1. **Is there a hypothesis (or more than one) underlying this research? If so restate it (or them) in your own words. What predictions would this/these specific hypothesis make?**

Example 1.

The hypothesis of this article is that there is an inverse relationship with plant diversity and the amount of soil eroded in a particular plot of land over time. If this is true, then an increase in plant diversity in a given plot should decrease the amount of soil erosion.

A second hypothesis is that an increase in plant diversity reduces soil erosion via the compensation effect. If this is true, then the extinction of a particular species should not have a large impact on biomass or soil erosion in a site if there is a high degree of diversity.

Example 2.

Yes. The hypothesis is that biodiversity impacts soil erosion, and more specifically that a loss of biodiversity would result in increased soil losses through erosion. In other words, loss of species, such as plants, would lead to the removal and subsequent transportation of soil to other locations. The hypothesis is primarily based in the knowledge of two things: environments with fewer species are unable to compensate when other species become extinct due to fluctuating environmental conditions, and species loss has been shown to have a negative effect on plant production and root mass. Using that information, a logical prediction is that with fewer plants and species covering the soil, it has less protection and thus a higher possibility of erosion.

Example 3.

The hypothesis underlying this research is that plant species diversity is negatively related to soil loss from erosion. It is predicted that the greater the number of plant species in a plot, the less soil loss it will experience. Plots with a greater biodiversity will have a greater biomass, and will have a higher capacity to replace species that have gone extinct due to changing environmental conditions.

2. **This paper is concerned with soil losses through erosion. Why is erosion of particular concern in the context of this study and beyond? What are some of the negative effects of soil losses for ecosystems and people? (find one recent reference dealing with effects of soil losses at the ecosystem level)**

Example 1.

The researchers note that soil erosion plays an important role in human safety. The erosion of embankments causes the neighboring communities to become more susceptible to flooding and storm tides (Berendse et al.). This is especially important for coastal societies as sea embankments of offshore islands provide a safeguard against the infiltration of salt water as well as devastation associated with tidal surges and cyclone storms (Islam 2000). The implications of soil erosion can go beyond human safety; soil quality and structure can also be affected. Water erosion can cause the removal of small particles and entire layers of soil/organic matter which weakens the soils structure. This can in turn affect the capacity of the soil to retain water, making it more susceptible to drought (Ritter 2015). Soil erosion can permanently alter ecosystems, when soil erodes, the nutrient rich topsoil is typically the first to be removed, which makes it very difficult for plants and other organisms to survive. Pimental and Kounang (1998) describe the erosional process as reducing the productivity of the ecosystem. As a result, there is a decrease in the diversity of plants, animals and microbes- thereby altering the structure and stability.

Example 2.

Soil erosion is of a concern in this study because it can lead to drastic changes in an ecosystem. In the case where soil erosion is very rapid, it can lead to the loss of habitat for a number of plant and animal species. In addition, it has been shown that rapid soil erosion leads to a general decrease in soil and water quality (Legoupil et *al*. 2015). A decrease in soil quality (i.e. from rill erosion) can lead to a decrease in animal and plant diversity, and a decrease in water quality can have negative impacts on aquatic ecosystems (i.e. by changing the pH and the sediment levels in a river or a lake). Moreover, soil erosion can lead to considerable losses in agricultural lands and pastures and has the potential to have devastative effects on large cities also. This can furthermore lead to economic losses. Many cities, in the Netherlands, for example, are located below sea level and are protected by dikes and costal dunes. If soil erosion acts too quickly, it could lead an increase in the number of deadly floods in the area. Ecosystems in the area could also be heavily affected by these floods.

3. In Figure 2, what is the sample size on which the average estimates of soil erosion for each treatment are based? Explain your answer (and where the information can be found in the paper).

Example 1.

3. The sample size on which the average estimates of soil erosion for each treatment are based on is 98 (n=98). Figure 2 looks at plant species diversity and how it effects soil loss through erosion. They did this by taking the mean ±SE values of annual soil loss for each plot of different species diversities (1,2,4,8). The materials and methods section stated 98 plots total were created, 24 single-species, 28 2-species plots, 38 4-species plots and 8 8-species plot.

Example 2.

There were 24 single-species plots, 28 2-species plots, 38 4-species plots and 8 8-species plots. These individual treatment sample sizes cumulate to a total of 98 plots. There were 24 single-species plots as there were 3 plots per species. The 28 2-species plots contain all the possible 2 species combination once. All 38 4-species plot combinations were formed at random with each species occurring in half of the plots and without having two plots with the same combination. Although this information is not provided in the figure description, it can be found in the *Materials and Methods* section of the paper the second page, second column, and in the last paragraph.

4. Table 1 provides the statistical analysis for the results presented in Figure 2. Interpret in your own words the important results from this analysis. Explain how this Table helps determine the lowest species richness that ensures minimum soil erosion losses (and what is this critical species richness?).

Example 1.

Figure 2 in the paper provides a visual interpretation of the average soil erosion level and its uncertainty in relation to the degree of plant species diversity. In order to be able to well interpret the data, it is best to look at Table 1 which provides an overview of the mean differences in soil erosion between two distinct diversity treatments. All mean differences in soil erosion are accompanied by a standard error and a P-value, which indicates the degree of significance of the mean difference in soil erosion between two treatments. A P-value smaller than 0.05 means that we are over 95% confident that the mean difference in soil erosion between the two treatments is significant. Similarly, when we come across P-values that are greater than 0.05, we conclude that the differences in soil erosion between the two plots are not statistically significant and so we cannot conclude that there is a significant difference in soil loss between the two plots. Hence, the P-values allow us to determine the lowest species richness that ensures minimum soil erosion losses.

Based on the results provided in Figure 2, we notice that soil erosion is strikingly high in 1-species plots. Indeed, when looking at the results in Table 1, we notice that all differences in soil losses between 1-species plots and all the other treatments are significant. Moreover, we notice from Figure 2 and Table 1 that soil erosion is higher in 2-species plots than 4 and 8 species plots, but not as high as soil erosion in the 1-species plot. However, the difference in soil erosion between a 2-species plot and an 8-species plot is not significant, nor is the difference between a 4-species plot and an 8-species plot. However, there is a significant difference between soil erosion in a 2-species plot and in a 4-species plot. Since there is a significant difference between the 2-species plot and the 4-species plot, but that there is no significant difference between the 4-species plot and the 8-species plot, we can conclude that the critical species richness is 4 in a plot. In other words, 4 species is the lowest richness that ensures minimum soil erosion losses.

5. Some of the plant species tested provided better resistance to soil erosion than others. Rank the species according to their capacity to limit soil erosion (and justify with reference to the specific information on this point in the paper). Do the top species share any common traits?

Example 1.

Question 5

Table 1: Species rank according to their capacity to limit soil erosion (Highest meaning least erosion)

Highest Limit	*Festuca rubra (Fr)*
	Agrostis capillaris (Ac)
↓	*Holcus lanatus (Hl)*
	Anthoxanthum odoratum (Ao) or
	Leucanthemum vulgare (Lv)
	Centaurea jacea (Cj)
	Rumex acetosa (Ra)
Lowest Limit	*Plantago lanceolata (Pl)*

This information can be found in both the body of the results/discussion section (paragraph 1) or in figure 3, which demonstrates "The effects of plant species in single-species stands on soil loss through erosion," (Berendse et al.). The top species: Fr, Ac, Hl, and Ao are all monocot grasses. Monocot's tend to have very fibrous roots which will cover a greater area underground in comparison to the tap roots of dicot plants (lower half of list), which explains the differences in capacity to reduce soil erosion.

Example 2.

5. If we class the information of Figure 3 we can rank the species from the most effective at reducing soil erosion to the one that causes the most in the following manor: *Festuca rubra, Agrostis capillaris, Holcus lanatus, Anthoxanthum odoratum, leucanthemum vulgare, Centaurea jacea, Rumex acetosa and finally Plantago lanceolata* causing the most soil erosion. The first two species grow to similar sizes (between 150mm and 700mm), they both have spreading rhizomes, roots with myccorhizas and are both polycarpic perennials (Grime and al. 1989).

6. **Why were the authors interested in *Plantago* and the effect of its presence or absence? Interpret in your own words the results presented in Table 2 (i.e. explain the endpoints presented and what the P values provided mean? Explain the ecological significance of the results). What is the main take home message of this Table 2?**

Example 1.

6) During the winter of 2011/2012 many of the *Plantago* plants died. This provided the researchers the opportunity to study the buffering capacity of multi-species (2- and 4-species) plots. The buffering capacity of a system relates to the ability of remaining species to compensate for the loss of a species. The researchers investigated this relationship in more detail by analyzing the Relative Yields (in terms of biomass) of plots in which *Plantago* had been planted (and then went extinct) versus plots that were never subject to *Plantago*. They compared the yields in the year prior to (2011) and the year following (2012) *Plantago* extinction. They then compared the relative yield between +*Plantago* and –*Plantago* plots in order to determine if a buffering capacity was present. Table 2 outlines their results.

Relative yields between 2011 and 2012 increased in plots where *Plantago* was planted (and then went extinct) compared to those plots that were devoid of *Plantago* (it had never been planted). This trend was statistically significant in all species, except *Holcus lanatus*. Statistical significance was determined by the p values. P values test the null hypothesis. A small p value (less than 0.05) provides strong support for your hypothesis, indicating the data trend has a very small chance of occurring randomly (implies a correlation). All p values, except the *Holcus lanatus* comparision resulted in p values less than 0.05.

An increase in relative yield provides an index for species growth and indicates that the other species (with the exception of *Holcus lanatus)* present in the 2- and 4- multispecies plots provided a buffer, compensating for the loss of *Plantago.* From an ecological perspective, the ability of a system to compensate for the loss of diversity by expanding the distribution of other species can indicate the resilience or strength of the system. A fragile system would show less resilience (a lower buffering capacity) while a stable system would show a high buffering capacity. Diversity itself provides a buffer- the loss of one species does not necessarily indicate a decline of the ecosystem. There are also variances in the ability of individual species to act as buffers (as was observed with *Holcus lanatus*)

Excellent!

Example 2.

6. The authors were interested in *Plantago* because it had the highest soil loss due to erosion as a single species plot, and realized when comparing multi-species plots, *Plantago* also increased soil loss with the 2-species, but not significantly in with 4-species plot. This finding lead to the authors analyzing for the buffering capacity when there is a higher species diversity. The authors discovered in the presence of it but went extinct, the 2- and 4-species plots increased in the other species (except *Holcus*) compared with the plots where *Plantago* was not planted. Table 2 is demonstrating the change in relative yields (from 2011 to 2012) of each plant when in the presence (but went extinct) and complete absence of *Plantago.* The p values indicate whether there is a significant difference between the relative yields with *Plantago* when it was present and absent. The table shows $p<0.05$ for all plant species except *Holcus*. The ecological significance is that for almost all the species, the extinction of *Plantago* resulted in an increase of yield compared to the monocultures (except in *Holcus*). This result can apply to the buffering capacity, that after an extinction in a higher diversity community, the community can compensate for that extinction.

7. **Explain what the dependent variable is in Fig. 5? What is meant by the histograms separating "net diversity, selection and complementarity"?**

Example 1.

The dependent variable shown in Figure 5 is the effects of diversity on biomass production in g/m^2. Diversities effect on biomass production can be partitioned in two ways. The selection effect where the most productive species in a high-diversity community are selected for and the complimentary effect where diverse communities maximize resource utilization through resource partitioning and positive plant interactions (Loreau and Hector 2001). The combined effect of these two effects is equal to the net diversity. The histogram separates these three aspects allowing us to see and compare their individual and cumulative effects on biomass production.

Example 2.

The dependent variable in figure 5 is the diversity effect on biomass production and it is measured as g/m^2. It is the measurement of how much the level of diversity within a plot (m^2) effects the how much biomass is produced (g). The histogram demonstrates how much net diversity, selection and complementary effects affects the diversity effect on biomass production in order to determine the driving mechanisms for biomass production. The Cardinale et al. (2007) research paper defined the following three effect. They stated that the selection effect is the probability of sampling a dominant, high biomass species within a polyculture. They also stated that the complementary effect is the probability that the more diverse plots utilizes a larger concentration of the available resources compared to less diverse plots. Finally, the net effect was defined as the proportional difference between the mean value of biomass in the most diverse polyculture and the mean value of all species grown in monoculture (Cardinale et al., 2007). Overall, based on figure 5, it seems that the positive effect of diversity on biomass production was mainly explained by selection effects. However, in 2012, both the selection and complimentary effects explained the positive effect of diversity on biomass production (Berendse et al.).

8. The authors suggest in the Abstract that "the main mechanism explaining the strong effects of species diversity on soil erosion is the compensation or insurance effect…" Later on they compare this to financial investment strategies. Explain in your own words whether this analogy is appropriate.

Example 1.

8. The insurance effect is the ability of diverse plant communities to supply species to take over the functions of species that went extinct as a result of inconsistent environmental conditions (Berendse et al, 2015). This is analogous with financial investment strategies in that diverse investment portfolios have the ability to spread financial risks and thus assure high-average long-term performance (Berendse et al, 2015). Therefore, by having a diverse investment portfolio (plant community), you have an increased probability that if an investment (plant species) does not succeed in the event of fluctuating markets (environmental conditions), another investment in your diverse portfolio (plant community) will takeover the functions and success of the previous one. Consequently, by having a diverse plant community or investment portfolio, you have a higher probability succeeding due to the "insurance" that is provided by one successful species or investment taking the place of an 'extinct' one.

Example 2.

Compensation in terms of biodiversity is the ability of diverse communities to provide species that can take over the functions of extinct species due to unstable environments. Therefore, one can infer that the more diverse a community is, the more stable/the higher its buffering capacity in the face of fluctuations.

A main financial investment strategy is to diversify investments. This is the strategic decision to place money in a variety of different investments to ensure that if one asset loses money, there are others to compensate for the loss. Therefore, when comparing these two definitions, the financial analogy is appropriate because in the same way a diverse financial portfolio decreases risk of losing money in a fluctuating environment, a diverse community will decrease the risk of losing species and/or ecosystem functions.

9. **Consider the 20 tips for interpreting scientific claims from your reading of Sutherland et al. (2013) (Nature 503: 335-337). Where and how might Berendse et al. paper fall short? Can you suggest another approach for testing the hypothesis (ses) and further validating their findings?**

Example 1.

Berendse *et al.* (2015) conducted a fairly well designed study with a few key flaws in methodology and their discussion of results. Studies are best conducted with equally large sample sizes amongst treatment groups. Berendse *et al.* (2015) had variation in the number of plots comparing soil erosion in with 1, 2, 4 and 8 species present. Furthermore, a small sample sizes was present in the 8 species condition, thereby increasing the standard deviation and consequently, the ability to determine a difference between the 4 and 8 species condition. This short-coming falls under the heading "bigger is usually better for sample sizes" in Sutherland *et al.* (2013). To improve upon this, sample sizes for each condition should be equally large. I would suggest reproducing the study with ~30 plots of land designated for each diversity condition.

Although a laboratory setting is important to control for confounding variables, Berendse *et al.* (2015) extrapolates beyond their study by making claims that plant diversity is essential to minimize soil erosion, which can promote safety in estuarine areas around the world and maintain soil fertility in pastures. Unfortunately, this "extrapolation beyond the data", as outlined by Sutherland *et al.* (2013) is not appropriate, and can act as a disservice to the readership of the article. It is important to make *suggestions* based on your findings, but not imply that they are in any way definitive. This also falls under the heading "study relevance limits generalizations", outlined by Sutherland *et al.* (2013). This study is an example of pseudoreplication. Even though multiple replicates of plots of land were randomized along the slope, they were only measured in a single simulated dike. In order to be more confident in the conclusions made, plots of land should be examined in numerous dikes, as slopes may vary, among other factors. Even though it is not necessarily a flaw in the study design, it would be interesting to conduct a similar experiment in nature to examine the interaction of plant diversity with numerous ecosystem factors that may attenuate or augment soil erosion.

Example 2.

The researchers used several plots (98) to test out the different diversity groups which seems to be a large number of plots, but more is always better in scientific research especially since they tested the 4 species plots 38 times and the 8 species plots only 8 times. This inequality in sample size leads to an extrapolation of the data to make them comparable.

Also, if they would have done the same experiment on different types of soil in different locations we could eliminate any bias that could be due to the soil types. In this experiment the plots were grown on fertile soil, but the substrate was extremely nutrient-poor. This would have affected certain growth patterns for some of the plants leading to falsified data.

Again we could consider the amount of plant species tested to be a bias as the researches only used 4 different grass species and 4 dicot species. This is understandable because it is easier to manage a smaller sample size and it is more economically feasible, but if they had considered increasing the species types, the plots that were intended to demonstrate diversity would be considered a little more diverse and closer to what we could expect to find in nature.

Something they seem have failed to accomplish is the inclusion of a control group (a plot with no plants to compare the rest to). This would have solidified the results found showing the effects 1 plant had vs no plants and as you increase plant diversity the loss of soil decreases even less.