Reviewer 1 – Helen Briassoulis

GENERAL COMMENTS

The paper adopts the obvious and established thesis that differences in the underlying theory and assumptions of regional and larger scale LUC models (in fact, of any model) produce different projections of land use change (LUC) patterns, under alternative future scenarios, with different implications for pertinent land use decision making and planning. It presents a comparison of two large scale pan-European integrated land use models, a constrained optimising economic-equilibrium model and a stochastic agent-based model (ABM), which the authors consider as being representative of two different modeling paradigms, under the same set of alternative future scenarios.

This comparison is argued to be necessary to help model users learn about the possibilities and limitations of each modeling paradigm (and particular model) and use them intelligently. In its present form, the main issues the paper should address are: (a) the need for a structured and articulate conceptual/theoretical framework and an associated robust methodology for model comparison to warrant the validity of the results, strengthen their analysis and support their informed, comprehensive interpretation, (b) a clear and transparent presentation (definition, explanation) and use of certain terms and (c) issues concerning the use and users of the models. Selected important issues are detailed below that the authors might want to consider in revising the paper with the aim to improve and enhance its contribution to LUC modeling and discourse as well as to make it less esoteric and idiosyncratic and more accessible to a wider audience than it is presently the case.

We appreciate the detailed comments and suggestions, many thanks.

WRITING STYLE. Although the writing style of the paper is acceptable, it might be written more clearly, coherently and solidly. Several comments below indicate problematic sentences and expressions.

Thank you for identifying sections that need improvement; these suggestions will be followed in the revision and we will also carefully revise the manuscript with this comment in mind.

TERMINOLOGY. The authors use, but do not explicitly define, the term ‘model paradigm’ to refer to the set of underlying model theory, assumptions and structure. Given its central role in the paper, ‘model paradigm’ should be defined and explained. It seems, though, that the literature uses the term ‘modeling paradigm’ more often. This term is encountered twice in this paper only (page 3 and page 8). In my opinion, the term ‘paradigm’ should be used with caution given its strong meaning (Kuhn 1962) and should be justified based on the literature. In the present case, both models considered (optimizing and ABM), in one sense, belong to the same (reductionist) paradigm.

We agree that ‘modelling paradigm’ is more widely used and appropriate, and will adopt this term in the revision. We will also note the particular meaning of the term paradigm in the modelling literature.

Based on the definition of the modeling paradigm, the paper should justify and explain why the two models compared belong to different modeling paradigms. Part of the text in Discussion and Conclusions (that concerns the models as representative of different paradigms) should be placed in the ‘Methods’ section.

Good points, and we will do as suggested in the revision, introducing the models and their paradigms earlier and in a more structured way (as also suggested in the other reviews).

Explain the terms: Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways, spatial and aggregate land use change, aggregate comparison, spatial comparison.

We will explain these terms at first usage.

CONCEPTUAL/THEORETICAL FRAMEWORK FOR THE COMPARISON OF MODELS. It is absolutely necessary to describe the framework/schema used for the comparison of the models; i.e. define the main factors influencing the performance and output of a model (e.g. spatial and temporal frame of reference and resolution, model specification – definition and operationalization of variables, relationships among them, missing variables –, solution techniques, data), exogenous factors and conditions, contingencies (e.g. during data collection). This conceptual framework should serve as a systematic template for the comparison (what is being compared) and constitute the basis for (a) designing the methodology and (b) presenting and interpreting the results.

We will describe and use this framework as suggested, adding a model comparison table to present these factors (many of which are the same or similar in both models), a model structure diagram, and additional text as necessary. We will also use the framework to structure the methods and results.

COMPARISON METHODOLOGY. This should draw on the conceptual/theoretical framework and used as a basis for the design of the comparison of the models so that the factors that are not taken into account in the present comparison are held constant (controlled).

Yes, we agree, and will present the methodology in this way in the revision.

DESCRIPTION OF MODELS AND SCENARIOS. In the present form of the paper, the models and scenarios are not completely and systematically described; e.g. aim, land classes, land users, ecosystem services, other variables, etc. This makes understanding of the results and the discussion difficult.

We are sympathetic to this point, and will include more detail in the text, new table and diagram mentioned above. We will also add new scenario descriptions. We must also note that it would be impossible to fully describe two such (previously published) models in each paper that uses them, not least because we would have to pay substantial page fees to reproduce text already available in open access publications (notably the linked article of Brown et al. 2019 in the same journal).

The similarities and differences between the two models must be clearly shown (in a Table?) – variables considered, data, etc.

We agree this would be helpful and will add a table as suggested.

The limitations of ABMs should be mentioned; the emphasis on behavioural (and indirectly cultural) issues is not enough. Institutional and political issues play an important role as they are the quintessence of LUC decisions.

We're not entirely sure what limitations are referred to here, but the absence of institutional and political behaviours is neither a universal feature of ABMs nor unique to them, and indeed they are included in this ABM but not used here. We propose to add text to the discussion to highlight their importance.

It should be made clear that this modeling exercise concerns food security, rural land use and associated environmental concerns. Other model aims are possible that may not be well represented by the particular models compared and/or may not yield the same projections of LUC patterns.

A good point, we will revise as suggested.

The instrumental assumptions (e.g. homogeneity, uniformity and similarity of land classes, land users, decision makers, etc. across Europe) of the comparison exercise should be made clear and taken into account in the discussion and interpretation of the results.

Yes, we agree this is important and will clarify and account for these assumptions (incidentally they do not include homogeneity and uniformity of land classes, as we will also clarify in the revision).

The issue of aggregation (spatial, temporal definitional) of model inputs and outputs is not discussed.

We will add explanation and discussion of these issues, in the new model overview table and the discussion section.

PRESENTATION OF RESULTS. At present, it is descriptive and technical and does not account for the instrumental assumptions of the comparison.

The interpretation and explanation of the results should be made within the limitations of the models (not simply noted at the end); in particular, their aggregate and reductionist nature, the very coarse spatial and temporal scale, the use of a grid that may not coincide with ecological and socio-political boundaries and conditions over the study area, the jurisdictions within decisions are made, MAUP issues, the effects of the unstructured clusters (IMPRESSIONS), instrumental assumptions, etc.

We will acknowledge these issues (and the other limitations) more prominently, and present and interpret the results using the framework identified above (focusing on the differences between the models, both in terms of capabilities and limitations).

It should be underlined (and explained) that the study findings may not be applicable to lower scales.

We will revise as suggested.

MODEL USE AND USERS. The paper should dedicate some space (Introduction, Conclusions) to the discussion of the users and uses of these models. Who are, or might be, the current and prospective users of these European scale aggregate models? Are they interested in these large scales and very long time horizons, especially under conditions of serious uncertainty? Do they have authority to make land use decisions and guide LUC at this scale and over long time horizons? Are they really interested in providing ecosystem services? Which services in particular (use the MEA classification). Have these models been used in real world decision making and by whom? At some point, the authors state: “Optimising models have the advantage of representing idealised conditions”. Who decides what these ideal conditions are and for whom?

We will summarise these issues in the revision. The models are primarily intended and used for exploratory modelling in academic research, with the IAP in particular having also been used for capacity building (with stakeholders and students). While neither model is used directly for decision-support, there are some differences in their purposes that can inform the comparison.

SPECIFIC COMMENTS TITLE Two terms in the current title “How model paradigms affect our representation of future land-use change” may have to be modified. Model paradigms or modeling paradigms? Representation? The paper discusses estimates of future LUC, not representation which is something different and, in any event, it is reflected in the pre-defined land use classes and patterns used in the models.

Yes these are good points. We will use ‘modelling paradigms’ instead and change ‘representation’, with a new title of ‘How modelling paradigms affect simulated future land-use change’

“optimisation may be appropriate in scenarios that allow for coherent political and economic control of land systems, but not in scenarios where economic and other scenario conditions prevent the

normal functioning of price signals and responses." This is correct: model results are valid if model assumptions hold… but caution is needed here. Reality may change and render model assumptions invalid…

Yes we entirely agree and will reword to clarify our meaning.

What is the 'normal' functioning of price signals?

This was poorly phrased. We will use 'equilibrium' instead.

"structured comparisons of parallel, transparent but paradigmatically distinct models are an important method for better understanding the potential scope and uncertainties of future land use change" It is not clear that the present comparison is structured, or, at least, its presentation is not adequate and clear (see comments on conceptual framework and methodology). Parallel? Explain. Caution: understanding model results is not tantamount to understanding reality… Who wants to understand the potential scope and uncertainties of future LUC? (the issue of users mentioned above).

The structure of the comparison will be clarified in the revision as described above, also explaining in detail the respects in which the models are 'parallel'. We agree that model results are distinct from reality, and will deal with their interpretation in the new text on model uses/users.

"The optimisation model, in contrast, maintains food supply through intensification of agricultural production in the most profitable areas, sometimes at the expense of active management in large, contiguous parts of Europe."

This is unclear… active management? large, contiguous parts of Europe?

We will rephrase for clarity.

INTRODUCTION
"Computational models of the land system are essential in supporting efforts to limit climate change and reverse biodiversity loss (Harrison et al. 2018; Rogelj et al. 2018)"
These are not the only reasons for using these models. I suggest to broaden this sentence to encompass environmental and socio-economic change.

We will revise as suggested.

"The need to radically alter human land use to avert social-ecological breakdowns".
This is unclear. Is it supposed to describe the aim of planned and/or unplanned land use change? If yes, the statement should be obviously modified.
Moreover, LUC modeling is used to analyse the impacts of past and current LUC, not only to project LUC under future scenarios.

This sentence refers simply to the unsustainable impacts of current land use. We will clarify this and mention other model uses in an additional sentence in the revision.

"Because other methods are not available to generate alternative findings"
Of course, there are other methods, both quantitative and qualitative (e.g. Delphi dating back to the 1970s), as well as mixed methods.

Yes this was poorly phrased; we will clarify that modelling provides one approach to exploring possible future changes that, while useful, is not the only approach possible.

"This could be particularly misleading in social systems such as those underpinning human land use, where no universal laws or predictable patterns exist to guide model development, and modellers

must instead choose between a range of contested theoretical foundations, practical designs and evaluation strategies (Brown et al. 2016; Meyfroidt et al. 45 2018; Verburg et al. 2019)."
This is a confusing sentence, especially the first part. It mixes up several notions and issues. It should be simplified and clarified.
Comment: predictable patterns are rare in nature also as complexity theory underlines and experience reveals.

We will split and revise this sentence. We agree that predictability is rare in natural systems, but regard it as a particularly important issue in human/social systems where human behaviour introduces extra challenges beyond complexity.

"In this complex context, the proper analysis and interpretation of model outputs is just as important as proper model design"
Irrespective of context, the good modeling practice starts from the theory (however instrumental this may be) about the problem/situation modeled, that guides the development of the methodology, model design (model specification) and implementation (analysis), and, of course, the interpretation of model results.

We agree, and will emphasise that the current study aims to improve interpretation.

"Steps such as standardised model descriptions, open access to model code, robust calibration and evaluation, benchmarking, uncertainty and sensitivity analyses are all necessary to ensure that model results are used appropriately (Baldos and Hertel 2013; Sohl and Claggett 2013)."
What is the meaning of the word 'used' here? Model users are not model builders and vice versa. Clarify and modify. Moreover, the real test of a model's usefulness is model verification, not simply validation, however difficult to carry out (see, O' Sullivan).

We will change 'used' to 'interpreted'. Model uses certainly extend beyond the uses model builders put them to, and accurate interpretation underpins them all. We also agree that model verification is crucial and involves more than the steps we mention here, and will amend the sentence to reflect this.

"However, while comparisons of model outputs have been made (Lawrence et al. 2016; Prestele et al. 2016; Alexander et al. 2017), their ability to link particular outputs to particular methodological choices has been limited."
This is absolutely reasonable because the factors affecting model performance and results are interdependent, important factors may be missing and/or intangible, data are unavailable or inadequate, contingencies modify system characteristics and relationships, etc.

There are certainly limits to linking model design to model outputs, but we would suggest that these limits have not yet been reached, partly because model comparisons have been relatively few and relatively limited in their scope, for instance not including detailed comparisons of quite distinct but parallel models (in the sense of sharing application coverage, resolution, contextual data etc.) of the kind that we make here. We will more clearly present this as the motivation for the study in the revision, and carefully define the basis of the comparison in terms of model similarities and differences.

"Conceptual research suggests that large areas of system behaviour remain under-explored as a result (Brown et al. 2016; Huber et al. 2018; Meyfroidt et al. 2018), with the likely consequence that established findings have implicit biases and blind spots."
Yes, this is very true and should problematize efforts at comparing different models.

We will extend this point to acknowledge that comparisons can illuminate some but not all such biases and blind spots.

METHODS
This section should start with a description of the conceptual framework of the comparison.

We will revise as suggested.

IMPRESSIONS IAP. "Within this cross-sectoral modelling chain, rural land use is allocated within each 30-year timeslice according to a constrained optimisation algorithm that maintains equilibrium between the supply and demand for food and (as a secondary objective) timber, through iterating agricultural commodity prices (cereals, oilseeds, vegetable protein, milk, meat etc.) to promote agricultural expansion or contraction (Audsley et al. 2015)."
So, IMPRESSIONS' aim is to optimized food supply? This should be mentioned from the outset.

We will clarify from the outset that the model aims to satisfy food demand (taking account of net imports), and does so optimally subject to constraints imposed by biophysical and socio-economic conditions.

"similar production conditions (based on soil and agroclimate),"
Production conditions include many more factors, such as economic, fiscal, technological, institutional, etc.

Yes, we were referring more specifically to biophysical conditions here, and will amend as such ('similar biophysical conditions (based on soil and agroclimate)').

"profitability thresholds used to determine which land use and management intensity is allocated to each cluster."
There are other factors (planning, policy, cultural…) that affect land use allocation and management intensity.
Moreover, caution is needed to interpret these findings given the spatio-temporal and conceptual (land use classes) aggregation of large-scale models. The 'managers' are not real people… so, what is the meaning of profitability? Profitable to whom?

We will describe land allocation in both models more fully in the revision, and in particular the role of these and other additional factors (many of which affect allocation). Profitability is used here to mean the simulated profit available for a particular level of production in a particular cell, and indeed does not refer to profit to real land managers, which we will emphasise.

"Land use proportions within each 10' x 10' grid cell represent the aggregations of the solutions for each (up to 40) associated cluster."
What is the meaning of so aggregate results?

We will clarify the derivation and interpretation of the aggregated results. The aggregation is the result of spatial weighting of the optimised land use solution for each cluster containing the grid cell in question. The clustering recognises that different biophysical conditions (soil and agroclimate) differentially influence the suitability, productivity and profitability of different crops and different agricultural systems (arable, dairy etc.), leading to heterogeneity in agricultural land use within a grid cell.

"Modelled land manager agents compete for land on the basis of their abilities to produce a range of ecosystem services that society is assumed to require…"
How do you know that this is the aim of the land decision makers, especially at such coarse level of aggregation? I.e. to produce ecosystem services?
Psychological (emotional, political and institutional factors) regulate their relationships.
Power relations are also important determinants of land managers behaviour (however coarse their representation is).

This text describes processes in the model, as distinct from reality – the competition for land on the basis of ecosystem service provision is a modelling assumption analogous to the allocation of land uses on the basis of profitability in the IAP. We will describe the inclusion/exclusion of particular factors in more detail in the new model description table and also address missing factors and processes in the text.

"Land use productivities"
These should be defined taking into account the very high level of aggregation of the models.
One question is: given the high level of aggregation, how much sense do they make as goals of land managers and decision makers?
Another question is: which factors influence these very aggregate productivities?

We will rephrase for clarity (this refers to the yields / ecosystem service provision levels of the different simulated land use systems (crops, grassland, forestry etc.) under the agronomic scenario conditions.

"In CRAFTY-EU, these services are crops, meat, timber, carbon sequestration, recreation and landscape diversity. We therefore also compare ecosystem service production levels, which account for exact forms of management simulated in each cell"
The ecosystem services should be first defined in terms of the 4 main groups defined in MEA (2005) and then shown how they are operationalized.
Moreover, the sentence should be edited (crops, etc. are not services…).

We will revise as suggested.

"In this case, these functions are linear and equivalent for all services, meaning that the benefit of production of each service increases equally per unit of unmet demand."
A very restrictive assumption indeed…

This is deliberately restrictive, yes. It allows us to compare an equal weighting of service provision (in CRAFTY) with a focus on food production (in the IAP), and avoids a more complex but equally arbitrary weighting that would make results harder to interpret.

"Importantly for this study, CRAFTY-EU is parameterised on the basis of the IAP, taking IAP outputs as exogenous conditions and replacing only the land allocation component to provide alternative land use projections under identical driving conditions."
This is unclear.
Comparison of two models when one takes input from then other?

We will clarify, and describe the inputs and outputs of each model, and their relationships to one another, in the new table and diagram described above.

"For ecosystem services with economic values (meat, crops and timber), agents in CRAFTY therefore make production choices consistent with this basic level of economic rationality."
First question: who are these agents at such a high level of aggregation and what is the meaning of economic rationality in this case?
Second question: what about non-economic benefits?

We will revise this sentence for clarity. As described in the text, modelled agents do not correspond to real-world actors, but are used to capture elements of their behaviour within localised land systems. Non-economic benefits are also included in CRAFTY.

A note regarding NUTS2: They do not represent a uniform, EU-wide spatial division system and they differ significantly among countries.

We agree. There is no ideal resolution at which to make this comparison, but we chose NUTS2 as an established system to complement the results we present at cell and European scales.

Subsection: 3.1. Aggregate comparison
The presentation of the results is descriptive and technical.
The discussion is rather loose and tiresome with reference being made to the scenarios that have not been adequately described. The presentation of the results is rather boring and may not make a lot of sense to the reader.

We will add a description of the scenarios in the revision. We will also edit the text to ensure clarity and interest where we can.

One question here is: What is being interpreted? Model land use classes or real world land use? Also, the processes that produce LUC differ between countries and for each land use class, among other factors.

Model land use classes are being interpreted. We will clarify this prominently in describing the conceptual framework of the exercise. We agree that processes differ and will add discussion of this important point.

"because of the gradual decision-making of agents "
What does gradual decision making mean?

This refers to agents' decisions having some probability of being delayed across multiple timesteps (representing years), rather than taking immediate effect. We will explain this in the text.

"Conversely, CRAFTY responds most strongly to scenarios in which agricultural productivity decreases because its design emphasises changes in capitals that support production (climatic or socio-economic), as is particularly clear in SSP3."
The meaning is unclear.

To be rephrased.

Subsection: 3.2. Spatial comparison
This is not spatial but 'geographical' comparison because it refers to geographic areas in Europe.
The term 'spatial' is a general term and NOT identical to 'geographical'.

We will label this as a geographical comparison.

"In SSP4, the IAP projects substantially more very extensive and forest management than CRAFTY's more intensive results,"
extensive WHAT?
more intensive WHAT?

To be revised as 'extensive agricultural management' and 'intensive agricultural management'.

Subsection 3.3. Convergence experiment
The convergence/divergence of the results of different models owes to a host of factors, several of which were not examined here.
So, I wonder what is the meaning of carrying out this experiment?

We will clarify the purpose of this experiment in the text: it is indeed intended to identify these factors in this particular case. The observed divergence in this scenario is partly due to conditions differing in the models (because food prices rise higher in the IAP and production levels fall lower in CRAFTY). By controlling these differences, we are able to identify additional factors that cause

divergence – and in this case they reflect basic modelling assumptions, the effects of which would otherwise remain obscure.

4. Discussion and conclusions
I would have preferred a separate and proper Conclusions section.
The discussion of the results might be more meaningful to be combined and integrated with the presentation of results (previous section).

We will produce a stand-alone Conclusions section but prefer to keep results and discussion separate as we find it important to establish technical findings before interpreting them.

"Understanding the contributions of different modelling paradigms to land use projections is important for two main reasons. The first reason is that almost all large- to global-scale land system models share a single paradigm (economic optimisation of land uses). The second reason is that different paradigms are known to produce very different outcomes, but for reasons that remain unclear"
The question regarding those 'unclear reasons' is: what were the reasons hypothesized in this study? Otherwise, how was the comparison of model results carried out?

In this case, we hypothesise that the decision making / allocation paradigm is one dominant source of uncertainty in land use modelling, as opposed to uncertainty in crop yields, biophysical conditions etc. Hence we keep the latter factors common between the models and explore how different factors that influence decision making (profitability; demand; socio-economic conditions) affect the models. We will set this hypothesis out in the revision as described above and use it to structure the methods and results section.

"The focused comparison presented here is therefore intended to identify and explain key differences between models representing major, distinct paradigms to project land system dynamics on the basis of complex and integrated processes founded on a small number of key, transparent assumptions".
What are these key, transparent assumptions? Were these key differences explained? The issue of the conceptual/theoretical framework underpinning the comparison is critical here.

We will elucidate the underlying framework in the revision with particular emphasis on these key assumptions that differ between the models.

"An overarching distinction is apparent between the basic assumptions underlying the models. The IAP is an example of a 'topdown' model that simulates change at the system-level – in this case through an assumption of constrained economic optimisation - while CRAFTY is an example of a 'bottom-up' model that simulates change at the level of individual decisionmakers – in this case through an assumption of behavioural choices made at the level of local land systems (Brown et al. 2016).
This basic difference affects the rate, extent and pattern of simulated land use change. The consequences of top-down and bottom-up perspectives is apparent in the main forms of land use change as the models respond to scenario conditions…. "
I am not sure if any adequate explanation of the implications of different model assumptions is offered in the above excerpt.

Explanation of implications is in the text that follows the quoted sentences. We believe the additional structured comparison of the models in the revision will help to explain the assumptions and their implications.

"This difference is also apparent in our convergence experiment, where increased imports in the IAP lead to reduced agricultural area,"

But, doesn't it happen the other way around? Land is abandoned, then production drops and necessitates increase in imports… Do I miss something?

We will clarify this. The convergence experiment involved pre-emptively increasing imports in the IAP to mimic the lower European production levels generated by CRAFTY.

"One consequence of simulating demand and supply of a range of ecosystem services is that the relative economic support available for food production becomes a key determinant of the balance of different land uses"
What is the theoretical explanation offered?
The case may be that, because agriculture is the most extensive land use and occupies a larger number of cells, it leads to the results obtained. In other words, the results may owe to technicalities and not to real world market and social behaviour and responses.

An interesting point, and one we will address in the revision. The result is certainly due to technicalities, in the sense that the model is sensitive to the relative valuation because that is the basis for simulated land competition, but reflects the reality that land use, as primarily economically-driven, is subject to the relative economic support for food production and for other ecosystem service provision.

"In both models, the simulation of the European land system as distinct from the rest of the world requires implicit assumptions about conditions in other regions and their relationships to Europe. As conceptual alternatives, therefore, neither of these necessarily capture the true dynamics of food prices and production levels, which remains a major challenge for land system modelling (Pedde et al. 2019; Müller et al. 2020)."
This is a correct remark. The exogenous factors have been incompletely modeled. Their inclusion may have further differentiated the results of the two models.

Yes, we agree. We will add a sentence to emphasise that different approaches to modelling exogenous factors would likely introduce even greater differences.

"Cell level decisions"
Do cells decide? ( ). Which theory concerns cells?

We will rephrase as 'simulated decisions affecting individual cells'

"Indeed, their primary strength may be their ability to use theory as a guide to processes and conditions that empirical data and optimising models do not cover (Gostoli and Silverman 2020). "
This is partly true re ABMs. The question is: which theory do they use?

We will add a comment emphasising the importance of the choice of theory.

"The greatest value of these two approaches may therefore lie in their ability to provide alternatives; a value that is realised only in the (currently rare) cases when model assumptions are clearly communicated and when analogous models such as those used here are available for comparison (Polhill and Gotts 2009; Müller et al. 2014; Rosa et al. 2014)."
This sentence is unclear.

We will rephrase this sentence.

THE LAST PARAGRAPH of the paper is a rather unstructured list of open issues and future research directions that does not flow directly from the preceding analysis and does not offer much direction centered around a concrete model aim…

To be replaced with a Conclusion section.

The question is: why is it necessary to keep these modeling paradigms when alternatives are already tested and more meaningful? E.g. multi-paradigm modeling.

We are not entirely sure in what sense 'multi-paradigm modeling' is being used here, but the models and paradigms represented here have also been tested and found to be meaningful in a number of ways. In any case, to the extent that different paradigms are present within 'multi-paradigm modeling', our basic premise of understanding how underlying assumptions influence model outputs is still relevant.

It might be useful to discuss in the conclusions, issues of model users, use and usefulness that might further justify pertinent future research

Yes, we find this a good suggestion and will add some discussion.

TECHNICAL COMMENTS
Table headings should be placed at the top of the Table.
P. 23
The heading of the Table is long … it should be much shorter!
ecosystem service supply … SERVICES

Changes to be made.