

Plant Diversity in the Herbert Hoover Prairie: Long Term Trends 1982-1992

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Introduction

Since 1982 Dr. Christianson has recorded percent relative cover and/or other measures of population growth in the restored prairie. This report focuses on the long term trends in species richness and equitability of alien and native species so that we may better direct management and research on the prairie. This report should be used in conjunction with the report on plant relative cover. Because of the large volume of figures, they do not accompany this report.

Methods

For each year a maximum of five walking transects and ten permanent plots were measured for percent cover, percent relative cover, and percent frequency were calculated. The Shannon-Weaver diversity index as well as the associated formulas for species richness and equitability were calculated using percent relative cover as the species proportions because it standardizes all measurements to equal 100, thereby making all measurements comparable. Although diversity (D) was calculated and will be reported, it does not provide as much information as the separate measures of richness (S) and equitability (J). Not all transects or plots were investigated every year; therefore, I have interpolated points between 1982 and 1992. If the missing value was on the beginning or ending year, interpolation was not possible. It is not known if the plots or transects were randomly chosen. Transects are

of differing lengths. Is also not known the exact time and locations of prescribed burns; only recommendations are given in the Inventory Reports. Each plant species is identified as an alien or native species and the three measures plotted (total, native, and alien) for each transect/plot and globally.

Results

Plots

For the total of plots natives had 18 species, slightly higher than aliens at 15 species. A total richness of 37 is much greater than either natives or aliens which indicates that each species is in a mutually exclusive category. Equitability is relatively stable at 0.55. Alien equitability is declining from 0.35 to 0.15 in 1992. This indicates only 1-2 alien species dominate plots. Native species diversity is relatively stable at 1.6. Aliens fluctuated during the first half of the period then decline to 0.2 in 1992. Total diversity for all plots remains very high at 2.8, though declining slightly to 2.0 in 1992.

Species richness on plot 1 is extremely stable at 14 species. Natives had 9 species and tracks total species richness for the plot. Aliens averaged 5 species on the plot, somewhat lower than the native species and maintained this throughout the study period. Alien equitability is much lower at 0.4 than native equitability and in 1988 sharply declines to 0.1. Native equitability exceeds 0.5 and peaks at 0.8 in 1989 surpassing total equitability for the plot. Total equitability is relatively stable at 0.7. Alien diversity is very low (0.6) to start, but declines further and stabilizes at 0.1. Natives slightly fluctuate about 1.4 and total diversity for the plot slightly declines from 1.8 to 1.5.

In plot 2 all three lines track each other, indicating that perhaps some global

phenomenon, such as weather impacted all species at this plot. There are slightly more native species (6) than alien species (4). Total richness slightly declines to 6 species in 1988, but starts to increase and reaches 11 by 1992. Alien equitability shows a definite decreasing slope for the study period, from 0.45 in 1984 to 0.1 in 1992. Native equitability experienced a moderate dip to 0.3 in 1985 then increase to its former level of 0.5. Total equitability for plot 2 shows the same dip in 1985 and increases to stabilize at 0.45. Total diversity on plot 2 remains stable at 1.6, with a slight decrease to 1.4. Native diversity declined in 1985 to 0.6, but slowly increased to 1.0 in 1992. Aliens peak in 1984 at 0.7 and slowly decline throughout the rest of the study period.

For plot 3, all three categories track each other. Native, alien, and total species richness all decline in varying degrees in 1985. Aliens decline from 7 species to 2 and stabilize for the remainder at that point. Native richness is somewhat higher than alien richness at 10 species and has been increasing since then. Total shows the same general trend. Total equitability remains relatively stable at 0.6. Native species were consistently more equitable at 0.5 with a few small fluctuations. Alien species had deep fluctuations in equitability ending at 0.2, the same as in 1982, in 1992. Alien diversity remains very stable at 0.38 and somewhat declines to 0.15 in 1992. Natives have moderately higher diversity than alien species, but slowly increase from 1987 to the present. Total diversity is moderate at 1.5 and tracks native species.

In plot 4, alien, native, and total species richness steeply declined after 1984. All remained low, but steady at 8, 7, and 2 for total, native, and alien richness. All three track each other which may indicate weather effects. Alien equitability is much lower than native or total species. Alien equitability declines from 0.25 in 1982 to 0 in 1992. Total and native species equitability both increase from 0.6 to 0.75. Alien diversity remains much lower than native diversity. Alien diversity is approximately 0.4, but decreased to nearly 0 in 1989. Native diversity remains stable at 1.5. Total diversity for plot 4 is slightly higher than

natives at 1.7.

Alien richness in plot 5 was slightly higher at 5 for the first half of the time period, but slightly decreased to 3 in 1989. Recently alien richness has increased to 4 in 1992. Natives increased from 3 in 1985 to 10 in 1992. Total richness for plot 5 slightly increased over the time span. Native equitability remained relatively steady at approximately 0.55 with some peaks. Alien equitability had larger fluctuations from 0.15 in 1982 to 0.6 in 1989 to 0.2 in 1992, but was always less than native equitability. Total equitability remains high and stable at 0.6 with one peak of 0.75 in 1989. Native diversity increased slowly from 0.6 in 1985 to 1.1 in 1992 and remained higher than alien diversity. Alien and native diversity intersect at 0.6 in 1985. Alien diversity peaks at 0.7 in 1984 and slowly decline to 0.2 in 1992. Total diversity on plot 5 is stable at 1.4.

In plot 6, all richness track each other tightly which may indicate weather effects. Native richness (5) is consistently higher than aliens (2). Total richness declines slightly from 10 in 1985 to 6 in 1992. Native equitability experienced a huge increase from 0.4 in 1984 to 0.9 in 1988 where it stabilized well above alien equitability. Alien equitability remained very low compared to total and native equitability. But in 1989, alien equitability experienced a huge increase from 0.15 (1985-1989) to 0.9 in 1990. Alien experienced a similarly huge decrease to 0.1 in 1992. Total equitability followed native equitability, increasing from 0.4 to 0.9 in 1988, but then decreased to 0.6 in 1992. Plot 6 diversity is slowly increasing from 0.6 to 1.0 over the study period. Alien diversity remains low and stable at 0.15. Native diversity is slowly increasing throughout from 0.6 to 1.0.

Native and alien species richness are equal at 5 until 1985 when native richness increased and alien richness decreased. Natives dipped below alien richness in 1990, but remained higher than alien richness at 8 in 1992. Total richness remained higher than natives or aliens at 11. Alien equitability was stable at 0.35 for most of the study period until it decreased to 0.05 in 1992. Native equitability in plot 7 was much higher than alien

equitability, moderately fluctuating around 0.6 for most of the time period. In 1992 native equitability decreased to 0.55. Total equitability is slowly declining from 0.7 in 1984 to 0.5 in 1992. Plot 7 diversity decreased from 1.7 and stabilized at 1.3. Native diversity was very stable at 1.0. Natives decreased from 0.6 to 0.1.

Plot 8 richness is low compared to other plots, but stable at 10 and shows a slight increase to 13 in 1990. Native richness starts lower than alien richness at 4, but increases to 5 in 1988, when both are different by one species. This trend continues and both increase to 7 and 6, respectively. Native equitability starts low (0.2 in 1984) and increases to 0.65 in 1989. Native equitability slightly decreases to 0.5 in 1990. Alien equitability declines sharply from 0.65 to 0.32 in 1990. Total equitability for plot 8 fluctuates, but remains at 0.6. Plot 8 diversity fluctuates, but slightly increases from its 1984 value to 1.6. Native diversity somewhat rapidly increases to 1.19 where it levels off. Alien diversity starts the study period higher than native diversity at 1.0, but sharply decreases to 0.57 in 1988.

Plot 9 richness generally declined over the study period from 20 to 11 in 1989. Native richness is stable, but lower than alien richness at 5. Alien richness declined from 10 to 4, where it intersects native richness. Native equitability slowly decreased from 0.4 to 0.3 in 1989. Aliens fluctuate greatly, but show a decreasing trend from 0.62 to 0.56 in 1989. Total equitability decreased from 0.79 to 0.5. Plot 9 diversity sharply declined from a stable 2.0 in 1984 to 1.2 in 1990. Native diversity is much lower than alien diversity, but stable at 0.5. Alien diversity experienced a sharp decrease and became much closer to native diversity in 1990 (0.8).

Plot 10 richness slowly declines from 15 species to 8 species in 1992. Native richness slightly declines from 10 to 6, but remains higher than alien richness. Alien richness also slowly decline, from 5 to 3 species. Alien equitability is much lower than total or native equitability and is very stable at 0.14. However, in 1992, alien richness increased to 0.15. Native equitability generally increased, from 0.5 to 0.59 and had a slight peak of 0.7 in

1990. Total equitability increased from 0.5 to 0.59 over the study period. Plot 10 diversity is stable at 1.4. Native diversity also remains stable at 1.2. Alien diversity is much less than native or total plot diversity at 0.2 where it stays constant.

Transects

Total transect richness was very high and stable at 35 for most of the study period and has recently increased to 37 in 1990. Total alien richness has been on the increase (from 15 to 18), albeit slowly, since 1984. Total native species richness, for the most part remains higher (20 to 16 in 1992) than alien richness, except for their intersection at 13 in 1988. Total native equitability is very poor, 0.22 to 0.18 over the time frame. Total alien equitability increases from 0.23 to 0.52 in 1989, but experiences a sharp decrease to 0.34 in 1990. Total transect equitability stays relatively stable at 0.6, with few fluctuations. Total transect diversity is relatively stable at 0.2 and increases to 2.2 in 1990. Total native diversity (1.4) is much higher than total alien diversity (0.6). Both trends are relatively stable and all three track each other.

Alien richness on Transect 1 is consistently higher than native richness (10 aliens, 8 natives) until 1990 when native richness had 11. Total richness is moderate at 20 species. Total equitability increased to 0.8 in 1988 and then slowly declined to 0.68 in 1992. This trend will probably continue. This equitability is still very high compared to other plots/transects. Native and alien equitability have similar values (0.48) for most of the study period until 1989 when native equitability increased to 0.6 and aliens decreased to 0.3. Transect 1 total diversity remained stable at 1.9 throughout the time period. Native diversity was stable at 1.1 until 1990 when there was a large increase to 1.5. This is shadowed by the increase in alien diversity (1.2) until 1989 when diversity decreased to 0.52 where it stabilized.

Native and alien richness was similar (approximately 10) on transect 2 for at least half of the study period. However, in 1988 alien richness (12) increased slightly over native richness. Recently, alien richness has started to decline and native richness to increase. Transect 2 total richness has been increasing from 18 to 22 since 1988. Transect 2 total equitability increased from 0.62 in 1982 to peak at 0.8 in 1988. It declined to its 1982 level in 1992. Native equitability had a massive increase to 0.69 in 1988; up from its 1982 level of 0.54. Like total equitability, native equitability declined from its 1988 peak to 0.39 in 1992. Alien equitability remained lower than native diversity throughout the study period. Although it had a slight increase to 0.45 in 1985, it has steadily decreased to 0.39 in 1992. Alien diversity remained relatively stable at 0.8 with only a slight increase to 1.0 in 1985. Native diversity was stable at 1.2 until 1988 when it experienced a series of peaks and declines to end the period at 0.7. For most of the period, transect 2 total diversity remained stable at 1.8. It did experience fluctuation after 1988 and ended at 1.6 in 1992.

Transect 3 was not sampled in 1992. Native richness seemed to stabilize at 10 species. Alien richness was stable at 6 until 1988 when it declined to 2, but an upward trend since 1989 is indicated. Total richness for transect 3 has been declining (from 16 to 13) for most of the study period and in 1989 an upward trend is also indicated. The parallel nature of all three lines in a slight or large decline indicates a weather parameter may be involved. Total equitability is almost exclusively native equitability. Native equitability maintains a high level at 0.65 and peaked at 0.7 in 1989. Total equitability maintains a level of 0.69 and peaks at the same level as native equitability. Both experience a decrease to approximately 0.62 in 1990. Alien equitability is much lower than native levels. Aliens may be dominated by 3-4 species on this transect ($J=0.3$) and decrease to 0.1 in 1990 with even fewer species dominating. Native diversity is well above alien diversity and the trend seems to be for the two lines to diverge. Native diversity is relatively stable at 1.5. Alien diversity is very stable at 0.43 until 1989 when it experienced a decrease to 0.1. Transect 3 total diversity

remained fairly stable but slightly decreasing from 2.0 to 1.5.

Transect 4 total richness has been declining from 21 since 1984. Since 1988 it has stabilized at 14 species. Native richness had higher levels (12) than alien richness (6) until 1988 when both converged at 8 species. Total and native equitability are again very similar (0.62) and in 1987 native equitability exceeded total equitability and remained that way for the remainder of the study period. Total equitability maintained a stable level throughout. Alien equitability was low compared to native equitability. Aliens peaked at 0.32 in 1984 and slowly declined to 0.15 by 1992. Transect 4 native diversity was stable at 1.4 throughout the study period and maintained levels higher than alien diversity. Alien diversity peaked at 0.7 in 1984 then declined to stabilize at 0.2 in 1992. Transect 4 total diversity also peaked at 2.1 in 1984, then declined and stabilized at 1.6 for the remainder of the period.

For transect 5, all three lines are parallel and experience similar peaks and valleys, indicating weather effects to all. Native richness maintained higher levels (11) than aliens (6) throughout the study period. Total richness decreased from 20 in 1984 to 13 in 1989. Recently, total richness has been increasing slightly (16). Total equitability decreases for most of the study period, from 0.7 to 0.5 in 1989. Native equitability slightly increases from 0.48 in 1984 to 0.5 in 1989. Both native and total equitability experience a moderate increase to 0.7 in 1990, but both decrease to 0.5 in 1992. Alien equitability decreases from 0.49 to 0.04 in 1992. Transect 5 total diversity declines from 1.96 in 1982 to 1.35 in 1989. It recently experienced fluctuations and a net increase to 1.47. Native diversity was extremely stable at 1.3 until 1989 when it experienced similar fluctuations and a net increase to 1.46. Alien diversity showed a decreasing trend from 0.7 to approximately 0 in 1992.

Discussion/Recommendations

Although there were some fluctuations, total richness on both plots and transects remained greater than 30 species throughout the study period. Transects averaged 17 species and plots, though more dispersed, averaged 15 species. Total transect equitability remained relatively stable at 0.6 (with some fluctuation). Most individual transects were higher than the total.

Total plot equitability, although higher than transect equitability at 0.7, declined for at least half the study period to 0.5. Most plots fluctuated above total equitability.

Total plot diversity was very high, fluctuating around 2.4, but declining to 2.0. Individual plots averaged 1.6 and were more dispersed during the first half of the study period. Total transect diversity was 2.0 which fluctuated somewhat. Individual transects averaged 1.9 with about half above total diversity and half below.

Even though diversity was calculated and explained in this report, they are not as useful as the components of diversity, richness and equitability. From these two measures, it is easier to detect trouble spots as well as desirable increases. There is a high number of species on the prairie, although it seems (since 1982 at least) no management decisions have dramatically increased species number. However, management strategy may yet be effective since it is possible that as alien species were eliminated, native species filled in the gaps, resulting in a stable total richness.

Equitability measures how even distribution is between species. A value of 1.0 indicates total equitability or evenness and a value of 0 indicates total domination by one species. The values for total equitability indicate that species are more equitable than not and the prairie values are probably as even as we can ever hope them to be because of species life history, historical use of the land, and the nature of prairie itself (i.e. naturally heterogenous). There does seem to be a slight downward trend which should be carefully watched in the future.

To understand the prairie dynamics better, I placed each plant in either the native plant

category or alien plant category. We wish to enhance native species and reduce the effect of alien species (which are usually very opportunistic).

Total native species richness averaged 20 species in either plots or transects and remained remarkably stable for the study period. Individual plots averaged 8 species and transects slightly higher with 10 species. Individual transects were minimally dispersed and most tracked each other or had similar peaks and valleys. This indicates that some outside parameter, such as weather, was having a similar effect on all species. If lines had converged or diverged, it would indicate either very localized weather, soil, slope, or management decisions. Because of the limits of the data, it is virtually impossible to discern which one might be the cause.

Total native transect equitability was very stable at 0.5. Individual transects averaged slightly higher than the total at 0.58. Total plot equitability was slightly higher at 0.53. Individual plots were greatly dispersed, indicating domination of 2-4 species on some and almost total evenness on others.

Total native diversity, both on plots and transects, averaged 1.59. Plots experienced a slight decrease. A couple of plots experienced low diversity (0.6), probably due to decreased evenness. Most were moderately dispersed and averaged 1.3. Transects were minimally dispersed and averaged 1.4.

Since plot native species richness has remained constant for most of the time frame, probably prairie management is having only a small effect. Transect native richness experienced a slight decline, but may be regaining species since 1989. Equitability seems stable, but could be improved to 0.6 or higher. The large fluctuations seen in individual plots may be indicative of localized conditions, physical or biological (i.e. competition, predation) or some management strategy, such as fire or herbicide application.

Total alien species richness on plots fluctuated around 14 species. Individual plots averaged 5 or fewer species. Total richness for transects was slightly lower at 13 species

and relatively stable, but starting to increase as of 1989. Individual transects averaged 7 species.

There is a decreasing trend for alien species equitability in plots (0.3 to 0.15). Individual plots are very dispersed with the total probably close to the mean. Total transect equitability remained stable at 0.23. Again, individual transects varied so the mean is approximately 0.3.

Total plot alien diversity is decreasing (0.7 to 0.22) and total transect diversity is stable (0.5). Individual plots are very dispersed; the mean is approximately 0.6. Transects have a tighter dispersion, but the mean is still approximately 0.6.

Alien richness on the whole is lower than native richness, which is a management goal. Alien richness on transects is increasing and we should act now to prevent them from encroaching native richness. The good news is that there only 1-4 alien species dominating any plot or transect; therefore, management should be straightforward. It is probable that equitability will continue to decrease due to physical, biological, and management conditions. The accompanying report on percent relative cover should identify problem alien species as well as increasing native prairie forbs and grasses.

I have the same data concerns for this report that I have for the report on species cover. In addition, I have assumed that each plot or transect was measured with the same intensity which may or may not be the case. However, I believe that these measures of diversity will be an advantage in planning management strategy for the future of the prairie. Also, let me cite one implicit problem with diversity calculations. Although richness, equitability, or diversity remains stable, it does not indicate that species are static, i.e. there may be 30 species (or 10 species per plot/transect), but they are not the same ones from year to year. Since I am unfamiliar with many plant life histories, it is conceivable that reproductive strategy of the plant (annual, perennial, etc) has an effect on diversity calculations. This may explain why some trends were stable through much of the study

period.

In closing, let me restate a few predominate themes with respect to prairie diversity:

1. Current management since 1982 has not had much effect on increasing either total species richness or equitability. Except for the reason stated in that section.

2. Native species have higher values of richness and equitability than alien species.

3. Alien species have decreasing trends in richness and equitability. Therefore, only a few alien species are dominating sites and can be dealt with effectively.

