the effect sizes were also linked with soil carbon and nitrogen content.

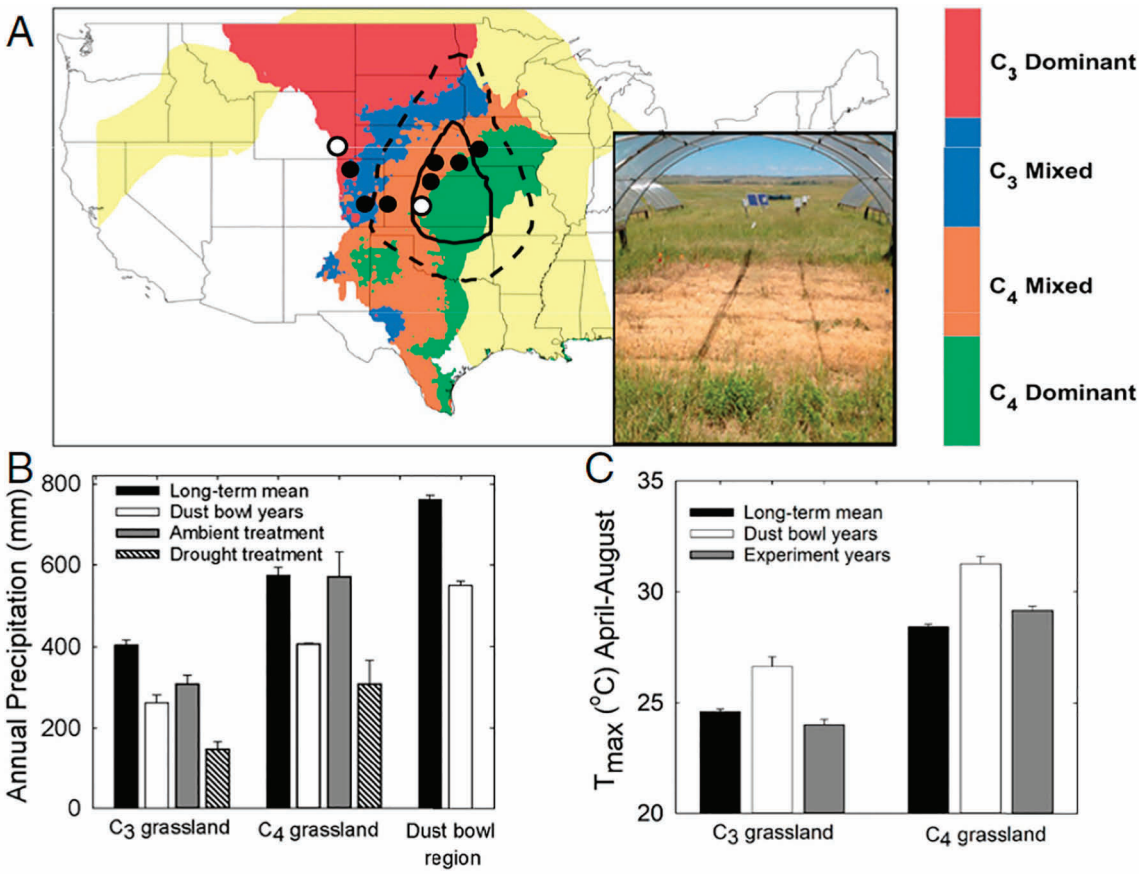

Fig. 1. (*A*) Extent of the Dust Bowl drought of the 1930s. Data from ref. 1. Black solid line encloses the region with greatest daily precipitation anomalies (>3 mm/day), dashed line denotes anomalies > 2 mm/day, and yellow shaded area denotes >1 mm/day (values averaged from 1932 to 1938). White dots denote approximate locations of experimental droughts imposed near Hays, KS, and Cheyenne, WY. Black dots indicate native grassland sites observed to undergo decreases in C_4 grasses during the 1930s (sites west of Hays) or increases in C_3 and decreases in C_4 grasses (east of Hays, *6-7, 11-12*). Also shown on this map is the proportional distribution of C_3 vs. C_4 biomass based on empirical data and statistical models for North America (*28*). C_3 Dominant = >60% C_3 biomass; C_3 Mixed = 50–60% C_3 biomass; C_4 Mixed = 50–60% C_4 biomass; C_4 Dominant = >60% C_4 biomass. (*Inset* photo) Experimental drought plot, Hays, KS, July 2015, during the second year of experimental drought. (*B*) Mean annual precipitation for the C_3 (Cheyenne) and C_4 (Hays) grassland sites for 1900–2015 (long-term mean), the four driest Dust Bowl years, and the ambient and 4-y drought treatments imposed from 2014 to 2017 (*SI Appendix*, Fig. S1). Long-term mean annual precipitation and Dust bowl precipitation are also shown for the region enclosed by the solid line (= Dust bowl region). (*C*) Mean daily maximum air temperature during April–August for the same time periods and locations as in *B*. Note that ambient and drought treatments in the experiment experienced identical air temperatures. Climatic data are from NOAA (www.ncdc.noaa.gov/). Means and +1 SEs are reported in *B* and *C*.

A global meta-analysis of livestock grazing impacts on soil properties

Lai, L., and Kumar, S., 2020. *PLoS ONE*. 15(8):e0236638. doi:https://doi.org/10.1371/journal.pone.0236638

Over many studies, soil responses to grazing depend strongly on grazing intensity, sometimes becoming enhanced by moderate grazing, and decreased by heavy grazing.

Wildfire effects and restoration

Postfire growth of seeded and planted big sagebrush-strategic designs for restoring greater sage-grouse nesting habitat

Pyke, D.A., Shriver, R.K., Arkle, R.S., Pilliod, D.S., Aldridge, C.L., Coates, P.S., Germino, M.J., Heinrichs, J. A., Ricca, M.A., and Shaff, S.E. 2020. *Restoration Ecology*. doi:10.1111/rec.13264

In cold desert rangelands of the western US, post-fire recovery of fire-intolerant shrubs such as sagebrush specifically is critical for dependent wildlife. Assessment of past manager's trials reveals that while outplanting sagebrush seedlings may accelerate the presence of small patches of larger shrubs for about a year, the size of plants originating from seed eventually surpasses the outplants.

The biggest bang for the buck: cost-effective vegetation treatment outcomes across drylands of the western United States

Munson, S.M., Yackulic, E.O., Bair, L.S., Copeland, S.M., and Gunnell, K.L. 2020. *Ecological Applications*. 30(7):e02151. doi:https://doi.org/10.1002/eap.2151

Restoration and rehabilitation are a key part of managing rangelands, owing to the increase in disturbance regimes. These authors evaluated historic records of vegetation

treatments done on rangelands in Utah (USA) and were able to show the benefit-cost of different treatment in terms of restoring perennial grasses per treatment costs. As an example, herbicides attained a higher ratio than mastication of encroaching trees into rangelands.

Spatial grain of adaptation is much finer than ecoregional-scale common gardens reveal
Davidson, B.E., and Germino, M.J. 2020. *Ecology and Evolution*. 10:9920–9931. https://doi.org/10.1002/ece3.6651

Selection of appropriately adapted seed is one of the greatest challenges of restoration in the vast areas of rangelands requiring restoration seedings. Seed transfer guidelines that are based on common-garden studies, in which plants of a species are collected (usually as seed) and grown together to allow study of genetic variation in relationship to the spatial variation in the source populations' home conditions. While these efforts and resulting seed-transfer guidelines are well established for forestry, there are fewer efforts in semiarid rangelands, causing the few available guidelines to be based on studies emphasizing range-wide variation. This current study revealed substantial differences in survival of sagebrush seedlings within a single seed zone, indicating an opportunity to incorporate both range-wide and local-scales for common garden studies.

Disentangling the effects of multiple fires on spatially interspersed sagebrush (*Artemisia* spp.) communities
Shinneman, D.J., McIlroy, S.K., and de Graaff, M.A. 2020. *Journal of Vegetation Science* 00:0–14. doi:https://doi.org/10.1111/jvs.12937

In the Columbia Plateau Ecoregion, Washington, USA, only one wildfire was required to convert shrublands invaded by exotic annual grasses into completely invaded exotic grasslands, whereas scablands retained some native species even after multiple fires.