The impact of agriculture on biodiversity

Context

Agriculture is used all over the world to supply the human population with natural food resources. Farmers use a variety of pesticides, herbicides and tools, such as ploughs, tractors or combine harvesters. These all shape the land to the farmer's will in order to ensure the earth is in the right condition for optimal crop growth and so able provide us with enough food. This, however, will hugely impact the surrounding biodiversity and this in turn has long term harmful effects on the environment.

CXT: The issue is outlined in very general terms. The environmental issue here is loss of diversity and the impact that agriculture has. This problem is well documented, and diversity of hedgerows and other borders between fields has been well studied. We can therefore expect a more thorough treatment than this.

The purpose of this investigation is to see if agriculture has an effect on biodiversity in a particular location in Switzerland where I live.

Research question:
To what extent does agriculture affect species composition and diversity?

CXT: The question is broad and should be focused more tightly. For example, "To what is extent is species diversity affected by distance from a ploughed field in Mettmenstetten, Switzerland".

Hypothesis:
Agricultural activities, such as crop growing and grazing, will reduce the biodiversity levels. The untouched wildlife will be more biodiverse.

The location I have chosen is just outside Mettmenstetten in central Switzerland. I will investigate the biodiversity along 5 parallel transects, each 25–30 metres long, starting in a field and moving into natural woodland, as shown below

CXT: The connection between the research question and the issue is implicit. Even though it might seem obvious, it should have been explained.

I divided each transect into five quadrat locations: one in the farmland, two in the grazing land and two more in the wildlife by the stream. I will then use the Simpson's Diversity Index to calculate the levels of biodiversity in each quadrat. This will allow me to see a change in biodiversity as I move further away from the farmland.

PLA: This last statement is an attempt at a justification of the sampling strategy, but more is needed. Why only one quadrat in the farm area and two each in the other two? Also, the student will have five quadrats per area, one in each transect, and this number will allow them to calculate means and standard deviations for each of the locations, thus strengthening the analysis. This should have been stated as one of the reasons for having five locations.

Planning

Materials:

- Tape measure
- Camera
- Kestrel 3000 (pocket weather meter)
- Gridded quadrat (0.5 m x 0.5 m)

Method for data collection:

1. Measure out a straight line from the farmland to the wildlife. (The length will depend on the distance between the farmland and the wildlife.)
2. Identify different areas in this transect (e.g. crops, grazing land and wildlife).
3. Locate the five different quadrat placements along the transect.
4. Place quadrat in the first location.
5. Count the number of individuals for each species of plant in the quadrat.
6. Take a picture of each species and label them with a letter.
7. Follow steps 4–6 for each planned quadrat location.
8. Repeat steps 1–7 for another four transects parallel to each other with the quadrat locations at the same distances along the transect.

PLA: The method provides plenty of data. One transect would be insufficient but five parallel transects will definitely provide enough data for a robust analysis.

Variables:

- Independent variable: The location of the quadrat along the transect.
- Dependent variable: The numbers of each species in the quadrat.
- Controlled variable: Each quadrat location. This is to ensure that each quadrat analyses the same type of land, so comparing the quadrats from the farmland will allow us to compare it objectively.

PLA: There is nothing in the way of risk assessment here, although there are risks involved. For example, if working alone, there is the danger of a fall and not having anyone close by. Also, the student should indicate if there are poisonous or stinging plants (such as nettles) or dangerous fauna (such as snakes) in the area. The ethical considerations might concern disturbing wildlife.

Results

Raw data:

<u>Individuals per species per quadrat per transect</u>

	Transect #1 (Number of individuals per species)	Transect #2 (Number of individuals per species)	Transect #3 (Number of individuals per species)	Transect #4 (Number of individuals per species)	Transect #5 (Number of individuals per species)
Quadrat #1	Crop: 13	Crop: 10	Crop: 11	Crop: 10	Crop: 11
Quadrat #2	a: 8b: 1d: 3	a: 6b: 4r: 3	a: 8e: 3	a: 9b’: 4b: 1	a: 7b: 10
Quadrat #3	g: 1d: 4a: 15b: 3	a: 9r: 5	a: 10x: 3 y: 2	a: 6b: 3y: 4	a: 9y: 7x: 4
Quadrat #4	i: 8a: 7l: 3b: 1m: 1p: 1	m: 27s: 2 a: 9	t: 4z: 1u: 1l: 5 a: 23	w: 6 U: 3l: 6 m: 22c’: 12	c’: 11e’: 13f’: 1g’: 1 l: 5
Quadrat #5	m: 18a: 8 q: 3	l: 9t: 6u: 2 v: 13w: 7m: 6	a’: 4t: 7 l: 3	l: 3d’: 1v: 9e’: 1t: 17m : 8	m: 3l: 11t: 10v: 5

Processed data:

Method:

To calculate the level of biodiversity I will use Simpson's Diversity Index represented by this formula:

$D = N(N-1) \div \Sigma n(n-1)$

Where N is the total number of individuals and n is the number of individuals per species.

Example:

Transect #4/Quadrat #4

[50(50 − 49)] ÷ [6(6 − 1) + 3(3 − 1) + 6(6 − 1) + 22(22 − 1) + 12(−1)] = 2450 ÷ 660 = 3.71

What will the number mean?

The number we will end up with will represent how diverse each quadrat is: the higher the number, the more diverse, and the lower the number, the less diverse.

Simpson's Diversity Index per quadrat

COM: The title of this table is not clear.

	Transect #1	Transect #2	Transect #3	Transect #4	Transect #5
Quadrat #1	1.00	1.00	1.00	1.00	1.00
Quadrat #2	2.12	3.25	1.77	1.45	2.06
Quadrat #3	2.19	1.97	2.14	3.25	3.01
Quadrat #4	4.03	1.81	2.08	3.53	3.25
Quadrat #5	2.20	5.69	2.45	3.65	3.44

Now I will calculate the averages in order to get a holistic view of the change in biodiversity levels.

Method:

To calculate the averages of each quadrat I will add the Simpson's Diversity Index of all the quadrats of one location then divide it by five (the number of quadrats).

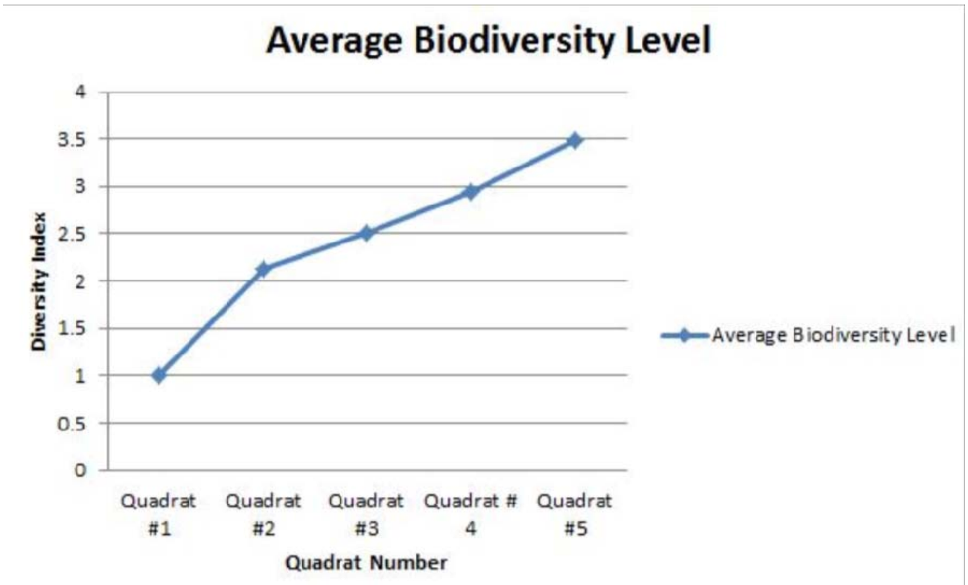
Example:

Quadrat #2: (2.12 + 3.25 + 1.77 + 1.45 + 2.06) ÷ 5 = 2.13

Average Simpson's Diversity Index per quadrat

	Average Simpson's Diversity Index
Quadrat #1	1.00
Quadrat #2	2.13
Quadrat #3	2.51
Quadrat #4	2.94
Quadrat #5	3.48

Change in biodiversity along the quadrats



As we can see in this graph, there is an increase in biodiversity as we move away from the farmland (Quadrat #1) and move closer to the wildlife (Quadrat #5).

RAC: With five diversity indices to average, a standard deviation could have been calculated and error bars placed on the graph.

RAC: The *x* axis in this graph does not suggest a line graph. If the distance along the transect had been measured instead, this would have been appropriate for a line graph.

COM: The caption gives context allowing a clear interpretation of the graph.

Since I collected the data on different days, I had to take into account other variables that could have affected my results. The five transects were taken on three different days.
Day 1= Transect #1
Day 2= Transect #2 and #3
Day 3= Transect #4 and #5

Day 1:
- Relative humidity: 58.7%
- Air temperature: 11.7°
- Average wind speed: 0.9 mph
- Dewpoint: 5.6°

Day 2:
- Relative humidity: 43.5%
- Air temperature: 28.1°
- Average wind speed: 1.1 mph
- Dewpoint: 12.5°

Day 3:
- Relative humidity: 58.8%
- Air temperature: 22.5°
- Average wind speed: 1.8 mph
- Dewpoint: 12°

Discussion

Analysis of each transect:
Transect #1: For the first transect, the data showed the expected progression at the beginning: Quadrat #1 being lower than the others and Quadrat #2 and #3 having similar values. However, the last two quadrats, from the wildlife, show very different values: Quadrat #4 is significantly higher than the Quadrat #5. This could be down to shade coverage, in other words, Quadrat #4 might get more sunlight than Quadrat #5.

Transect #2: The second transect has the most anomalies out of the five. Quadrat #2 is the second highest, above Quadrat #4, which it should not be, and Quadrat #5 is much higher than Quadrat #4, which is from the same area. This could be down to human error: I might not have counted the species properly or well.

Transect #3: The third transect shows a gradual increase in the diversity index but the second quadrat's index is closer to those of the last two quadrats. This could be because some plants may have spread out towards the farmland more in this transect than in other ones.

Transect #4: The penultimate transect does show an increase in biodiversity levels along the transect; however, there is a large jump from Quadrat #2 to Quadrat #3. It went from 1.45 to 3.25 but they should have similar levels since they are from the same land type.

Transect #5: The last transect shows the best example of biodiversity increasing as agriculture decreases. Quadrat #2 and #3 have similar levels but are still less than those of Quadrat #4 and #5, which are also very close.

Conclusion:

As we can see from the processed data, there is an increase in biodiversity levels as we move further away from agriculture. The raw data may not have clearly shown this trend, nor the indices for each quadrat, but averaged out this pattern is seen very clearly. This means my hypothesis was correct: agriculture does indeed reduce biodiversity levels. It is hard to place the blame of low biodiversity levels on anything other than agriculture since the processed data clearly shows an increase in biodiversity with distance from land heavily affected by human activity.

RAC: The conclusion is valid and supported by the data.

What does this mean?

How does agriculture affect biodiversity?

We now know that agriculture does affect biodiversity, but how does it reduce diversity? The first impact that farming has on surrounding biodiversity is from the usage of pesticides and herbicides. When spraying these chemicals on their crops, the smallest breeze of wind would spray the surrounding ecosystems, hindering or even preventing species' growth. Farmers also use fertilizers to enrich the soil with nutrients. This will, however, pollute the water, potentially harming species that absorb the water or use it in photosynthesis. On a larger scale, changing the landscape drastically for monoculture farming also affects other biodiversity hugely. Cutting down forests or clearing the land to make way for crops destroys habitats for many animal species who, without a suitable habitat, will not be able to live in that area.

DEV: The student discusses pesticide and fertilizer use and their impacts on biodiversity but these are not especially relevant to the present study. The distances away from the ploughed field would seem to be too small to offer much protection from pesticides and fertilizer runoff. The effect here has probably more to do with direct loss of habitat, as suggested at the end of the paragraph.

Why is it relevant?

Some people do not think that biodiversity is important, and argue that farmers should be free to produce large amounts of food for the population. However, biodiversity has been, and always will be, at the core of human survival. It supplies us with a variety of food, which is essential for life in the long term. It is important because all the organisms are interdependent, so if one species suffers, so will others. Without biodiversity we might not be able to get new types of food in the future.

DEV: There is little in the way of an evaluation of the conclusion although the student does describe how it is related to the environmental issue at hand.

Evaluation:

Possible improvements for this experiment could be made in my method. Since it is my first time doing some practical ecology I doubt my method was the best or the most accurate. This means that I may not have spotted all the different species and may have classified two species as one. Also, I could have improved the method by repeating the experiment in another area even further away from the field to see if the biodiversity in my "wildlife" area was really as large as you would expect in a completely remote area.

DEV: Some strengths and weaknesses are described. Good suggestion for improvement.

Nevertheless, my data and my calculations were accurate, after a few attempts, and it did prove my hypothesis right. Other areas of research could be to do with investigating the presence of the various species in the various transects. In this research, one could look at why they would appear in these different locations by taking measurements of other factors, such as soil pH or light intensity.

DEV: The student could actually try to determine what species are there and why.

DEV: The modifications are realistic and would be useful in order to get a better idea of what is happening in this ecosystem.

Application:

This research question was, in my eyes, relevant since sustainable food production is a worldwide issue but also because agriculture is hugely subsidized here in Switzerland so crops and fields are seen everywhere. Farmers might be encouraged to produce more and more food without being aware of the effects on biodiversity. After research, I not only found out that it was a worldwide problem but also that biodiversity could be harmed by the physical manipulation of the land. This research suggests that farmers should be made aware of the impact of the way they use the land and should be encouraged not only to grow crops for today, but to conserve biodiversity for the future.

APP: The student should suggest how to achieve this. There are techniques that can increase biodiversity in managed fields, such as strips of forest between fields that are interconnected and provide access to larger untouched tracts of land. The problem here is that the student has focused on pesticides and agriculture as a problem but has not considered how to maximize diversity within farming systems.

Action can be taken by the farmers using these chemicals on their crops. Some farmers are now attempting not to use chemicals on their crops to protect the biodiversity growing around the fields. For other people, giving money to a charity or a fund to help scientists develop chemical-free, or at least less harmful, methods of pest control is a solution. Farmers could also increase the distance between the field and the wildlife to ensure that the chemicals they spray do not affect the plants. These measures might be unpopular because farmers might make less food and less money, and other people might not want to give their money to charity. People will need to be made aware of the importance of these steps.

APP: The student could have looked at raising the value of agricultural products through the use of organic certification. Also integrated pest management could be mentioned.

Word count: 2003

COM: The report is easy to follow, makes good use of terminology and is concise.