Dear Editors,

We thank Ben Woodcock and an anonymous Reviewer 2 for their comments. We have addressed their concerns point-by-point concerns (see below), and have attempted to clarify points that seemed confusing. Our main changes to the manuscript are:

* Clarifying the study design, specifically the number of individual fields locations
* Explaining how we estimated the field edge location and type
* Provided background information on Alberta agriculture (relative abundances of crop types, commonly-used crop rotations)
* Minor clerical errors (table numbers and abbreviations) throughout the text

Thank you for your consideration, and we look forward to hearing from you.

Sincerely,

Samuel V. J. Robinson

Lan H. Nguyen

Paul Galpern

Reviewer #1 (Ben Woodcock)

*This paper uses precision yield mapping to look at spatial patterns in yield for key economic crops in Canada and relates this to the occurrence of semi-natural boundary features that may be expected to support beneficial insects promoting increased yield. Its very well written, its concise and will make a great contribution to AGEE. I think they need to emphasize where possible the boundary shelterbed effect where possible as this movers it away from being a purely agronomic paper - but they do a good job of this in general. I look forward to a revision. Ben Woodcock*

Many thanks! We hope it will be of interest to other readers as well.

*Highlights - seem fine*

*Abstract: well written. No problems here. Would have like line numbers, but seeing as I don't actually have criticisms that a bit of a moot point.*

In that case, we have left the Abstract as-is.

*Introduction*

*L8 - It would be good to have a few examples of this - i.e. not just agrochemical, but mechanization, changing cultivation practices, new breeds etc - some general list will do - its more to give the context of it being a multifactorial thing, and something that is changing constantly.*

That is correct; the dimensions of agricultural changes have indeed been multi-factorial. We have added “both in terms of area and intensity, such as enhanced tillage or the addition of synthetic fertilizers and pesticides” within the line.

*L27-28: - see Pywell, R.B., et al (2015) Wildlife-Friendly Farming Increases Crop Yield: Evidence for Ecological Intensification. Proceedings of the Royal Society, Series B, 282, 20151740. Have a look at this (probably worth citing) as it also uses precision yield mapping to link field boundary habitat manipulation to increased / maintenance of yields. Note this is interesting as it actually accounts for the area of field taken out of production to create semi-natural habitats for beneficial insects had been accounted for.*

This is a very relevant paper that we missed, and is one of only a few papers we’ve been able to find that uses precision yield to ask agroecological questions. We have added it to the list of citations in L37-38, as well as L45 and L56.

*L29: Also compaction tends to be greater at the field edges as well as the application of agrochemical can be achieved in a less successful way.*

We agree. We have changed the sentence to “Low yields near may occur near the edge of the field because of patchy seed emergence, poor microclimate, shading from trees, soil compaction, or patchy herbicide application leading to higher weed competition (Figure 1, Scenario 2).”

*L36: Really good point - probably true also for predators, although their distributions can be more complex with generalist predators overwintering external to the crop more likely to show spill over effects, while parasitoids breeding within the crop may not be characterised by such an effect - I think John Holland using SADIE looked at this years ago.*

Holland’s work looks interesting (especially <https://doi.org/10.1046/j.1461-0248.2001.00269.x>), but unfortunately we didn’t monitor any predators or prey directly.

*L53-57: found this a bit abrupt - maybe start with a sentence along the lines of Alberta has over X km^2 of agricultural land with a net worth of XX, focusing on crops YYYY. There has been a widespread adoption of agri-tech, including precisions ag allowing new insights in to within field spatial patterns of yield (or something like that).*

We added “Within the Canadian prairies, the province of Alberta has roughly 58300 km2 of cultivated agriculture (excluding pasture), of which the majority is spring wheat, canola, barley, and peas (36.6%, 30.8%, 17.1%, and 7.0% in 2020, respectively; Agriculture and Agri-Food Canada 2022). Roughly 85% of growers in western Canada have precision yield monitoring capability Steel 2017), but these data are seldom used to answer large-scale agroecological questions.”

*Overall really well written introduction - no major criticisms.*

*Methods*

*L60: so to be clear what you are saying is actually 5 farmers - each with c. 9 fields and data from this over 7 years. This is slightly less impressive that the introduction suggests and I would be inclined to maybe specify this more clearly). You are emphasising this is one of the first very large scale studies (and its good) but if its still 5 farms from Alberta (I don't know how big Alberta is, but I am guessing its got a shit load of farms so this cant be representative of everyone). This doesn't detract from the study, but give it some context. One way to do this would be to say the total area of fields (max in one year) as well as the total number of fields overall in any single year.*

This was an oversight on our part; we’ve clarified the second sentence of that paragraph: “Farmers were solicited for yield data through local agronomists, and we received data from 5 growers for 87 individual fields across 7 years (2014-2020), for a total of 298 field-years of data”. Unfortunately, it’s difficult to find growers who are willing to share yield data, but when you do they usually have large numbers of records; hence the clusters of data shown in Figure S1.

*L 79: great you explain how data was cleaned - maybe say why its so variable, i.e. turning circles, people driving down roads with the sensor on, variable speeds etc. Did you have fixed procedures for dealing with this - maybe discus in an appendix.*

We have an example of this at the end of Appendix B, where we show the steps in the filtering pipeline. We’ve also changed the sentences at L76 to read “Precision yield data can be highly variable and is prone to extreme outliers, especially when ground speeds are low, during turning on headlands, or when the combine is changing speed (Arslan & Colvin 2002, Griffin et al. 2007, Whelan & Taylor 2013). Recording data between different fields can also cause extreme “jumps" in location, and we verified that all the data points were located within the given field boundaries.

*L75: Really? Across all 298 field years and 5 growers they all sued exactly the same seed rate? Seems unlikely. I am not sure it matters if they didn't as seed rate is normally used to compensate for local limiting factors (pests for example) and varietal needs. It shouldnt really mess with your assessment. I am guessing variety wasn't the same, and it's a similar issue. Ultimately your looking for (and show) general patterns so consistency in the face of this underlying variability is whats interesting. IF you get the trends on real system (as you have done) for me its so much more meaningful as its not a controlled university farm where everything is perfect. That said I guess with 5 farms and the same agronomist same seed rate is not impossible.*

This is a mistake on our part: seeding and applications were constant *within-*field, not between field (most of the data also contained data on seeding and fertilizer application, and none of the growers reported using variable-rate seeding or application). We changed the sentence to: “...seeding and application rates were constant within fields, so we did not consider these inputs in our analysis.” The reviewer is also correct that between-field differences (soil types, seeding rates, rotation history, crop variety) cause variation in our data, but that our models show consistent general patterns even when this variation is not “controlled for” in a systematic way.

*L96: So Maybe state the pixel resolution of Google so you can justify identifying a 5 m wide strip along the boundary*

The areas we sampled typically used imagery from SPOT, which has a resolution of 1.5 m. We changed the sentence to “Field boundaries were digitized using buffers from the yield data locations, then manually checked using satellite imagery from Google Earth (CNES/Airbus imagery, 1.5 m resolution) and classified land cover data (Agriculture and Agri-Food Canada 2022).”

*L89: So in the UK and Europe we have a lot of agri-environment schemes that establish field boundary habitats like flower rich field margins. By the looks of it that is not really a thing in Alberta - is that the case, i.e. all of these are present by chance, as opposed to be actice design to support beneficial insects etc.*

That is correct. Unfortunately, there are no analogous agri-environment schemes in Alberta. However, there is interest from some growers in reducing pesticide usage, so hopefully this work will help to (eventually) change this!

*L89-102: So how was this classification done? Was this just done by eye based on knowledge of the farms (I guess with 5 farms this is possible) or was this done using a clustering algorhythm on pixel spectrums to which you allocated habitat units. I think this needs to be clear as to how this was done, as if its got a high potential for variability that trying to allocate effects to a particular habitat would be hard.*

We categorized these boundaries by eye, assisted by classified land cover data. In the case of the Vermilion data, we were able to visit the fields and confirm that our classifications were correct. The AAFC classified land cover is provided at a fairly coarse resolution (30 m), so we used this mainly as confirmation in the case of ambiguous edges. The paragraph now reads: “Field boundaries were digitized using buffers from the yield data locations, then manually checked using satellite imagery from Google Earth and classified land cover data. Edge location and type were usually clearly visible from the Google Earth imagery (CNES/Airbus imagery, 1.5 m resolution), but if they were ambiguous we used classified Agriculture and Agri-Food Canada (2022, 30 m resolution) data to confirm the land cover types surrounding each field. The location of a given crop edge is flexible and can change yearly, depending on planting and emergence conditions. For example, ephemeral wetlands are flooded during some years, but consist mainly of grasses during dry years, and grass boundaries can change if fields are used for as haying or pasture during crop rotation. This makes consistent classification of field boundaries difficult, but we used the following general categories for field boundaries...”

*L104: Not sure if you covered this by why those crops - needs some discussion in methods of the fact that they are (I am guessing )dominant crops, used in rotations etc - just give some context ideally with some numbers. You may want to say other minority crops are present but not considered here. Also general background info - typical rotation etc .*

At L65, we changed the sentences to read: “85% of the crop types where either wheat, canola, or peas, three of the most common crops in rotation in Alberta (Agriculture and Agri-Food Canada 2022). Crop rotations in Alberta usually consist of a combination of wheat - canola - pulses - barley, with other crops being included dependent on the regional growing conditions (e.g. sunflowers, flax, corn).”

*L118 - fair enough.*

*L125-127: It would be amazing if this wasn't present.*

*Your stats sounds well thought though. I am not particularly familiar with GAMS, but from your description this seems a valid approach. One question is the extent to which its possible to account for farm level random effects, as presumably these may affect the extent of boundary effects (for example if one manager uses controlled traffic to minimise compaction which may mitigate edge effects on one farm compared to another).*

Our statistical methods account for this only indirectly, as any between-field or between-manager differences would show up within each field-level smoother. In the meta-smoothing process, we used a random field-year effect to control for differences in intercepts, but this used the same smoother effect for all fields (L146).

*Results*

*Looks good - no real criticisms.*

*L166 - need to put in table number*

Inserted: “Table 1”

*L169 - just checking - this is metric tonnes right? You use T, however t is the normal symbol for metric tones. If you are using non-metric ton I suggest you don't (I am sure you are not).*

That’s correct; we used metric tonnes (1000 kg). We’ve changed “T/ha” to “t/ha” throughout the manuscript as well as in the figure axes.

*Discussion*

*SO one thing that important in the discussion I think is to really drive home the shelterbelts aspect of this. The fact yield is lower at field edges is itself not something that is new - certainly farmers are aware of this effect. The shelterbelt aspect and its associated mechanisms also gives this paper relevance for AGEE as a journal (otherwise the paper slips into being very agronomic and probably not that suited to this journal). I think this is a great paper - looking forward to a revision.*

Not sure what else could be done to enhance this. Paul, any ideas?

*One thought that's just occurred is whether you specify if these farms are conventional agriculture with agrochemical (including pesticide use). Given you have Canola I am guessing it is, but worth stating if you don't.*

Yes, all the fields we used were conventional (i.e. pesticides were used) fields. We suspect that there is a large amount of variation within “conventional” fields, as some of the growers we talked to reported using essentially no pesticides (at least during some years) but we didn’t systematically account for this. We changed the sentence at L75 to “Fields were all conventional (standard herbicide and fungicide application), and seeding and application rates were constant within fields, so we did not consider these inputs in our analysis.”.

Reviewer #3

*The current MS of 'Livin' on the edge: Precision yield data shows evidence of ecosystem services from field boundaries (AgEE31114) given me a very interesting and impressive work on the ecosystem services of field boundaries on crop yield at large-scale evidence in 252 field years of yield monitor data from three common crops of wheat, canola, and peas across Alberta, Canada. Glad to see fields work at large spatial scales and long duration of successive 7 years, measures of common crop yield to analyze the ecosystem services of field boundaries. This 7 year replicated effort on common crops of wheat, canola, and peas provides interesting and impressive example data to show that yield tended to increase with distance from the boundary until about 50 m, shelterbelts caused an intermediate increase in wheat, but not canola or pea yields, Canola was more sensitive to edge effects than wheat or peas.*

*This topic is rare, very impressive, and it will certainly influence others to follow. The meaning of the current study contributes to enriching the theory of ecosystem services of semi-natural land of field boundaries on crop yield. In practice, it will be significant to establish the application mode of landscape ecosystem services on farmland consolidation, lay the necessary basic data for further enhancing the ecosystem services function of the large-scale agricultural landscape.*

*Recommendation*

*Acceptable after minor revision*

*Here are some specific comments/questions to improve the clarity of the manuscript.*

*Line 75: Seeding and application rates were constant across fields. How about the Variety or the strain? Are all fields the same or not? Does this be a control variable?*

Reviewer 1 also noted this. This is a mistake on our part: seeding and applications were constant *within-*field, not between field. We changed the sentence to: “...seeding and application rates were constant within fields, so we did not consider these inputs in our analysis.” Reviewer 2 is also correct that between-field differences (soil types, seeding rates, rotation history, crop variety) cause variation in our data, but our models show consistent general patterns even when this variation is not accounted for in a systematic way. We did not collect information on variety, but this could be done for future work.

*Line 79-88, for the filtering procedure to clean the data, it should be in sequential logic, therefore, the number should be 1st, 2nd, 3rd,… 6th, similar sorting numbers below can refer to processing.*

We listed the procedure in the sequential order that it occurred, but what the reviewer wants us to do here is unclear. Do they want us to change the list indices from {1. 2. 3.} to {1st 2nd 3rd}?

*Line 166-167, Table ??, row 6? As there are only Table 1 in the MS, however, Table 1 row 6 is Wetland, and (rows 1-5, cols 3+5)? this makes me confused.*

That is correct; we changed this to “Table 1”.

*Figure1, How about adding a title for the Y axis?*

We had originally included “Effect” on the Y-axis, but removed it as it seemed unnecessary. If the Editor thinks that this would be useful, we can add this, but otherwise we prefer to leave the figure as-is.