Soil Carbon Sampling on Kachana Station Illustrates the Potential of Improved Pasture Management for Carbon Sequestration

Summary

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We chose Kachana station as a case study to illustrate the potential of improved pasture management for soil restoration and soil carbon sequestration. Our objective was to compare two paddocks with nearly identical topography, water availability and soil type, but different pasture management history since 1991. One paddock (RP) has been managed intensively with the aim of increasing soil fertility and livestock carrying capacity while reducing erosion, using various management tools including “high-impact” grazing. The other paddock (ER) was managed passively to keep soil erosion and fertility stable. We investigated total soil carbon (C) and total nitrogen (N) content, soil-bulk density and -water content, and estimated total soil C stock and C sequestration potential of the paddocks.

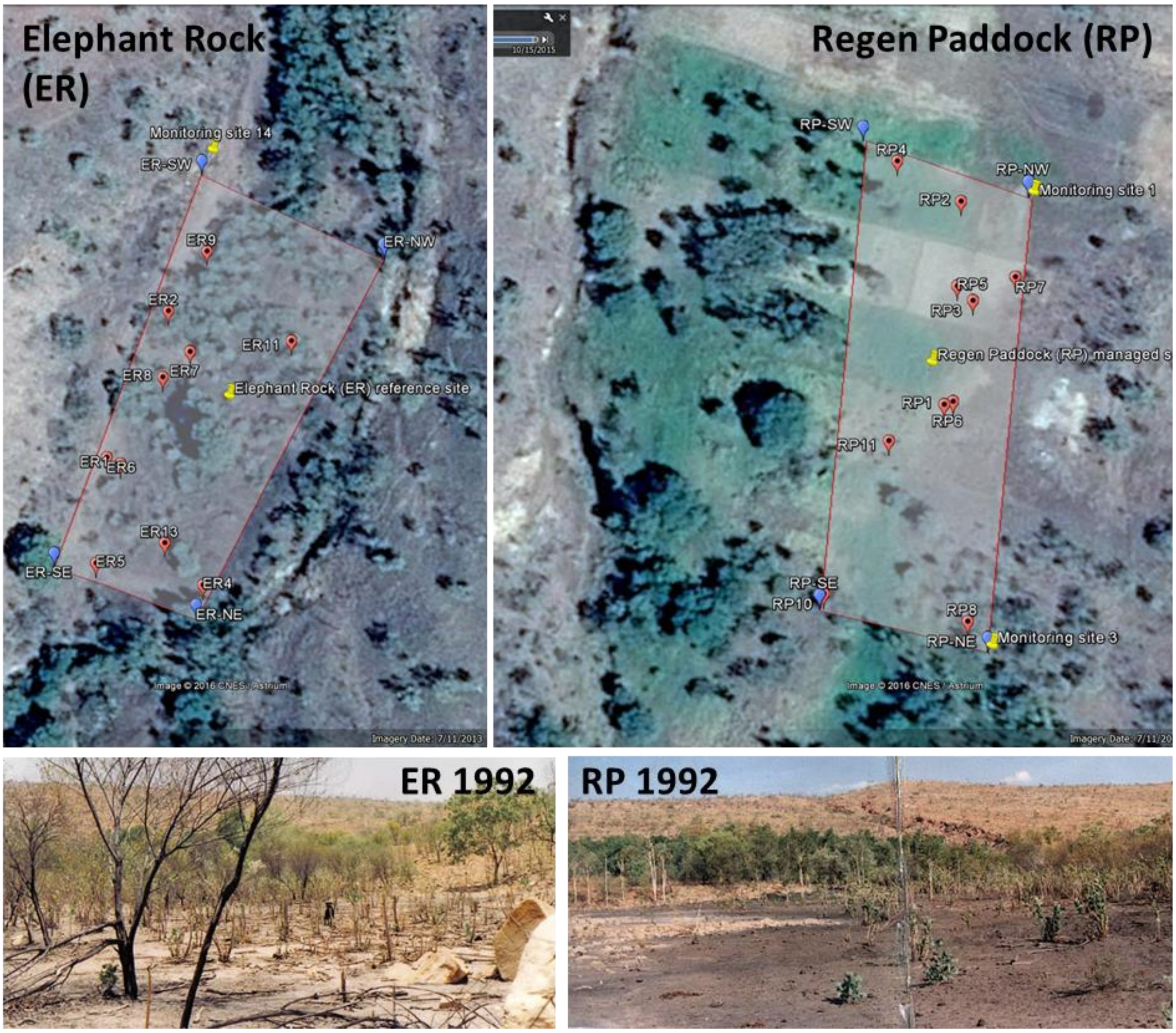

Figure 1: Aerial view of sampling sites with random sampling points, and starting conditions at beginning of management. Left: Elephant Rock (ER) reference site: passive grazing and fire management. Right: Regen Paddock (RP) intensively managed site: active grazing and fire management. Links to monitoring sites photos:
http://www.kachana.com/photo_gallery/pm_site_1.php
http://www.kachana.com/photo_gallery/pm_site_3.php
http://www.kachana.com/photo_gallery/pm_site_14.php

At the intensively managed site, bulk density was on average 25% lower, soil water content 50% higher, and air-filled pore space at 40 vol% equally high. This is surprising, as intensive grazing is generally associated with soil compaction and a decrease in soil aeration. It seems that the soil in RP actually acted like a sponge, i.e. the additional water did not decrease air-filled pore space in the soil, and the risk for widespread oxygen deficiency in the soil is low, even when the soil water levels are higher during the wet season. Furthermore, the large air-filled pore space may facilitate the uptake and conversion of methane from the atmosphere by soil bacteria, and thus offsets part of the methane produced by cattle (Livesley et al., 2011).

The intensively grazes site RP featured a three-fold higher soil C content (65 ±6.6 g C /kg soil) compared to the passively managed ER site (22 ±2.6 g C /kg soil). Both sites had an average carbon content well above typical rangeland levels, which is around 5-15 g C /kg soil. Total soil N was found to be 2.5 times higher in RP (3.9 ±0.5 g N /kg soil) compared to ER (1.6 ±0.3 g N /kg soil). Most of this N is bound in organic matter as a stable pool, and will be gradually released by the activity of soil microbes.

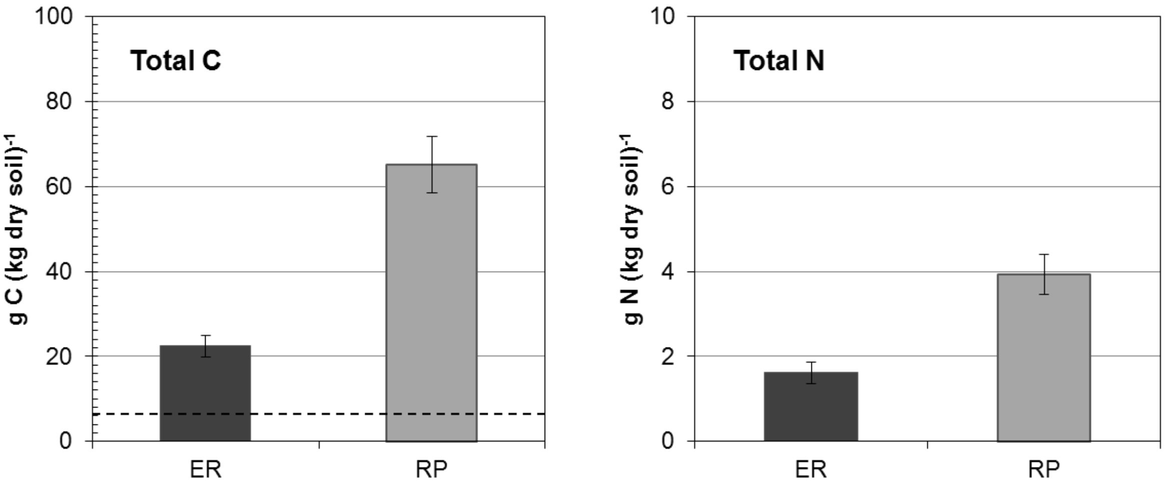

Figure 2: Mean values and standard error of the mean for total C (left) and total N (right) in the two paddocks. The dashed line indicates typical rangeland levels for soil organic C (Allen et al., 2014). Inorganic C has been measured in a subset of samples and found to be negligible.

Based on the average thickness of the upper soil horizon we estimated total soil C stocks on a per-hectare basis, which was 85.4 t/ha for ER, and 237 t/ha for RP. Even though it is a crude estimate it allows us to compare it to the scientific literature, and also to illustrate the soil C sequestration potential in Australian rangelands. The soil C stock in RP is comparable to the highest values measured in an inventory of soil C stocks in Queensland rangelands (Allen et al., 2016). Assuming that the difference in ER and RP soil C stocks (151 t/ha) was a result of 25 years of improved management, we can estimate an average yearly increase of 6 t C/ha. This is equivalent to 22 tons of the greenhouse gas CO_2 sequestered from the atmosphere and stored in one hectare of soil each year. This is twice the yearly amount of CO_2 estimated to be sequestered during a 20-year hardwood afforestation project (Lin and Lin, 2013), and offsets approximately 110’000 km driving with an average car per ha each year.

This pilot study illustrates that intensive grazing management such as practiced on Kachana station for 25 years (and ongoing) has great potential to improve soil physical conditions and fertility and sequester high amounts of carbon from the atmosphere. While the paddocks studied here may represent the optimal of what is realistically achievable, similar environmental conditions may be found in a wider are in the Kimberley, and northern Australia in general. However, further research, including a large-scale soil C inventory and complete greenhouse-gas budget, is necessary to assess this potential more accurately.

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