## Response to Feedback from Reviewer 1

### Summary

Animals impact elemental cycling in many direct and indirect ways. Evidence from several biomes demonstrates that even after death, animal carcasses can change the biogeochemistry of ecosystems and these impacts can be long lasting. Most studies of carcass impacts on ecosystems, however, are done on small to medium (1kg to 200kg) sized animals. In this contribution, the authors investigate the effects of elephant megacarcasses on the biogeochemistry of soils and plants. The authors report significant effects of elephant carcasses on components of soil and plant elemental cycling and they discuss how these effects may be important components of spatiotemporal heterogeneity in ecosystems.

### General comments

1) Overall, I found the writing good. The authors have crafted a nice narrative that makes a compelling case that megacarcasses can be important parts of ecosystems and therefore we need to learn more about the impacts of these carcasses on ecosystems.

AUTHORS' RESPONSE: Thank you! We appreciate your kind words and thoughtful review.

2) I have a few questions about the analysis. The effective sample size is 10. Obviously, it is hard to find carcasses (I would have great difficulty in finding 10 fresh moose carcasses in my system!) but the authors are trying to squeeze a lot of information out of very few data points. I have the following specific questions about the analysis:

i) While I like the transect approach, the design may have been stronger if the authors had random transects (ie, transects with no known carcass) like Risch et al. work. This would strengthen inference.

AUTHORS' RESPONSE: Thanks for the suggestion, and we definitely appreciate the value of control/random sites. In fact, our original plan was to use random transects as controls (Risch et al. 2020), but during a pilot experiment we realized that high landscape heterogeneity (differences in hill slope, vegetation, water drainage, proximity to termite mounds, etc.), all of which have implications for nutrient distribution across the landscape (Venter et al. 2003; Holdo & McDowell, 2004), made the random transects challenging for interpretation as controls. Instead, we looked at our pilot data to see whether there was a consistent size of the impact site and found that soil nutrients were elevated until about 5-8m away from the center of the carcass site. Past this 5-8m radius, soil nutrients dropped to consistently lower levels, indicative of background concentrations. Thus, we designed the sampling scheme of 0.5m, 2.5m, 5m, 10m, and 15m distances away from the carcass site to capture both the impact of the elephant carcass and the background ("control") concentration of soil nutrients (at the 10m and 15m distance). There was never a significant difference in nutrient concentrations between the 10 and 15m distances, suggesting our sampling scheme successfully captured the transition from the influence of the elephant carcass through to the background level of nutrients in the matrix soils.

We have updated the methods section of the manuscript as follows: “Based on pilot data, we treat the 10-15m distances as controls, sine the high degree of landscape heterogeneity in the system (e.g., differences in hill slope, vegetation, water drainage, proximity to termite mounds) made random transects difficult for interpretation.”

Venter FJ, Scholes RJ, Eckhardt HC. Abiotic template and its associated vegetation pattern. In: JT Du Toit, KH Rogers, HC Biggs, eds. The Kruger experience: ecology and management of savanna heterogeneity. Washington, DC, USA: Island Press, 83–129, 2003.

Holdo, R. M. & McDowell, L. R. Termite mounds as nutrient-rich food patches for elephants. Biotropica, 36, 231-239, https://doi.org/10.1111/j.1744-7429.2004.tb00314.x, 2004.

ii) lines 180-183. The author’s approach to checking for normality of response data does not seem sound to me. The assumption of normality (for linear models) is normality in light of the model, i.e., investigating the normality of residuals is a more common approach to this. Either way, it is often better to avoid transforming the data and generalized linear models do allow for a lot of flexibility to fit different error distributions. For example, the gamma family in glm is very flexible and can handle log-normal data sets. Did the authors try different families of error distributions before transforming their data?

AUTHORS’ RESPONSE: Thanks so much for this suggestion. We have revised our analysis and implemented the gamma family (link = log) in for all of our models now instead of log-transforming and have updated the text in the methods accordingly. We have updated all results, and new versions of all tables and figures (including supplemental) are appended at the end of this document for reference. Even with this change in the structure of the analyses, the major patterns across the different analyses did not change. In fact, these changes actually strengthen the major patterns in the results showing the importance of elephant carcasses in savanna nutrient dynamics.

iii) lines 187-189. How many data points did the authors have per estimated parameter in the most complex model here?

AUTHORS’ RESPONSE: For each of these models, we had 50 observations total (10 sites x 5 samples per site). In our most complicated model, that averages to ~17 observations per parameter, which is above the recommended 10 observations per parameter (Burnham & Anderson, 2002).

iv) line 194. This is fine but I think Burham & Anderson would say that any model within deltaAIC of 2 of the null model should not be considered to be supported. In several cases, the authors interpret top models that are ranked above the null but within deltaAIC of 2 of the null as supported (e.g., lines 217-218, 218-221).

AUTHORS’ RESPONSE: With the updated model structure (see response to 2.iii), there are now only three response variables (soil water, soil pH, and foliar calcium) for which the null and another model fall within a ΔAICc value of 2 (Table S1). In all three cases, we will interpret this as the results not supporting a relationship between the response variable and soil type, distance from the carcass, or soil type by distance interaction.

v) what R^2 are the authors reporting? In the captions of Tables S1 and S2 (thank you for providing full AIC and coefficient tables), the authors state "R^2 is the proportion of variance explained by a model". This is unclear. These are mixed models, and the most common approach is to report the marginal R^2 and conditional R^2. Is the R^2 in these tables one of those or another pseudo R^2? This is critical for many reasons but most importantly, given the small sample size and large number of mixed-models, I would expect at least one of the models to not converge. There are many indicators when a mixed-model does not converge and one of the best is when the marginal R^2 = conditional R^2. Without having both of these pieces of information, the reader is unable to adequately assess the fit of the models. Other indicators of models not converging are coefficients estimates or errors that are very large or very small (i.e., 0 – see next comment).

AUTHORS' RESPONSE: We have updated supplemental tables (see below) to include both marginal and conditional R^2 values. The only place where we had issues with model non-convergence was soil phosphate; two of the five models failed to converge and are indicated in Table S1.

vi) I am confused by the magnitude of Table S2 sodium and iron coefficients and/or the scale of reported on the y-axis of Figure 5 for these. The iron coefficients in Table S2 seem small relative to the Figure 5c? Or am I misreading things?

AUTHORS' RESPONSE: The original models for soil and leaf micronutrients used log-transformed data, which meant that the coefficients and standard errors were in log units as well. When plotting, we back-transformed the data to make the axis scales easier to interpret, which is why the values in the table and the figures were different. The updated models (see response to 2.iii) still use a log link, so the model outputs in the updated tables are still in log units as well. Again in this version, we exponentiated when calculating the prediction lines so that we could plot them with the raw data, which we believe is visually more intuitive than figures with axes on the log scale. We have updated the table captions for clarification as follows: "Coefficients (± standard error) are shown for each predictor and model and are in log units."

3) the reporting of results could be improved. I recommend, the authors report: top ranked models (AIC + measure of independent fit like R^2). Then report effect size or relationships (coefficients). I found key statistics to be missing throughout. Statements like "Phosphate concentrations were greater in granitic soils…" would be more informative if they included the coefficient + error in parenthesis. Coefficients can be reported for the top-ranked model or from model averaged results when there are several competing models.

AUTHORS' RESPONSE: We appreciate this feedback and have updated the tables accordingly, including AIC values, marginal and conditional $R^2$, and coefficients + standard error (see below). In the text of the results section, we will include the coefficient + standard error from the top-ranked model in parentheses. We agree that this will make the interpretation of the results much more straightforward for the reader.

4) in section 3.2 I think the reader may be more interested in coefficients and confidence intervals around those relationships than p-values that are currently reported.

AUTHORS' RESPONSE: We will replace the p-values in this section with coefficients + standard error and agree this will help greatly with interpretation.

**Specific comments:**

5) I found the use of three different terms that mean similar things (nutrient flows, ecosystem processes, nutrient availability) in the introductory sentence confusing. I recommend the authors replace "nutrient availability" with "ecosystem processes" or "nutrient flows". Surely living animals (not just carcasses) influence nutrient availability (which is just a part of a continual nutrient cycle).

AUTHORS' RESPONSE: We will edit that line for consistency in phrasing: "Living animals affect nutrient flows through ecosystems (Schmitz et al. 2018), but we have only recently acknowledged that animal carcasses could also influence ecosystem processes."

6) line 83. I believe there is no "e" at the end of the citation Risch et al.

AUTHORS' RESPONSE: We have corrected the citation. Thanks for catching it!

7) lines 96-111. How do these elephants die? As someone with no experience with megacarcasses, I would appreciate some insight on the causes of death. Most large herbivore deaths in my empirical systems are from predation which I assume is not the case for elephants.

AUTHORS' RESPONSE: We received GPS coordinates for carcasses from KNP rangers, who also keep record of the cause of death for each elephant. The reviewer is right that predation tends not to be a major issue for elephants, and none that we know of died from it. Most of the elephants in our dataset died of natural causes such as old age, illness, injury, or, in the case of one young bull, a territorial dispute that ended in his death.

We have updated the methods section as follows: "Most elephants died of old age, illness, injury, or, in the case of one young bull, territorial fighting."

8) really excellent job with clear hypotheses and nice work carrying forward these hypotheses throughout the ms – really makes the job easier for the reader.

AUTHORS' RESPONSE: Thank you!

9) lines 132-133 Why 10cm deep core? Is that mineral soil only?

AUTHORS' RESPONSE: We used a 10cm core to ensure that we captured the soil surface horizon. It is a commonly used depth and is more conservative than shallower sampling. Prior work on the soil impacts of carcasses uses this depth (Bump, Peterson, & Vucetich, 2009; Monk et al. 2024). Moreover, previous work in the same system has shown that soil auger sampling depths of 7.5-10cm are sufficient for detecting differences in N, C, and soil micronutrients (Gray & Bond 2015, Holdo & Mack 2014). We will update the text in the methods to include these references.

Bump, J. K., Peterson, R. O., & Vucetich, J. A. Wolves modulate soil nutrient heterogeneity and foliar nitrogen by configuring the distribution of ungulate carcasses. Ecology, 90, 3159–3167, 2009.

Monk, J. D., Donadio, E., Smith, J. A., Perrig, P. L., Middleton, A. D., & Schmitz, O. J. Predation and Biophysical Context Control Long-Term Carcass Nutrient Inputs in an Andean Ecosystem. Ecosystems, 27, 346–359, 2024.

Gray, E. F. & Bond, W. 2015. Soil nutrients in an African forest/savanna mosaic: Drivers or driven? South African Journal of Botany, 101, 66-72. https://doi.org/10.1016/j.sajb.2015.06.003

Holdo, R. M. & Mack, M. C. 2014. Functional attributes of savanna soils: contrasting effects of tree canopies and herbivores on bulk density, nutrients and moisture dynamics. Journal of Ecology, 102, 1171-1182. https://doi.org/10.1111/1365-2745.12290

10) the discussion is well done – concise and touches on all hypotheses.

AUTHORS' RESPONSE: Thank you!

11) Figure 1 is an outstanding visual!

AUTHORS' RESPONSE: Thank you!

12) in figures 2-5 I recommend the authors consider reminding the reader of the sampling resolution because the jitter of points makes it impossible to see what distances were measured below 5m.

AUTHORS' RESPONSE: We have updated the captions in figures 2-5 to include sampling resolution as follows: "Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap."

## Revised Main Figures

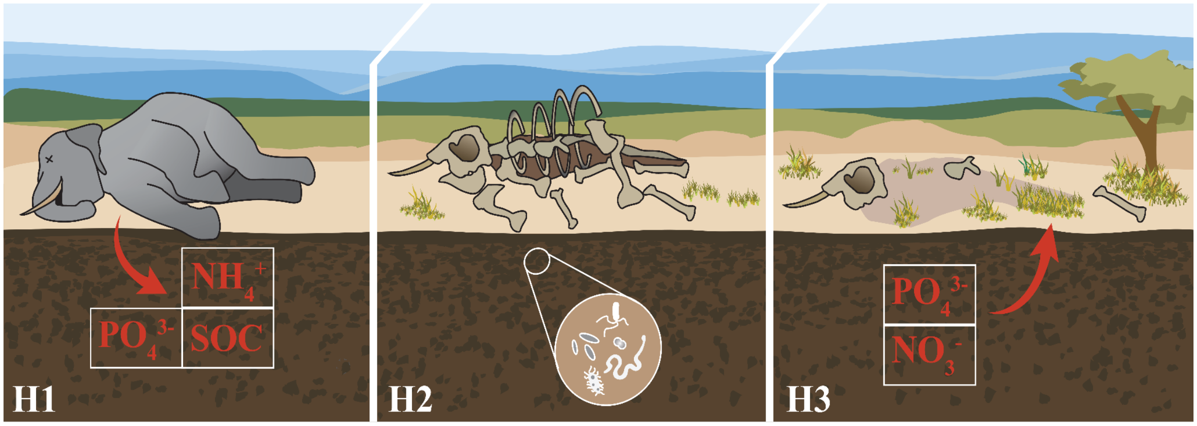



**Figure 1.** Hypothesized impacts of elephant megacarcasses on soil and plant nutrients. First (H1), we hypothesized that elephant carcasses would release pulses of nutrients into the soil, resulting in higher concentrations of soil nutrients such as nitrogen (ammonium, $[NH_4]^+$), phosphorus (phosphate, $[PO_4]^{3-}$), and soil organic C. Second (H2), we hypothesized that C inputs from the carcass would result in increased soil microbial respiration potential. Third (H3), we hypothesized that plants would take up nutrients from the carcass soil, resulting in plants with distinct nutrient profiles and increased concentrations of key limiting nutrients such as N and P. Image credit: Kirsten Boeh.

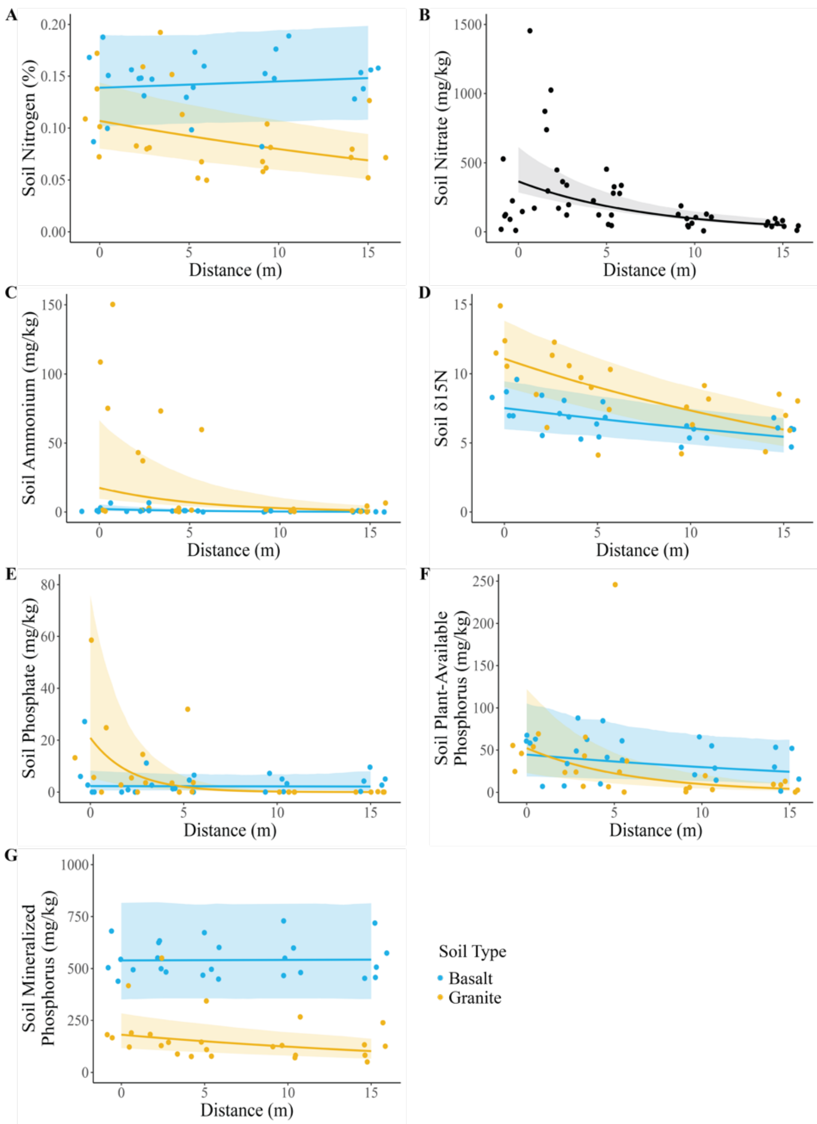



**Figure 2.** Soil N and P responses to elephant carcasses. (A) Soil N (%) was greater in basaltic soils, and in granitic soils it decreased with distance from the carcass site. (B) Soil nitrate nitrogen decreased with distance but did not differ with soil type. (C) Soil ammonium nitrogen and (D) $\delta^{15}N$ were both greater in granitic soils and decreased with distance from the carcass. (E) Soil phosphate, (F) plant-available P, and (G) mineralized P decreased with distance in granitic soils but not basaltic soils. Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap. Lines show predictions calculated from the top model. Shading indicates the 95% confidence interval.

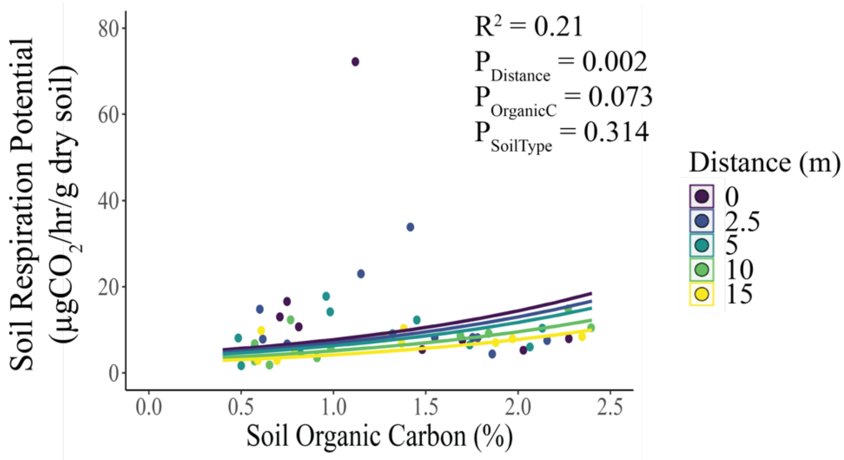



**Figure 3.** Soil respiration potential was marginally positively correlated with soil organic C (%) and decreased significantly with distance from the carcass. Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap. Lines represent model predictions.

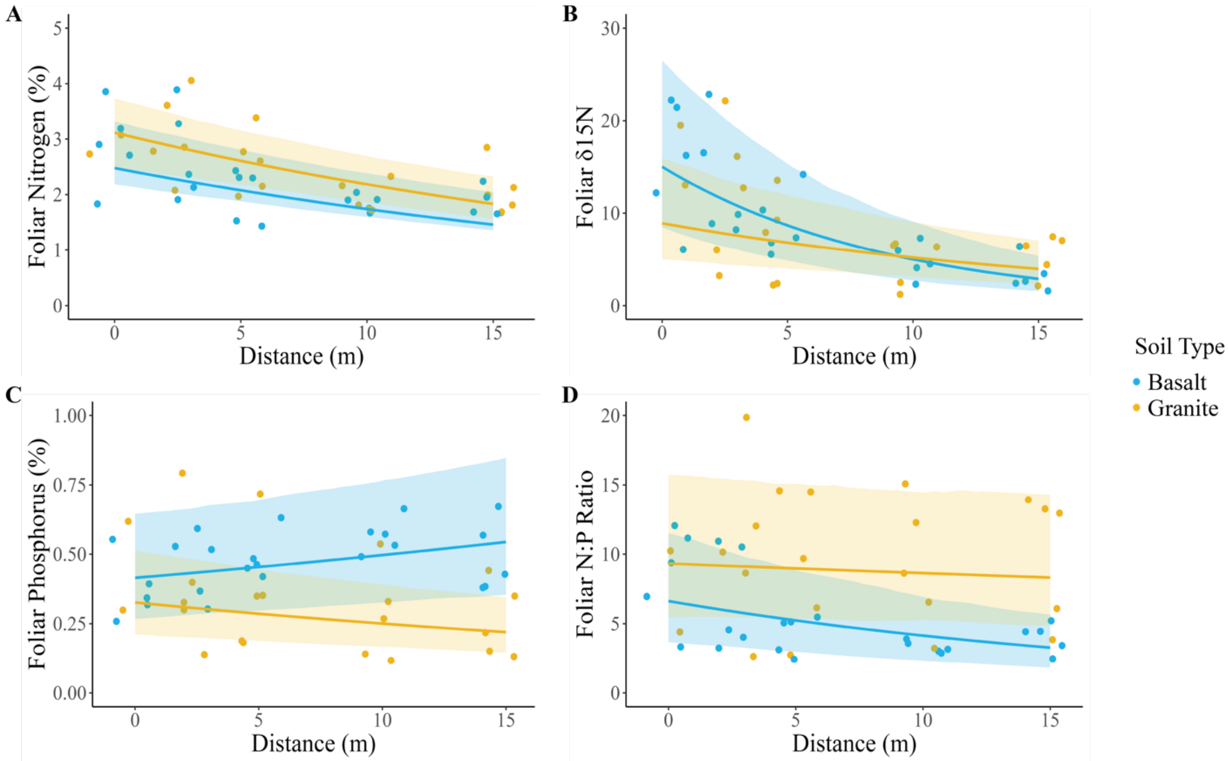
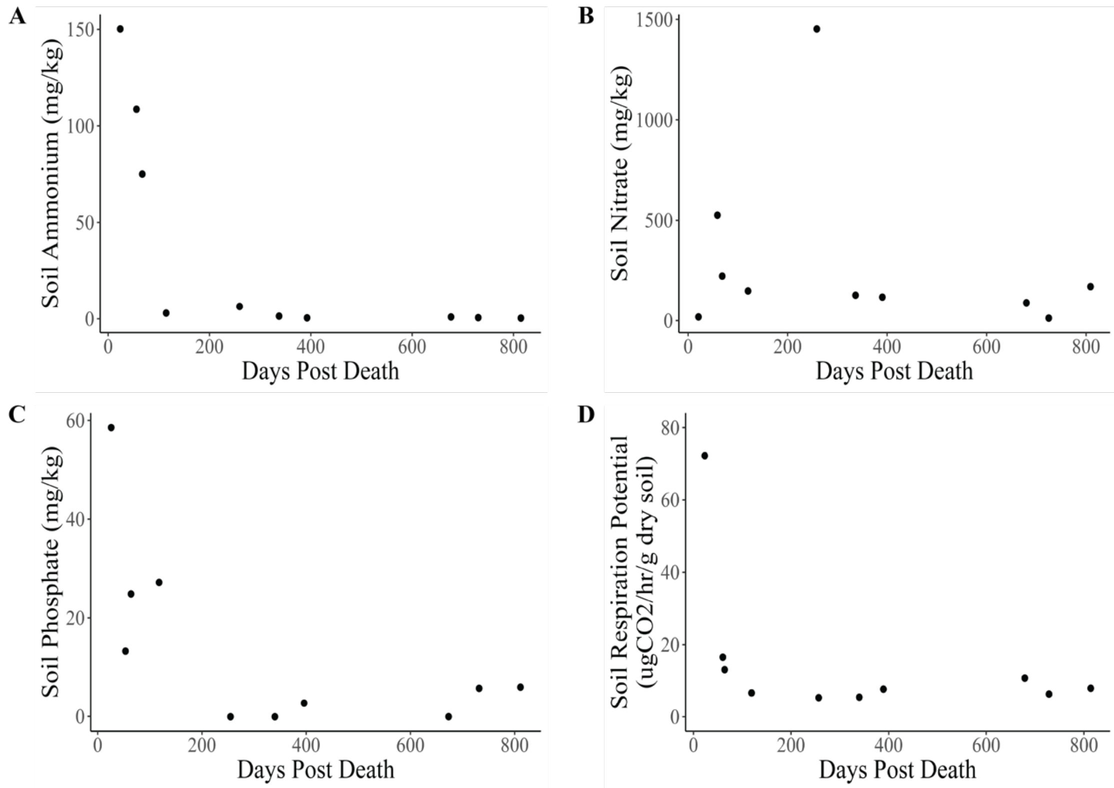



**Figure 4.** Foliar N and P responses to elephant carcasses. (A) Foliar %N and (B) $\delta^{15}N$ both decreased with distance from the carcass center. (C) Foliar P was greater in basaltic soils and decreased with distance in granitic soils. (D) Foliar N:P ratio was greater in granitic soils and decreased with distance from the carcass center. Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap. Lines show predictions calculated from the top model. Shading indicates the 95% confidence interval. Three of the ten sites had bare ground at the 0 m distance, resulting in a sample size of 7 sites for that distance and 10 for the other distances.




Relationship between carcass age and key metrics (soil ion concentrations and respiration potential). (A) Soil ammonium, (B) soil nitrate, (C) soil phosphate, and (D) soil respiration potential are all higher at fresher carcass sites. Point respresent values at the center of the carcass site (distance = 0-0.5m).

**Figure 5.** Relationship between carcass age and key soil metrics (soil ion concentrations and respiration potential). (A) Soil ammonium, (B) nitrate, (C) phosphate, and (D) respiration potential are all higher at fresher carcass sites. Points represent individual measurements taken at the center of the carcass site (distance = 0-0.5m).

## Revised Supplemental Tables

**Table S1.** Generalized linear mixed model results for soil variables. The same five models were run for each response variable, including a null model, and each included site as a random effect to account for repeat measurements. AICc is Akaike's Information Criterion, and ΔAICc is the difference between a given model and the best fit model for that response variable. Cum.Wt stand for cumulative weight; it gives the sum of Akaike's weights and indicates the likelihood that the models up to that point are the best in the set. Models with a ΔAICc value of 2 are considered roughly equivalent in fit and are italicized. Marginal $R^2$ is the proportion of variance explained by both fixed and random effects in a model, and conditional $R^2$ is the proportion of variance explained by fixed effects. Coefficients (± standard error) are shown for each predictor and model and are in log units. Rows are organized in blocks by response variable. Within blocks, models are listed in order of increasing ΔAICc.

| **Model** | **Model Fit** | | | | | **Coefficients ± *SE*** | | |
|---|---|---|---|---|---|---|---|---|
| | **AICc** | **ΔAICc** | **Cum.Wt** | **Mar. $R^2$** | **Con. $R^2$** | **Soil** | **Distance** | **Soil × Distance** |
| **Nitrogen (%)** | | | | | | | | |
| *Soil × Distance* | *-227.32* | *0.00* | *0.99* | *0.54* | *0.74* | *-0.26 ± 0.22* | *0.00 ± 0.01* | *-0.03 ± 0.01* |
| Soil + Distance | -216.13 | 11.20 | 1.00 | 0.46 | 0.67 | -0.48 ± 0.21 | -0.01 ± 0.00 | |
| Distance | -214.95 | 12.37 | 1.00 | 0.04 | 0.52 | | -0.01 ± 0.00 | |
| Soil | -212.36 | 14.97 | 1.00 | 0.40 | 0.62 | -0.47 ± 0.21 | | |
| Null | -211.23 | 16.09 | 1.00 | | | | | |
| **δ15N** | | | | | | | | |
| *Soil × Distance* | *180.87* | *0.00* | *0.77* | *0.55* | *0.70* | *0.39 ± 0.16* | *-0.02 ± 0.01* | *-0.02 ± 0.01* |
| Soil + Distance | 184.66 | 3.79 | 0.88 | 0.50 | 0.66 | 0.26 ± 0.15 | -0.03 ± 0.00 | |
| Distance | 184.67 | 3.79 | 1.00 | 0.34 | 0.60 | | -0.03 ± 0.00 | |
| Soil | 219.35 | 38.47 | 1.00 | 0.20 | 0.34 | 0.28 ± 0.14 | | |
| Null | 219.96 | 39.09 | 1.00 | | | | | |
| **Nitrate (mg/kg)** | | | | | | | | |
| *Distance* | *624.84* | *0.00* | *0.70* | *0.48* | *0.52* | | *-0.14 ±* 0.02 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Soil + Distance | 627.06 | 2.23 | 0.93 | 0.48 | 0.52 | -0.14 ± 0.27 | -0.14 ± 0.02 | |
| Soil × Distance | 629.51 | 4.67 | 1.00 | 0.48 | 0.52 | -0.24 ± 0.39 | -0.14 ± 0.03 | 0.02 ± 0.04 |
| Null | 649.77 | 24.93 | 1.00 | | | | | |
| Soil | 651.82 | 26.99 | 1.00 | 0.01 | 0.04 | -0.18 ± 0.31 | | |
| **Ammonium (mg/kg)** | | | | | | | | |
| *Soil + Distance* | *219.52* | *0.00* | *0.65* | *0.58* | *0.77* | *2.49* ± 0.66 | *-0.18* ± 0.03 | |
| *Soil × Distance* | *220.94* | *1.43* | *0.97* | *0.60* | *0.77* | *2.91* ± 0.73 | *-0.15* ± 0.04 | *-0.07* ± 0.06 |
| Distance | 225.87 | 6.35 | 1.00 | 0.21 | 0.77 | | -0.18 ± 0.02 | |
| Soil | 244.57 | 25.05 | 1.00 | 0.34 | 0.70 | 2.51 ± 0.76 | | |
| Null | 249.38 | 29.86 | 1.00 | | | | | |
| **Phosphate (mg/kg)** | | | | | | | | |
| *Soil × Distance* | *167.99* | *0.00* | *0.98* | *0.52* | *0.79* | *2.20 ± 0.96* | *0.00 ± 0.05* | *-0.46 ± 0.08* |
| Soil + Distance | 178.68 | 10.69 | 1.00 | 0.18 | 0.18 | -0.38 ± 0.70 | -0.14 ± 0.06 | |
| Null | 180.65 | 12.66 | 1.00 | | | | | |
| Soil | Model did not converge | | | | | | | |
| Distance | Model did not converge | | | | | | | |
| **Plant Available Phosphorus (mg/kg)** | | | | | | | | |
| *Soil × Distance* | *447.18* | *0.00* | *0.94* | *0.34* | *0.63* | *0.16 ± 0.62* | *-0.04 ± 0.03* | *-0.13 ± 0.04* |
| Distance | 453.68 | 6.50 | 0.98 | 0.20 | 0.55 | | -0.10 ± 0.02 | |
| Soil + Distance | 454.80 | 7.62 | 1.00 | 0.26 | 0.55 | -0.66 ± 0.55 | -0.11 ± 0.02 | |
| Null | 467.35 | 20.17 | 1.00 | | | | | |
| Soil | 469.19 | 22.01 | 1.00 | 0.03 | 0.30 | -0.35 ± 0.47 | | |
| **Mineral Phosphorus (mg/kg)** | | | | | | | | |
| *Soil × Distance* | *537.77* | *0.00* | *1.00* | *0.86* | *0.95* | *-1.09 ± 0.32* | *0.00 ± 0.00* | *-0.04 ± 0.01* |
| Soil + Distance | 560.48 | 22.71 | 1.00 | 0.82 | 0.92 | -1.35 ± 0.31 | -0.02 ± 0.00 | |
| Distance | 566.38 | 28.61 | 1.00 | 0.04 | 0.76 | | -0.02 ± 0.00 | |
| Soil | 573.55 | 35.78 | 1.00 | 0.78 | 0.89 | -1.33 ± 0.31 | | |
| Null | 579.62 | 41.85 | 1.00 | | | | | |
| **Sodium (mg/kg)** | | | | | | | | |
| *Soil × Distance* | *438.56* | *0.00* | *0.73* | *0.29* | *0.59* | *0.22 ± 0.35* | *-0.03 ± 0.01* | *-0.04 ± 0.02* |
| Distance | 441.09 | 2.53 | 0.94 | 0.22 | 0.54 | | -0.05 ± 0.00 | |
| Soil + Distance | 443.53 | 4.97 | 1.00 | 0.22 | 0.54 | -0.06 ± 0.35 | -0.05 ± 0.01 | |
| Null | 464.02 | 25.45 | 1.00 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Soil | 466.38 | 27.82 | 1.00 | 0.00 | 0.34 | 0.00 ± 0.00 | | |
| **Potassium (mg/kg)** | | | | | | | | |
| *Soil × Distance* | *676.07* | *0.00* | *0.94* | *0.29* | *0.81* | *-0.23 ± 0.42* | *0.01 ± 0.00* | *-0.02 ± 0.01* |
| Null | 682.93 | 6.86 | 0.97 | | | | | |
| Soil | 684.55 | 8.48 | 0.99 | 0.25 | 0.78 | -0.37 ± 0.41 | | |
| Distance | 685.17 | 9.10 | 1.00 | 0.00 | 0.72 | | 0.00 ± 0.00 | |
| Soil + Distance | 686.89 | 10.82 | 1.00 | 0.26 | 0.78 | -0.37 ± 0.41 | 0.00 ± 0.00 | |
| **Calcium (mg/kg)** | | | | | | | | |
| *Soil* | *749.09* | *0.00* | *0.60* | *0.82* | *0.94* | *-1.45 ± 0.41* | | |
| *Soil + Distance* | *751.01* | *1.92* | *0.83* | *0.82* | *0.94* | *-1.45 ± 0.01* | *0.00 ± 0.00* | |
| Soil × Distance | 753.00 | 3.91 | 0.91 | 0.82 | 0.94 | -1.42 ± 0.41 | 0.00 ± 0.01 | -0.01 ± 0.01 |
| Null | 753.55 | 4.46 | 0.97 | | | | | |
| Distance | 755.37 | 6.27 | 1.00 | 0.00 | 0.81 | | 0.00 ± 0.00 | |
| **Iron (mg/kg)** | | | | | | | | |
| *Soil* | *914.44* | *0.00* | *0.67* | *0.88* | *0.96* | *-1.22 ± 0.28* | | |
| Soil + Distance | 916.83 | 2.39 | 0.87 | 0.88 | 0.96 | -1.22 ± 0.28 | 0.00 ± 0.00 | |
| Soil × Distance | 918.54 | 4.10 | 0.95 | 0.88 | 0.96 | -1.19 ± 0.28 | 0.00 ± 0.00 | 0.00 ± 0.01 |
| Null | 920.27 | 5.83 | 0.99 | | | | | |
| Distance | 922.55 | 8.11 | 1.00 | 0.00 | 0.82 | | 0.00 ± 0.00 | |
| **Magnesium (mg/kg)** | | | | | | | | |
| *Soil* | *700.88* | *0.00* | *0.63* | *0.87* | *0.96* | *-1.53 ± 0.37* | | |
| Soil + Distance | 703.33 | 2.45 | 0.81 | 0.87 | 0.96 | -1.53 ± 0.37 | 0.00 ± 0.00 | |
| Soil × Distance | 703.97 | 3.09 | 0.95 | 0.88 | 0.96 | -1.48 ± 0.37 | 0.00 ± 0.00 | -0.01 ± 0.01 |
| Null | 706.40 | 5.52 | 0.99 | | | | | |
| Distance | 708.75 | 7.87 | 1.00 | 0.00 | 0.84 | | 0.00 ± 0.00 | |
| **Water (mmol/mol)** | | | | | | | | |
| *Null* | *111.87* | *0.00* | *0.32* | | | | | |
| *Distance* | *112.09* | *0.22* | *0.61* | *0.03* | *0.38* | | *0.02 ± 0.01* | |
| *Soil* | *112.92* | *1.05* | *0.80* | *0.12* | *0.40* | *0.45 ± 0.38* | | |
| *Soil + Distance* | *113.27* | *1.40* | *0.96* | *0.14* | *0.42* | *0.45 ± 0.38* | *0.02 ± 0.01* | |
| Soil × Distance | 115.86 | 3.99 | 1.00 | 0.14 | 0.42 | 0.44 ± 0.42 | 0.02 ± 0.02 | 0.00 ± 0.03 |
| **pH** | | | | | | | | |
| *Soil × Distance* | *55.04* | *0.00* | *0.37* | *0.07* | *0.44* | *0.05 ± 0.07* | *0.00 ± 0.00* | *-0.01 ± 0.00* |
| *Null* | *55.26* | *0.22* | *0.71* | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Distance* | *56.94* | *1.90* | *0.86* | *0.01* | *0.38* | | *0.00 ± 0.00* | |
| Soil | 57.63 | 2.59 | 0.96 | 0.00 | 0.37 | 0.00 ± 0.07 | | |
| Soil + Distance | 59.41 | 4.37 | 1.00 | 0.01 | 0.38 | 0.00 ± 0.00 | 0.00 ± 0.00 | |

**Table S2.** Generalized linear mixed model results for leaf variables. The same five models were run for each response variable, including a null model, and each included site as a random effect to account for repeat measurements. AICc is Akaike's Information Criterion, and ΔAICc is the difference between a given model and the best fit model for that response variable. Cum.Wt stand for cumulative weight; it gives the sum of Akaike's weights and indicates the likelihood that the models up to that point are the best in the set. Models with a ΔAICc value of 2 are considered roughly equivalent in fit and are italicized. Marginal $R^2$ is the proportion of variance explained by both fixed and random effects in a model, and conditional $R^2$ is the proportion of variance explained by fixed effects. Coefficients (± standard error) are shown for each predictor and model and are in log units. Rows are organized in blocks by response variable. Within blocks, models are listed in order of increasing ΔAICc.

| **Model** | **Model Fit** | | | | | **Coefficients ± *SE*** | | |
|---|---|---|---|---|---|---|---|---|
| | **AICc** | **ΔAICc** | **Cum.Wt** | **Mar. $R^2$** | **Con. $R^2$** | **Soil** | **Distance** | **Soil × Distance** |
| **Nitrogen (%)** | | | | | | | | |
| *Distance* | *56.12* | *0.00* | *0.64* | *0.40* | *0.60* | | *-0.03 ±* 0.00 | |
| Soil + Distance | 57.79 | 1.67 | 0.92 | 0.43 | 0.61 | 0.13 ± 0.14 | -0.03 ± 0.00 | |
| Soil × Distance | 60.33 | 4.20 | 1.00 | 0.43 | 0.61 | 0.15 ± 0.15 | -0.03 ± 0.01 | 0.00 ± 0.01 |
| Null | 89.78 | 33.66 | 1.00 | | | | | |
| Soil | 91.66 | 35.53 | 1.00 | 0.03 | 0.21 | 0.10 ± 0.13 | | |
| **δ15N** | | | | | | | | |
| *Soil × Distance* | *229.95* | *0.00* | *0.95* | *0.51* | *0.77* | *-0.52 ± 0.43* | *-0.11 ± 0.01* | *0.06 ± 0.02* |
| Distance | 236.55 | 6.60 | 0.99 | 0.44 | 0.70 | | -0.08 ± 0.01 | |
| Soil + Distance | 238.97 | 9.02 | 1.00 | 0.45 | 0.70 | -0.12 ± 0.40 | -0.08 ± 0.01 | |
| Null | 282.45 | 52.50 | 1.00 | | | | | |
| Soil | 284.30 | 54.34 | 1.00 | 0.04 | 0.36 | -0.30 ± 0.41 | | |
| **Phosphorus (%)** | | | | | | | | |
| *Soil × Distance* | -87.04 | 0.00 | 0.99 | 0.47 | 0.75 | -0.24 ± 0.31 | 0.02 ± 0.01 | -0.04 ± 0.01 |
| Soil | -76.10 | 10.94 | 1.00 | 0.38 | 0.68 | -0.55 ± 0.31 | | |
| Null | -75.98 | 11.06 | 1.00 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Soil + Distance | -73.69 | 13.34 | 1.00 | 0.38 | 0.68 | -0.55 ± 0.31 | 0.00 ± 0.01 | |
| Distance | -73.68 | 13.36 | 1.00 | 0.00 | 0.56 | | 0.00 ± 0.01 | |
| **N:P Ratio** | | | | | | | | |
| *Soil × Distance* | 209.64 | 0.00 | 0.86 | 0.41 | 0.71 | 0.34 ± 0.38 | -0.05 ± 0.01 | 0.04 ± 0.01 |
| Distance | 214.60 | 4.96 | 0.94 | 0.09 | 0.59 | | -0.03 ± 0.01 | |
| Soil + Distance | 214.85 | 5.21 | 1.00 | 0.36 | 0.67 | 0.62 ± 0.01 | -0.03 ± 0.00 | |
| Null | 225.74 | 16.10 | 1.00 | | | | | |
| Soil | 226.21 | 16.57 | 1.00 | 0.23 | 0.57 | 0.55 ± 0.37 | | |
| **Sodium (mg/kg)** | | | | | | | | |
| *Soil + Distance* | *839.97* | *0.00* | *0.60* | *0.62* | *0.78* | *-0.99 ± 0.32* | *-0.03 ± 0.01* | |
| *Soil × Distance* | *841.56* | *1.59* | *0.88* | *0.62* | *0.79* | *-0.88 ± 0.34* | *-0.03 ± 0.01* | *-0.02 ± 0.01* |
| Distance | 843.18 | 3.21 | 1.00 | 0.09 | 0.64 | | -0.03 ± 0.01 | |
| Soil | 852.98 | 13.02 | 1.00 | 0.53 | 0.71 | -1.00 ± 0.32 | | |
| Null | 856.49 | 16.52 | 1.00 | | | | | |
| **Magnesium (mg/kg)** | | | | | | | | |
| *Soil × Distance* | *722.20* | *0.00* | *0.99* | *0.45* | *0.80* | *-0.20 ± 0.28* | *0.00 ± 0.00* | *-0.02 ± 0.01* |
| Distance | 731.74 | 9.54 | 0.99 | 0.07 | 0.66 | | -0.01 ± 0.00 | |
| Soil + Distance | 732.78 | 10.58 | 1.00 | 0.39 | 0.76 | -0.36 ± 0.28 | -0.01 ± 0.00 | |
| Null | 743.56 | 21.36 | 1.00 | | | | | |
| Soil | 744.46 | 22.26 | 1.00 | 0.31 | 0.69 | -0.37 ± 0.28 | | |
| **Potassium (mg/kg)** | | | | | | | | |
| *Distance* | *936.99* | *0.00* | *0.73* | *0.20* | *0.57* | | *-0.03 ± 0.00* | |
| Soil + Distance | 939.50 | 2.51 | 0.94 | 0.20 | 0.57 | 0.02 ± 0.25 | -0.03 ± 0.00 | |
| Soil × Distance | 941.96 | 4.97 | 1.00 | 0.20 | 0.57 | 0.05 ± 0.26 | -0.02 ± 0.01 | 0.00 ± 0.01 |
| Null | 956.55 | 19.57 | 1.00 | | | | | |
| Soil | 958.95 | 21.96 | 1.00 | 0.00 | 0.38 | 0.00 ± 0.24 | | |
| **Calcium (mg/kg)** | | | | | | | | |
| *Null* | *799.64* | *0.00* | *0.42* | | | | | |
| *Distance* | *800.68* | *1.04* | *0.67* | *0.01* | *0.50* | | *0.00 ± 0.00* | |
| *Soil* | *801.22* | *1.58* | *0.86* | *0.14* | *0.53* | *-0.20 ± 0.21* | | |
| Soil + Distance | 802.36 | 2.72 | 0.96 | 0.14 | 0.54 | -0.20 ± 0.21 | 0.00 ± 0.00 | |
| Soil × Distance | 804.45 | 4.81 | 1.00 | 0.15 | 0.54 | -0.16 ± 0.22 | 0.01 ± 0.01 | -0.01 ± 0.01 |
| **Iron (mg/kg)** | | | | | | | | |
| *Distance* | *591.87* | *0.00* | *0.69* | *0.21* | *0.57* | | *-0.08 ± 0.01* | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Soil + Distance | 594.14 | 2.27 | 0.92 | 0.23 | 0.58 | -0.26 ± 0.50 | -0.08 ± 0.01 | |
| Soil × Distance | 596.15 | 4.27 | 1.00 | 0.23 | 0.59 | -0.09 ± 0.39 | -0.07 ± 0.00 | -0.02 ± 0.02 |
| Null | 616.95 | 25.08 | 1.00 | | | | | |
| Soil | 619.06 | 27.19 | 1.00 | 0.02 | 0.48 | -0.31 ± 0.00 | | |

**Table S3.** Generalized linear mixed model results testing for correlations between leaf and soil micronutrients. The same model was run for each of five micronutrients (Na, K, Ca, Mg, and Fe) with leaf micronutrient concentration as the response variable, soil micronutrient + distance as the main effects, and site as a random effect. Marginal $R^2$ is the proportion of variance explained by both fixed and random effects in a model, and conditional $R^2$ is the proportion of variance explained by fixed effects. Coefficients (± standard error) are shown for each predictor and model.

| **Leaf Micronutrient** | **Mar. $R^2$** | **Con. $R^2$** | **Soil Micronutrient Coefficient ± *SE*** | **Distance Coefficient ± *SE*** |
|---|---|---|---|---|
| Sodium | 0.08 | 0.82 | 11.56 ± 11.67 | -146.47 ± 43.04 |
| Potassium | 0.29 | 0.73 | 0.00 ± 0.00 | -0.06 ± 0.01 |
| Calcium | 0.12 | 0.58 | 0.00 ± 0.00 | 0.00 ± 0.00 |
| Magnesium | 0.17 | 0.79 | 0.00 ± 0.00 | 0.00 ± 0.00 |
| Iron | 0.11 | 0.32 | 0.00 ± 0.01 | -52.85 ± 20.57 |

## Revised Supplemental Figures

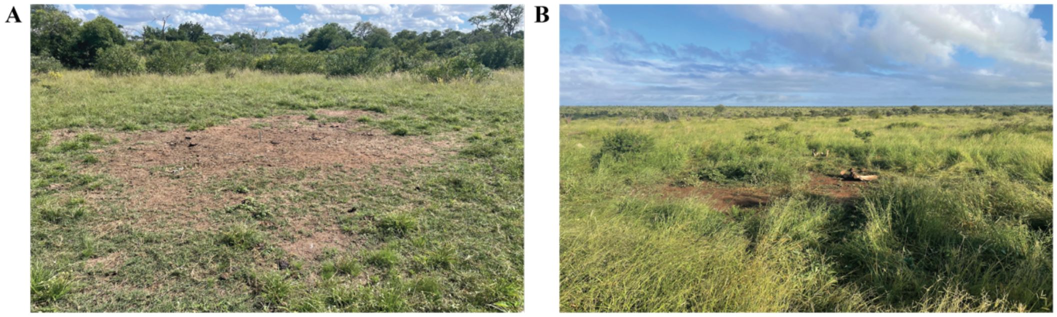


**Figure S1.** Representative photos of two elephant carcass sites of different ages and soil types. (A) The first site is 67 days post-death and is on granitic soil. (B) The second site is 811 days post-death and is on basaltic soil. In both images, there is a visible impact zone with reduced vegetation coverage. At the first site, elephant bones have all been dispersed, though some are still present at the second site. Photos taken by Deron Burkepile at time of sample collection in March 2023.

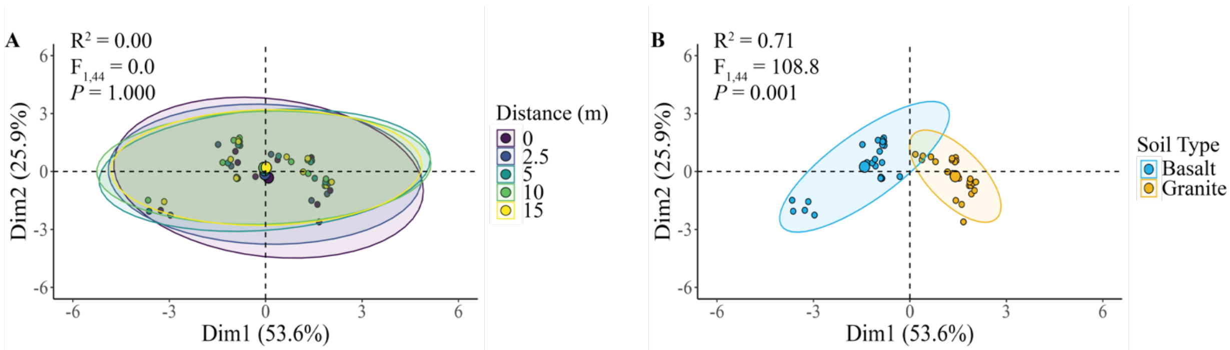



**Figure S2.** (A) Soil micronutrient composition did not differ significantly with distance from the carcass but (B) was distinct in different soil types.

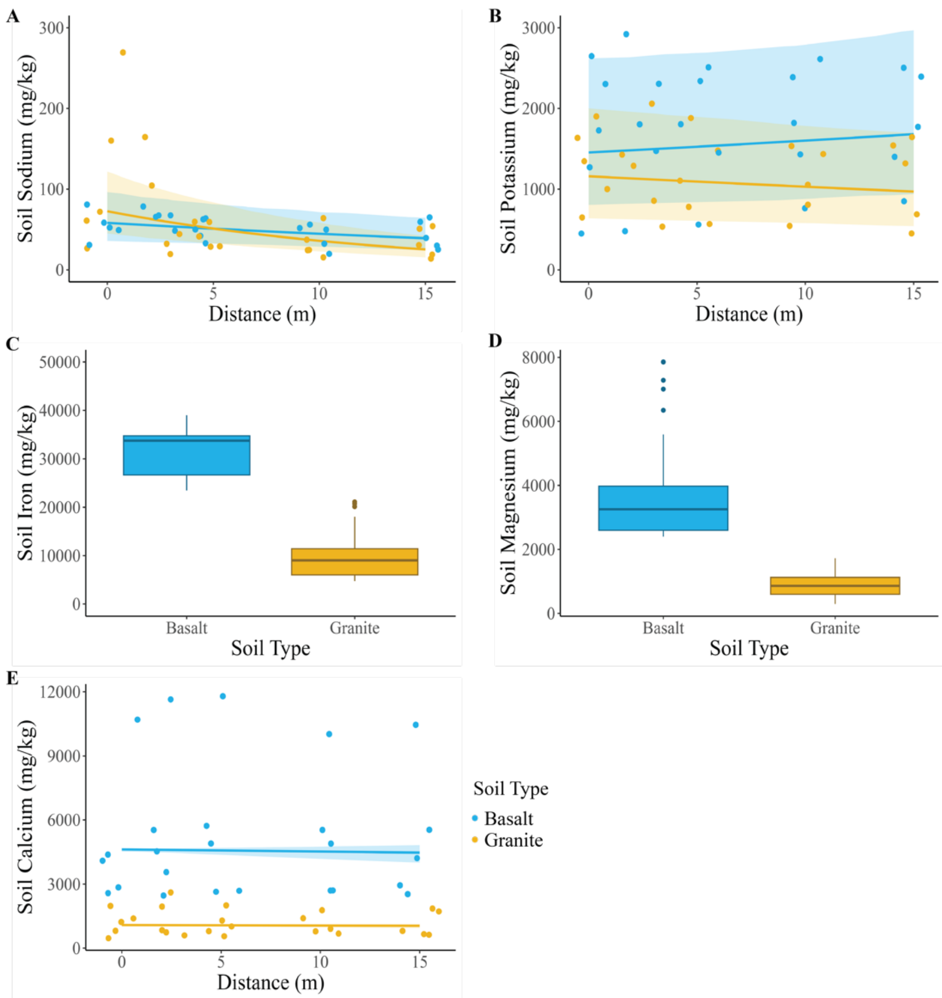



**Figure S3.** Effects of elephant carcasses on soil micronutrients. (A) Soil sodium decreased significantly with distance from the carcass. (B) Potassium decreased with distance but only in granitic soils. (C) Iron, (D) magnesium, and (E) calcium were greater in basaltic soils. Distance appeared in the top model for calcium, but the effect size was minimal. Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap. Lines show predictions calculated from the top model. Shading indicates the 95% confidence interval.

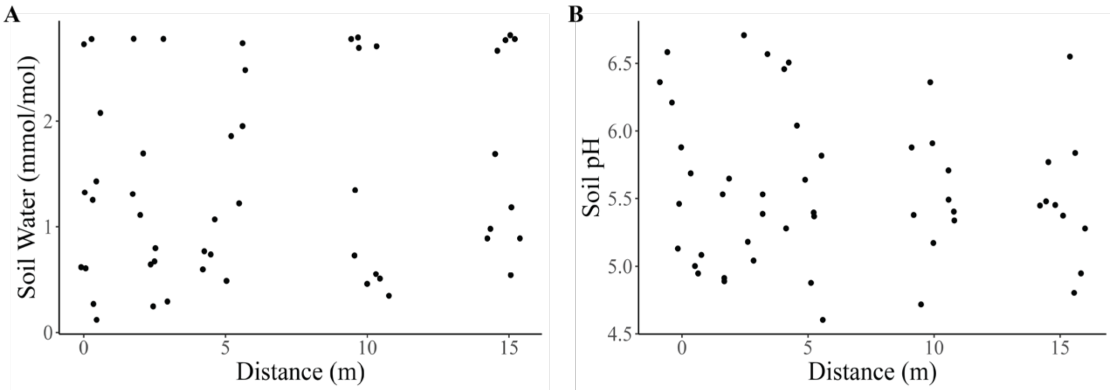



**Figure S4**. Neither (A) soil water nor (B) soil pH differed with distance or soil type. Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap.

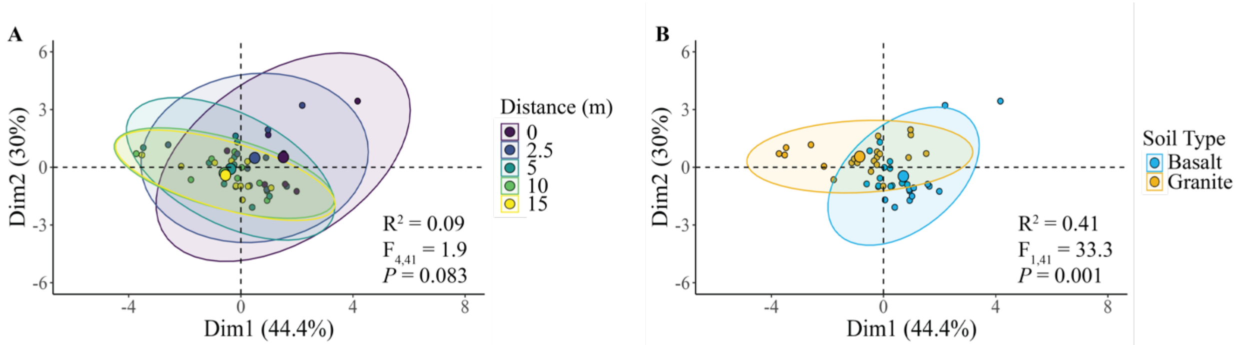



**Figure S5.** (A) Foliar micronutrient composition did not differ significantly with distance from the carcass but (B) was distinct in different soil types.

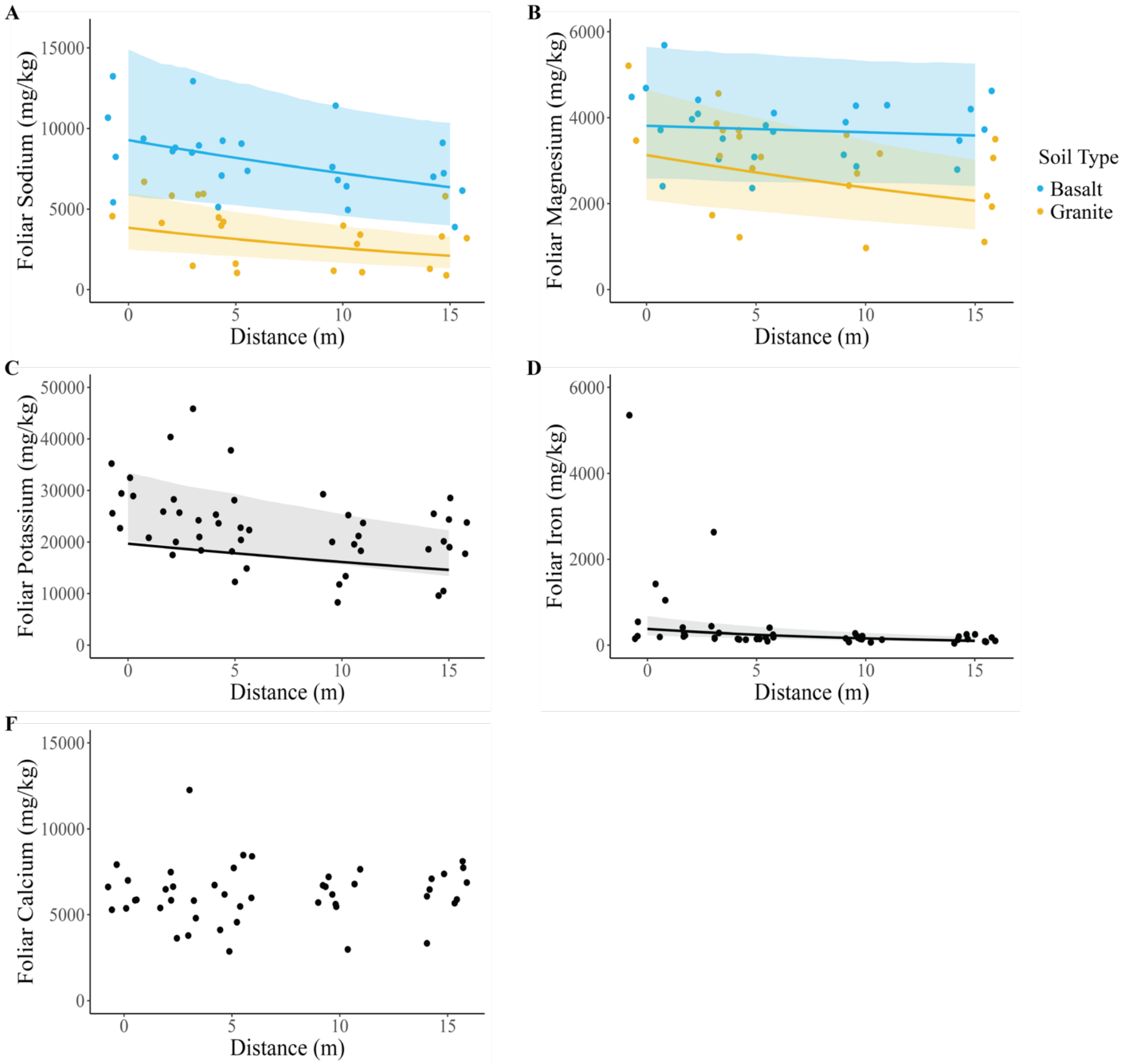



**Figure S6**. Effects of elephant carcasses on grass foliar micronutrients. (A) Foliar Na and (B) Mg were greatest in basaltic soil and decreased significantly with distance. (C) Foliar K and (D) Fe decreased with distance but did not differ with soil type. (E) Foliar Ca did not differ with distance or soil type. Points represent individual measurements taken at 0, 2.5, 5, 10, and 15m and are offset to be visible when they would otherwise overlap. Lines show predictions calculated from the top model. Shading indicates the 95% confidence interval.