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Seed germination cues and the importance of the soil seed bank across an environmental gradient in the Serengeti

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Soil seed banks are an important source of new individuals for many plant populations and contribute to future genetic variability. In general, the size and persistence of soil seed banks is predicted to be greater where growth occurs in unpredictable pulses, where opportunities for disturbance-related recruitment are frequent and where the probability of recruitment failure is high. In savanna ecosystems, characterized by disturbance from fire and unpredictable water availability, soil seed banks should be relatively important sources of recruitment. However, the few studies conducted in savannas are inconclusive about the importance of soil seed banks and, more specifically, how seed banks should change across environmental gradients. We determined the number of viable seeds in the soil seed bank across savanna-grasslands in the Serengeti, an ecosystem characterized by frequent fire and seasonal drought. Soils were exposed to a combination of smoke and heat, cues which may be required to break seed dormancy in such ecosystems. Our a priori expectation was to observe large seed banks in regions characterized by seasonal drought and comparatively smaller seed banks in regions of higher moisture availability and high fire frequencies. In contrast to our hypothesis, seed germination increased strongly with precipitation and fire frequency. In addition, there was a significant interaction effect between fire and rainfall: low rainfall sites with frequent fire had greater seed germination than low rainfall sites with low fire frequency. Moreover, in laboratory experiments, heat had a negative, smoke a positive effect on final seed germination numbers. Together, these findings suggest that fire may be a key factor in driving herbaceous seed bank dynamics in tropical savannas.

Many tropical savannas are characterized by high rates of disturbance from fire as well as unpredictable water availability (Bourlière 1983, Solbrig et al. 1996). Herbaceous plant species inhabiting savannas have evolved a suite of adaptations that allow them to cope with such conditions. For example, species can invest in seeds that germinate quickly in response to favorable conditions or in seeds that postpone germination, thus hedging their risk of mortality by spreading germination across time (Baskin and Baskin 2001). In dry savannas, where water availability is unpredictable, species are expected to invest in seeds that can form a persistent seed bank either through delayed germination (Moles and Westoby 2004a, b, Williams et al. 2005) or true seed dormancy (Thompson et al. 2003, Baskin and Baskin 2004). In mesic savannas, where favorable conditions are common, species are expected to invest in seeds that germinate quickly because there is less of an advantage to delaying germination. Therefore, across a gradient from dry to mesic savannas a logical prediction is that the size of the soil seed bank should decrease with increasing water availability.

The situation is, however, more complex because savannas are often characterized by disturbances, such as fire, which co-vary with water availability. For example, high rainfall savannas have increased grass fuel loads and thus higher fire frequency, yet fire is expected to favor delayed germination or seed dormancy (Jurado and Flores 2005, Wright and Clarke 2009) whereas higher rainfall is not. Because water availability and fire frequency co-vary across savannas, and thus may have opposing effects on plant investment in seed persistence, predicted impacts on the size of the soil seed bank in savannas is unclear (Williams et al. 2005, Wright and Clarke 2009).

The paucity of soil seed bank studies conducted in savannas also contributes to a lack of understanding: whereas soil seed banks have been investigated in temperate herbaceous communities (Thompson et al. 1998, Ehrlén et al. 2006), Mediterranean shrub communities (Keeley 1991, Pausas et al. 2006, Paula and Pausas 2008, Thomas et al. 2010), and desert ecosystems (Wright and Clarke 2009), fewer studies have been conducted in savannas. Moreover, the few seed bank studies that have been carried out in savannas are highly inconsistent in their results. For example, O'Connor and Pickett (1992) reported, based on results from sites in eastern Transvaal, South Africa, that drought and sustained heavy grazing eliminated long-lived palatable species with a low output of large seeds from the seed bank (O'Connor and Pickett 1992). Skoglund (1992), working in the Serengeti ecosystem of east Africa, reported the presence of an abundant seed bank, reaching up to 21 000 seeds m^2. In contrast, Belsky (1986), also working in Serengeti, found no evidence of a seed bank at any site transecting a rainfall and gradient in grazing intensity. Seedling emergence in disturbed plots was, however, highest in dry sites and declined with increasing rainfall (Belsky 1986).

To better understand seed bank dynamics in savannas and to address the inconsistencies in previous findings, a specific aim of this study was to determine the number of viable seeds in the soil seed bank across the environmental gradient in the Serengeti ecosystem. This ecosystem is ideal for addressing the relative roles of resource availability and disturbance on seed bank dynamics because the landscape is characterized by a gradient of rainfall, seasonal drought and fire. In general, total precipitation and fire frequency increase from south to north, while seasonality displays the opposite pattern (Fig. 1; Sinclair 1995, Anderson et al. 2008). Our a priori hypothesis was that moisture availability will be the primary determinant of seed bank size, and thus the seed bank will be highest in the south, where seasonal drought predominates, and decrease towards the north, where soil moisture availability is more consistent throughout the year (solid line in Fig. 1). An alternative hypothesis is that disturbance, in this case fire, overrides the soil moisture gradient in determining the size of the soil seed bank. Under this alternative hypothesis, high fire frequency in the north promotes seed persistence, and thus the size of the soil seed bank would increase from south to north (dashed line in Fig. 1).

Due to the prominence of fire in the Serengeti ecosystem (Dempewolf et al. 2007) and the tendency for fire-related germination triggers (e.g. heat and smoke) to break seed dormancy in other fire-prone systems (van Staden et al. 2000, Clarke and French 2005), a secondary objective of this study was to investigate the ecological significance of heat and smoke on seed germination from Serengeti soils. For example, it is plausible that failures to identify a seed bank in Serengeti soils (i.e. Belsky 1986) occurred because of the lack of important ecological germination triggers. We investigate this hypothesis by quantifying the effects of heat and smoke on seed germination from soils collected across the Serengeti rainfall gradient compared with untreated controls. To the best of our knowledge, this aspect of seed germination has not been previously explored in seed bank studies of East African savannas.

Material and methods

Study area and sampling design

The field study was conducted in Serengeti National Park (SNP), which is the central protected area in the larger 25 000 km^2 Serengeti-Mara ecosystem. The system is a semi-arid *Acacia*-dominated savanna, and is typical except for the large number of migratory wildebeest *Connochaetes taurinus* and zebra *Equus quagga boehmi*. The volcanic highlands to the southeast and Lake Victoria to the west create a strong ecological gradient that varies in elevation, rainfall, soil fertility, and woody species cover (Anderson et al. 2008, Reed et al. 2009). SNP has two characteristic wet seasons: the short rains, lasting from November to December, and the long rains, typically starting in March and lasting until May (Norton-Griffiths et al. 1975).

In May of 2009, just after the end of the long rains, ten sites were sampled along a 60 km transect in the central region of the Serengeti. Sites were separated by distances

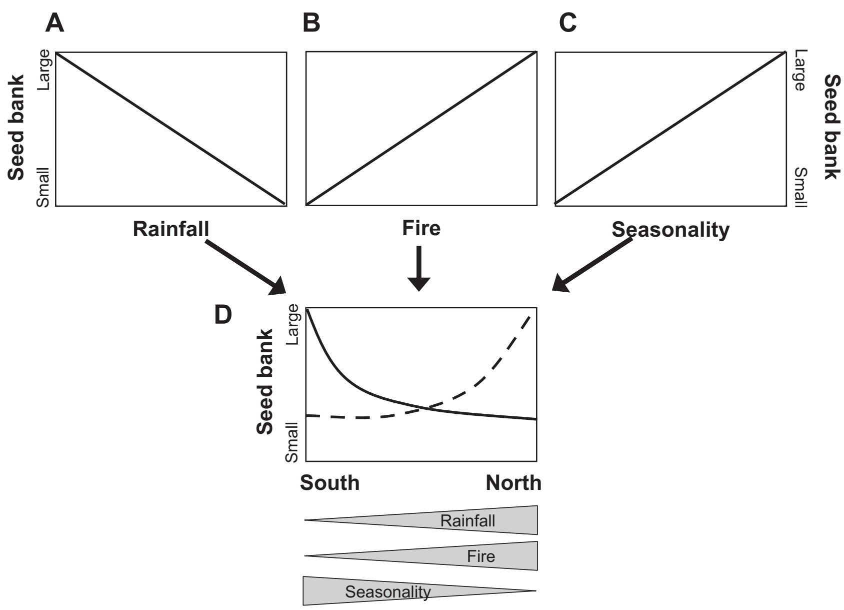

Figure 1. A conceptual schematic representing the individual effects of rainfall (A), fire (B) and seasonality (C) on the composite size of the soil seed bank across the Serengeti environmental gradient (D). The a priori expected response, when soil seed storage decreases with rainfall and increases with seasonality, is shown as the solid line in panel (D). Under this hypothesis, we expect a large seed bank in the south compared with the north as a result of predictable and highly seasonal drought in the Serengeti plains. In contrast, the alternative hypothesis, when soil seed storage increases with fire frequency, is shown as the dashed line in panel (D). Under this scenario, fire frequency increases to the north and would therefore favor the build-up of a seed bank in this region of the ecosystem.

of between a minimum of 5 km and maximum of 18 km. Average rainfall at the sites was interpolated from 58 rain gauge locations using >40 years of data (see Anderson et al. 2007a for more details). The sites ranged in average annual rainfall from ~680 mm $year^{-1}$ in the south to ~830 mm $year^{-1}$ in the north. Because these are long term averages, the maximum rainfall difference across sample locations (i.e. ~150 mm $year^{-1}$) does not reflect the strong gradient in standing plant biomass, herbaceous height and rainfall seasonality that exists across the extent of the study area. For example, composite images from the moderate-resolution imaging spectroradiometer (MODIS) show that the near-infrared difference vegetation index (NDVI) differs by 47% between the southern-most and northern-most site, indicating a strong divergence in greenness and herbaceous biomass (see Appendix A in Anderson et al. 2010 for more information). Landscape-level fire frequency at the sites was estimated for a 9×9 pixel window using the 250 m^2 fire maps from Dempewolf et al. (2007). Although the fire data do not extend up to the time of our study, the relatively large scale at which fire frequency was estimated should be highly representative of the long-term fire frequency at the sites.

At each site, four 10 cm diameter $\times$ 20 cm depth soil cores were collected at each of two locations separated by approximately 10 m. Immediately after collection, the four cores at each location were combined and thoroughly homogenized by hand. A random 1 kg sample was taken from each mixture, sieved through a 4 mm screen to remove roots and small stones, air dried and shipped to the Swiss Federal Inst. for Forest, Snow and Landscape Research in Switzerland (WSL). Upon arrival, soil samples were dried at 35°C for 24 h to remove excess moisture. Subsequently, 500 g of dried soil was removed from each mixture and split into four equal 125 g portions for use in the seed germination experiment that began in June 2009. Three additional 5 cm diameter $\times$ 20 cm (length; volume: 392.7 cm^3) soil cores were collected at each site, shipped to WSL, dried at 105°C for 24 h and weighed to determine soil bulk density.

One of the four 125 g sub-samples was left untreated and served as a control. The remaining three 125 g sub-samples were treated as follows to break seed dormancy: 1) heat: exposed to 110°C heat for 5 min in a convection oven; smoke: exposed to cold smoke for 1 h generated by a portable Bradley propane smoker; 3) heat + smoke: exposed to cold smoke for 1 h followed by a heat treatment of 5 min at 110°C (Enright et al. 1997, Tieu et al. 2001). Subsequently, each of the samples was spread in a thin layer (<1 cm) on trays filled with sterilized woody substrate covered with cotton fleece. The trays were randomly placed on shelves in a greenhouse and rearranged every two weeks to prevent local micro-climatic effects. Trays were illuminated with natural light, shaded from bright sunlight and regularly watered with tap water. Temperatures ranged from 30°C during the day to 15°C during the night. Five additional trays containing only woody substrate were used to test for seed contamination of the woody substrate. As soon as possible after germination, we counted and removed seedlings to reduce competitive effects. After two months soils were remixed and remaining seedlings were allowed to emerge. Seedling counts were conducted at least once a week for a total of 116 days. All plants were identified to the lowest taxonomic group possible; no attempt was made to assess the number of dormant seeds remaining in the samples. For comparative purposes, soil bulk densities were used in conversions so that seed germination number can be reported per unit area.

Statistical analyses

To test how the experimental treatments and environmental site variables affected seed germination, the total number of seedlings (i.e. counts) that emerged per site and treatment after 116 days was analyzed with a generalized liner model using treatment (heat, smoke, heat + smoke or control) as a predicator and rainfall and fire frequency as covariates. Analyses were conducted in R (ver. 2.10.1) using the 'glm' statement and, due to the non-normal error distribution of count data, the family = Poisson and link = log were specified in the model statement. In the case that residual deviance was significantly larger than the degrees of freedom we refit the model with the family = quasipoisson to compensate for overdispersion. The final acceptable model was determined iteratively in R using the 'update' statement as recommended by Crawley (2007); statistical significance of the full factorial model (i.e. treatment $\times$ rainfall $\times$ fire) versus reduced models was assessed with AIC values and χ^2-tests using the 'anova' statement.

Results

Overall, 135 seeds germinated from the soils: 47.4% (64) of the individuals were graminoids (grasses + sedges) and 52.6% (71) were forbs. Out of a total of 34 'morpho-species' encountered, 24 species were positively identified taxonomically (Appendix 1), which represented 74.8% (101) of total individual seedlings that emerged.

Seed germination: experimental treatments and environmental covariates

In the control treatment, the mean number of seeds germinated ($mean_{control} \pm SE = 1581.3 \pm 494.4$ seeds m^{-2}) was significantly lower then the number germinated from the smoke treatment ($mean_{smoke} \pm SE = 2588.6 \pm 855.6$ seeds m^{-2}) and significantly greater then the number germinated from the heat treatment ($mean_{heat} \pm SE = 628.7 \pm 223.7$ seeds m^{-2}). In contrast, the control was not statistically different from the number germinated in the heat + smoke treatment ($mean_{smoke+heat} \pm SE = 1123.2 \pm 344.9$ seeds m^{-2}).

The final acceptable model, which included a rain $\times$ fire interaction and main effects of treatment, rain and fire, provided a superior fit over more complex models in terms of modeling seed germination ($AIC_{reduced} = 147.3$, $AIC_{full} = 152.8$; Table 1). A χ^2-test confirmed that including the rain $\times$ fire interaction was justified over the simplified model that included only main effects (model comparison: deviance = –5.017, p-value = 0.025). The main effects of the experimental treatments were consistent across the gradients of rainfall and fire, as shown by the lack of a significant interaction terms involving the treatment variable (Table 1, Fig. 2). The unexpected negative interaction term between fire and rain (Table 1) indicated that seed germination was greater at sites with low rainfall and high fire frequency

Table 1. Results from the generalized linear model in R testing the effects of treatment (control, heat, smoke and heat + smoke), rainfall and fire frequency on the seedling germination counts from soils collected across the Serengeti rainfall gradient. The default in R is to show the first treatment (in this case the control) as the intercept, to which all other treatments are compared. p-values ($p\ (>|z|)$) in bold are considered significant at $\alpha = 0.05$; final model residual deviance = 38.115 on 33 DF; AIC = 147.3.

	Estimate	SE	z-value	p (>|z|)
Intercept	−26.56772	9.62056	−2.76	**0.0058**
Heat	−0.91629	0.31623	−2.90	**0.0038**
Heat + Smoke	−0.29725	0.25891	−1.15	0.2509
Smoke	0.45199	0.21622	2.09	**0.0366**
Rain	0.03326	0.01246	2.67	**0.0076**
Fire	14.53028	6.15054	2.36	**0.0182**
Rain × Fire	−0.01657	0.00792	−2.09	**0.0364**

compared with low rainfall and low fire frequency and that this effect diminished with increasing rainfall (Fig. 3).

The strong positive main effects of rainfall and fire frequency were contrary to our initial prediction that the soil seed bank would decrease with rainfall and the seasonal predictability of soil moisture (Fig. 1). Instead, our results supported our alternative hypothesis, that fire has a predominant influence on the soil seed bank by favoring species that rely on unpredictable disturbance for seed germination. Thus, the size of the soil seed bank was smallest at dry sites in the south and increased substantially towards the north where rainfall and fire frequencies are higher (Fig. 2).

Discussion

Given the predominance of grasses in the Serengeti, which is often >90% of the herbaceous biomass (Anderson 2008) the numerical abundance of forb seedlings (>50%) was unexpected. While this result was due in large part to the successful germination of *Oldenlandia wiedemannii*, forbs were still more numerous than expected by their relatively rare occurrence in the vegetation (McNaughton 1983, Anderson et al. 2007a). These results may reflect life-history tradeoffs between the forbs and perennial grasses that dominate SNP, with forbs being shorter-lived (i.e. the prevalence of annual forbs in Appendix 1) but having seeds that persist longer in soil. In theory, short-lived species tend to form a persistent seed bank more so than perennials (Rees 1994, Honda 2008) and a notable fraction of the forbs that germinated in our study were short-lived annual or biennial species (Appendix 1). Perennial grasses, in contrast, are assumed to be longer-lived but produce seeds that rarely persist more than one season in the seed bank. This characteristic has been observed in many tropical savannas grasses, including *Themeda triandra*, which produces a transient seed bank. *Themeda triandra* remains in the soil during the dry season and then either germinates or dies with the onset of the rainy season (O'Conner and Pickett 1992, O'Conner 1996, Williams et al. 2005). Therefore, it is noteworthy that the three most abundant species to germinate in our study were all perennials, one forb (*O. wiedemannii*) and two grasses (*Digitaria macroblephara* and *Sporobolus stapfianus*). Further research will be required to determine whether these and other species have persistent or transient seed banks.

In addition to the main effects of rainfall and fire, there was an unexpected rainfall × fire interaction that was independent of the experimental treatments meant to break seed dormancy (Table 1). This interaction effect provides indirect evidence for the importance of fire, in that higher fire frequency significantly increased soil seed germination across all sites, but the effect was more pronounced at lower rainfall (Fig. 3). Like all observational studies, there may be other, unaccounted for, variables that influenced our results. The most notable candidate in Serengeti is the conspicuous effects of large ungulate grazers, which we discuss below. However, the laboratory experiment provided further support that fire indeed has an important influence in that smoke had

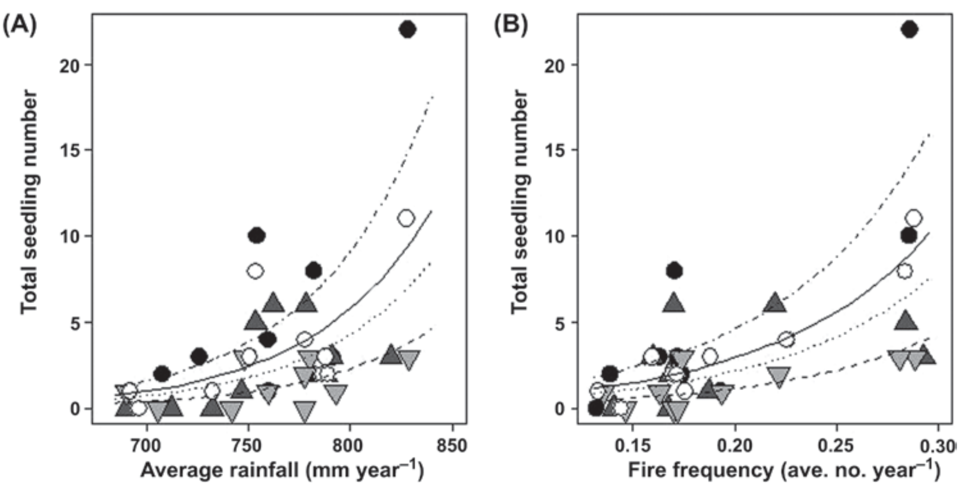

Figure 2. (A) Relationship between the counts of seeds germinated in the control (white circles), smoke (black circles), heat (light grey upside-down triangles) and heat + smoke (dark grey triangles) treatments as a function of mean annual rainfall at the sites. Lines are best fit regressions for control (solid), smoke (dash-dot), heat (dashed) and heat + smoke (dotted) treatments. (B) The same treatments, symbols and lines as in (A) but plotted against the mean large-scale fire frequency at the sites. Note: for statistical purposes (see methods) the values are presented as seedling counts per treatment; seedling estimates on an aerial basis (seeds m^{-2}) are provided in the results section.

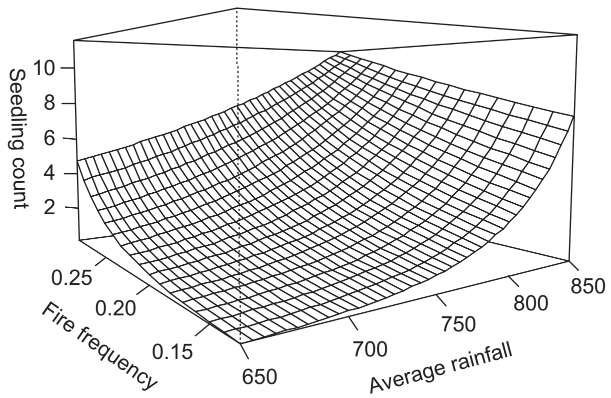

Figure 3. Three-dimensional plot showing the relationship among average rainfall, fire frequency and seedling count; the trend surface is the best fit glm result from the fire × rainfall interaction model in R (i.e. Table 1). The figure demonstrates that high fire frequency promotes seed germination, but the effect is stronger at low rainfall than at high rainfall.

a significantly positive influence on seed germination. On the other hand this effect was only attributable to smoke as heat had a negative effect on germination, possibly because it damaged or physiologically impeded germination in seeds that were otherwise stimulated to germinate by smoke alone (Thomas et al. 2007). Together, the strong seed germination response to smoke in both grasses and forbs and the fire × rainfall interaction effect corroborates the view that fire plays a key evolutionary role in the dynamics of seed germination across tropical African savannas. We acknowledge that there may have been seeds present from other species that did not germinate because we failed to represent their optimal germinal cues. However, as our estimates for seed bank sizes on an aerial basis are equivalent to or greater than similar sites (O'Connor and Pickett 1992, O'Connor 1996, Williams et al. 2005), this effect is likely relatively negligible in relation to comparable studies.

There are several additional mechanisms that might contribute to the variation in the soil seed bank observed across the SNP environmental gradient. First, a larger seed bank at wetter, frequently burning sites could result from site differences in plant species composition that resulted in seeds having greater temporal continuance in the seed bank. Indeed species subject to higher fire frequencies that are killed more often by fire often have larger seed banks than those that survive fire (Clarke and Dorji 2008). However, Serengeti savannas, dominated by perennial grasses, may function somewhat differently: concomitant with the increase in precipitation and fire frequency, there is a well-documented increase in the proportion of tall, obligate seed producing, caespitose grasses that appear tolerant of fire, and thus resprout after burning (McNaughton 1983, Belsky 1992, Anderson et al. 2007b, Anderson 2008). Among these plants are several species in a closely related clade of grasses consisting of *Heteropogon*, *Themeda*, *Hyparrahennia*, *Hyperthalia* and *Bothriochloa* (Anderson et al. 2011). These species are similar in their stature, in their tolerance of fire and the conspicuous presence of awns on their seeds (Campbell et al. 1996, Orr et al. 1997). Consistent with the idea that these species are uniquely adapted to germinate under conditions of frequent fire, previous research has suggested that the presence of awns is an evolutionary adaptation to facilitate seed burial after fires and that awn length is under natural selection by fire frequency (Garnier and Dajoz 2001).

Second, differences in actual seed dormancy among species or differences in the minimum environmental conditions required for normal germination could also explain our findings. The latter has been referred to as 'enforced dormancy', but should not be confused with true physiological dormancy (Baskin and Baskin 2001, Thompson et al. 2003). In fire-prone savannas, such as South Africa and northern Australia, smoke or heat is often necessary for seed germination (Williams et al. 2005, Ghebrehiwot et al. 2009). Our study suggests that smoke is also an important germination cue in the Serengeti and probably in east African savannas in general. Moreover, our results suggest that previous studies in Serengeti that failed to identify a significant seed bank (i.e. Belsky 1986) may have done so because at the time of the study it was not yet widely known that smoke was needed to break dormancy.

Finally, in addition to differences in plant species composition or dormancy, variation in the size of the soil seed bank could also be attributed to abiotic factors, such as increased light at soil surface in the more open short grass plains in the south. The lower standing plant biomass could lead to increased seed germination and thus a depletion of the size of the seed bank stored in the soil until the following season (Clarke et al. 2000). If true, it is possible that seeds in the Serengeti plains had already germinated during the rainy season that preceded our sampling. However, there is little reason to expect this, as the largest pulse of germination in seasonal savannas typically occurs at the end of the rainy season (Williams et al. 2005), which is when our sampling took place. Nevertheless, studies on the seasonal composition of the soil seed bank within Serengeti currently underway will provide clarification of this issue.

To conclude, we end with a hypothesis related to the variation in plant height and seed production which has been observed along the Serengeti rainfall gradient (McNaughton 1983, 1984, Belsky 1992, Hartsvigen and McNaughton 1995). Grasses on the dry end of the gradient, which are also intensively grazed during the wet season, tend to be prostrate and favor clonal reproduction (the so-called 'lawn grasses'). Grasses on the wet end tend to be tall, caespitose, fire rather than grazing adapted, and obligate seed producers (the so called 'bunch grasses'). The seeds of these functional types also differ: lawn grasses produce unprotected seeds which are often consumed by herbivores (Gardener 1993) while bunch grasses produces protected seeds, such as the awns discussed previously (Garnier and Dajoz 2001). Here we speculate that the tradeoff in plant height and grazing tolerance observed across the Serengeti is also associated with tradeoffs in reproductive life-history variation in which the seeds of species are adapted to herbivory, and have evolved to disperse in dung, or are adapted to fire, and have evolved to persist in the soil seed bank. Since large mammalian grazers directly consume flowers and seeds (McNaughton 1983) and other studies show that ungulates are significant seed dispersers by endozoochory (Gardener 1993, Eycott et al. 2007), it is possible that for grasses adapted to grazing the large mammalian herbivores, rather than the soil, represent a transient 'seed bank' during periods when they are intensively grazing in the southern plains. Studies currently underway in Serengeti may elucidate the role of herbivores as vectors for seed dispersal in the Serengeti ecosystem, a topic which is made more interesting by the long-distance migration of several key grazing species. One evolutionary consequence of the increased proportion of sexual reproduction and successful seed germination at higher rainfall (observed in this study) is a concomitant increase in plant population genetic diversity as rainfall and fire increase across the Serengeti environmental gradient. Future studies can easily refute or support this hypothesis through the study of population genetic markers across sites. The Serengeti may provide an ideal setting to test these and other related hypotheses because of its status as one of the last natural grazing ecosystems remaining on earth (Frank et al. 1998).

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Appendix 1. List and number of grass, sedge and forb species that germinated in soils collected across an environmental gradient in Serengeti National park, Tanzania.

ID	Species (or morphospecies)	Functional type	Longevity	Positive ID	No. of seedlings
1	*Amaranthus graecizans*	forb	annual	yes	5
2	*Chloris pycnothrix*	grass	annual	yes	1
3	*Chloris roxburghiana*	grass	perennial	yes	1
4	*Commelina benghalensis*	forb	perennial	yes	1
5	*Crotalaria deserticola*	forb	perennial	yes	1
6	*Digitaria macroblephara*	grass	perennial	yes	25
7	*Eragrostis cilianensis*	grass	annual	yes	4
8	*Eragrostis racemosa*	grass	perennial	yes	1
9	*Eragrostis tenuifolia*	grass	perennial	yes	1
10	*Euphorbia inaequilatera*	forb	annual	yes	1
11	*Gutenbergia petersii*	forb	perennial	yes	1
12	*Indigofera hochstetteri*	forb	annual	yes	1
13	*Melhania sp.*	forb	perennial	yes	1
14	*Oldenlandia wiedemannii*	forb	perennial	yes	35
15	*Orthosiphon parviflorus*	forb	perennial	yes	3
16	*Panicum atrosanguineum*	grass	annual	yes	1
17	*Portulaca quadrifida*	forb	annual	yes	1
18	*Sida ovata*	forb	perennial	yes	1
19	*Sporobolus pyramidalis*	grass	perennial	yes	4
20	*Sporobolus stapfianus*	grass	perennial	yes	7
21	*Talinum caffrum*	forb	perennial	yes	1
22	*Themeda triandra*	grass	perennial	yes	2
23	*Tragus berteronianus*	grass	annual	yes	1
24	*Tephrosia pumila*	forb	perennial	yes	1
25	unknown monocot	grass	na	no	10
26	unknown dicot	forb	na	no	9
27	unknown Cyperaceae 1	sedge	perennial	no	1
28	unknown Cyperaceae 2	sedge	perennial	no	1
29	unknown Poaceae 1	grass	na	no	1
30	unknown Poaceae 2	grass	na	no	1
31	unknown Poaceae 3	grass	na	no	1
32	unknown Poaceae 4	grass	na	no	1
33	unknown dicot 1	forb	na	no	1
34	unknown dicot 2	forb	na	no	8