

2nd Review Phase of IPBES Deliverable 3c) Fast-track methodological assessment on scenarios and models Chapter 4 ‘Impacts’

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 Yann Clough
 Franziska Schrodt

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
1	4	General				I was very surprised to learn that the document makes no reference to Dynamic Energy Budget theory. I understood that one of the lead authors wrote a section on this theory that passed internal review of draft 1, but that this section has been deleted, in this second draft version on the basis of the argument that it would only be of relevance to a very small number of theoreticians. Some 500 papers document this theory and its applications, see the bibliography	Sebastiaan A.L.M. Kooijman	Given space constraints the reference to a given theory cannot be extended. However, we have now included a reference to DEB theory in the new

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						<p>since its creation in in the early 80's http:// www.bio.vu.nl/thb/deb/DEB_papers.pdf This theory has been used to predict details of geographic distributions of species, see e.g. Kearney, M. Metabolic theory, life history and the distribution of a terrestrial ectotherm. <i>Functional Ecology</i>, 2012, 26, 167-179 Although being process-based, and this second draft mentions that such models require more knowledge to apply, it is the only mechanism-based model that is available for which the parameters has been fitted to 400 species http://www.bio.vu.nl/thb/deb/deblab/add_my_pet/add_my_pet.html with very good results in terms of goodness of fit. All data, parameters and code are freely available and ready to be used.</p> <p>The bibliography and the data-base that is available does not support's view and I must admit that I find it a shame that personal opinions of a single individual have such a dramatic effect on a report that is supposed to express the opinion of the full community of experts.</p>		version of the chapter.
2	4	General				In chapter 4, the point about needing model inter-comparisons is a good one. Perhaps elevate to a clearer recommendation.	Jason Link	This is now one of the key recommendations from the chapter.
3	4	General				Table 5.2 (on page 522) presents a summary of major ecosystem service models and modelling approaches which is quite useful. Could something similar be done for the models in Section 4? I recognize that there are far more models than can be fitted in a table of any reasonable size, but perhaps exemplars of each type, scale, approach, or complexity could be included to pull together in one place a summary of what is out there for the reader.	Derek Tittensor	After discussion with Chapter 5, we now have incorporated new table (table 4.3) linked with table 5.2.
4	4	General				This chapter does a generally good job of pointing out the issues with modelling approaches and the inherent uncertainties, but it might also be useful to highlight questions that models <i>cannot</i> answer, at least in the near-future, either due to their spatial or temporal scales, or due to the overwhelming level of stochasticity.	Derek Tittensor	We think that the chapter does identify integration of drivers and ecological process as main challenges of current modeling approaches. However, we recognize than in a extension of the chapter questions that models cannot answer could have been handled in greater detail.

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5	4	General				Overall: Chapter content very relevant and well written. A few typos spotted eg in ILK section.	Shane Orchard	Thanks for the comment. An effort has been now made to eliminate typos.
6	4					General: Well written, but the sub-headings don't always clearly portray the content of that section (applies partly to all chapters). For example, a lot of modelling approaches are discussed in Section 4.2, but then this is the heading of Section 4.3 which then provides more detail. Content is fine, but better structuring of chapters or simply labelling of sub-headings could improve clarity.	Paula A Harrison	An effort has been now done to improve readability, reduce sub-headings and enhance the linkage between subheadings and main text (4.2 and 4.3 have been specially restructured).
7	4	General				Chapters: 2; 3; 4; 5; 6; 8: The issue of dealing with uncertainty in models and scenarios (identifying, managing, communicating) is considered in almost every chapter in an explicit and broader part (see 2.3.4, 2.4.3, 3.5, 4.6, 5.5, 6.5, 8.2.3) This causes overlaps in content. Moreover, chapter-specific aspects of uncertainty are difficult to identify. We propose to deal with general aspects of uncertainty only in one or two chapters. The chapter-specific aspects of uncertainty might be additionally described in other relevant chapters. You may also wish to consider analysing the language used in the IPCC when discussing uncertainty and elaborating further steps in dealing with uncertainty. The IPCC uses qualitative “levels of confidence (comprised of “levels of evidence and agreement”) and quantitative “levels of likelihood”, if possible. Please see https://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf . Such terminology might also be helpful for IPBES.	Germany	Uncertainty issues have been discussed across chapters and clarified in the final version of the deliverable. Chapter 4 is now the central reference of the deliverable for model related (i.e. scientific) uncertainty. With the general uncertainty typology introduced in chapter 1.
8	4	General				Chapters 2; 3; 4; 5: Chapter 3, 4 and 5 treat general aspects (importance, types etc.) of models and scenarios. This causes redundancies and inconsistencies. The given conceptualisations should be adjusted and common aspects should be placed together (e.g. in chap 2).	Germany	After discussions among CLAs from different chapters, an effort has been made to homogenize and use consistent terminology across chapters (i.e. uncertainty and model typology).
9	4	General				The key findings and key recommendations need to be brought out more in the text within the chapter. Go through each key finding and ensure that it is clearly and explicitly brought out in the text of the chapter.	Robert Dunford	We have revised the key findings to better link them with the main text of the chapter.
10	4	Gener				I would suggest a section on data at the beginning that goes beyond what is	Robert	Structure of section 4.2

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		al				<p>currently in the (slightly confused) inputs section.</p> <p>Key things to include are things that link to your key recommendations i.e. ILK and the importance of long-term datasets.</p> <p>More clarity is needed to separate direct and indirect drivers. There are other inputs to modelling beyond drivers (e.g. state variables etc.)</p>	Dunford	has been completely changed to better accommodate the role of state variables, drivers and processes linking both.
11	4	General				The structure could be improved with some tightening up and clarification: signposts are needed so that it reads as a cohesive whole with a clear path between sections. It feels as if it were written by many separate authors without a final overview editor.	Robert Dunford	Efforts have been made to strengthen the linkages between the different parts.
12	4	General				I would be tempted to include a mention of uncertainty at each stage (i.e. mention data uncertainty at the input stage etc.) with a reference to the uncertainty section for the more detailed discussion.	Robert Dunford	Uncertainty issues have been discussed across chapters and a collective decision on where to introduce uncertainty issues have been reached. The current structure of the chapter and use of uncertainty reflects this decision.
13	4					General comment: chapter 4 is lacking coupling models using SDM's and VHRS (high resolution images) and /or LIDAR and other new tools to support work on remote regions and improve accuracy in regions where good field data exists to calibrate such models. This approach could provide an innovative insight into <i>Modelling impact of drivers on biodiversity and ecosystem</i> functioning. Otherwise the chapter is a good summary on classical methods but lacks a vision and innovative techniques to provide improvements and solutions	Sandra Luque	Now included in section 4.3.2.1 on meeting policy information needs.
14	4	General	0	00	0	This seems to be a well written chapter with clear KF.	David Cooper	Thanks.
15	4	General		0		Chap. 4; this is an excellent document, well-written, solidly anchored in science/policy knowledge. As evident throughout my comments, I see a need to emphasize better that the effectiveness (confidence, reliability) of scenarios/models in support of policy directions and realizations ultimately depends on 1) our knowledge base (data quantity, quality, availability), 2) our understanding and interpretation of ecosystem or other targeted processes/functions derived from these data, and 3) the integration of these for scenarios/model development.	Christine Michel	Acknowledged. The decision context is not explicitly treated in this chapter. Our aim has been to indentify elements from biodiversity models that may be relevant when building and

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								using models to unravel links between drivers and biodiversity responses. Further info on the decision making context can be found in chapter 2.
16	4	General				<p>General: This chapter is commendable in that it is packed with an almost overwhelming volume of evidence, covering population and community models in great detail. It is very thorough and well written, although there is a lot of extra detail in places that could be left out and some repetition that has led to it becoming 68 pages long, so that the reader is unsure of where it is all leading.</p> <p>It would help to stat the aims and objectives of the chapter at the start before key findings and recommendations- it seems to be a review of biodiversity modelling approaches, identifying examples of practical application and drawing messages for model choices and application of good practice in adopting modelling approaches that leads to identification of where IPBES could operate to increase adoption of biodiversity modelling for a range of policy purposes.</p> <p>Key findings must be summarised from the evidence, Key recommendations must start with action words, and should include a few that are of interest to policy makers, not just IPBES. E.g. Key finding- policy makers have been involved in and used biodiversity models in a range of policy decisions at a range of geographical scales (e.g. x, y, z), Key recommendation policy makers can use models to explore a, b, c , but could benefit from better guidance on model options for particular circumstances etc. especially when models are seeking to answer questions at regional and international scales where data sharing and collaboration becomes important.</p> <p>It would help also to list a few of the policy areas where biodiversity modelling was applied. Identification of policy uses is weak in all chapters, yet they can be found if the reader is prepared to search.</p> <p>As with comments on other chapters, the information would be more accessible if greater use was made of tables, so that the reader could easily look at various population or community models, situations for their uses, policy application (eg fisheries, farming, biodiversity conservation) data requirements, limitations, notes on good practice and supporting evidence (references). The long text is difficult to negotiate and does not draw us back to the purpose of the review</p>	UK Government	The chapter has been greatly reduced and better structured to better convey the information contained in the first version of the ms. Key findings and recommendations have been also reduced and streamlined. See also comment 3.

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						<p>This would also shorten the chapter on modelling options, strengths and limitations.</p> <p>Section 4.3.2 Modelling options, strengths and limitations seems to overlap with subsequent chapters, complexity, accounting for uncertainty, options to reduce uncertainty, S 4.7 communicating model properties and findings- and there are snippets of good practice tacked into the ends of some paragraphs. It would be helpful to readers to use a table and summarise main points of good practice against this information, which would greatly reduce the amount of repetition and give IPBES something to focus on, ie generating good practice in biodiversity modelling as well as where the gaps and research needs are.</p> <p>These suggestions are to help make all this information more accessible and to clarify model choices and where their applications demonstrated good practice.</p>		
17	4	General				<p>In general, the linkage between Chapters 4 and 5 seems weak. In particular, Chapter 4 describes many kinds of ecological models, though some of them are not really linked with the context of IPBES assessment. Many ecological models can predict populations, biological community and ecosystems, however, the prediction of biological diversity is not closely connected to the ecosystem services, which is important in CF of IPBES assessment. I think, at least, the models useful for IPBES CF should be recommended in Chapter 4, and some kinds of models necessary to fulfill the IPBES CF should be pointed out. Also, since the scale of IPBES assessments are regional or subregional, some of the models could not be applied in actual. Models driven by socio economic drivers are not described very much.</p>	Tohru Nakashizuka	<p>Our approach in chapter 4 focus on linkages between drivers (direct) and biodiversity or ecosystems. Whereas the link with ecosystem services being the focus of chapter 5. However, we have now included a reference in the introduction to be more explicit on the fact that models commonly used in ecosystem service assessments implicitly use biodiversity models to some degree.</p>
18	4	General				<p>The models to describe tipping points or regime shifts should be described in Chapter 4. They must have serious effects on ecosystem and ecosystem services, and important in IPBES CF.</p>	Tohru Nakashizuka	<p>We have decided to not explicitly introduce this topic as we consider that regime shift analyses is an application and not a type of model.</p>

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19	4	General				<p>Dynamic Energy Budget (DEB) theory (Kooijman, 1993, 2003, 2010) is not at all mentioned in this report, but should in fact have a special place in it, since:</p> <ul style="list-style-type: none"> - it is the only individual level process based general metabolic theory in Ecology, comprising multiple empirical facts (e.g., von Bertalanffy growth, Kleiber's rule for oxygen consumption, Lavoisier's indirect calorimetry) and subsuming or superseding several other theories (e.g., Metabolic Theory of Ecology, Ecological Stoichiometry) and models (e.g., Droop growth, Liebig multiple nutrient limitation) in Ecology; - it is now parameterized with success for more than 400 species in multiple taxa of animals (http://www.bio.vu.nl/thb/deb/deblab/add_my_pet); - it comprises a systematic and consistent understanding of life stages, starting from the standard model, with embryo, juvenile and adult stages, but having been successfully expanded to much more complex life cycles (e.g., holometabolous insects with embryo, larval, pupal and imago life stages, Llandres <i>et al.</i>, 2015) - it supplies a mechanistic underpinning for trait based (namely size based) models for ecosystems (e.g., Maury and Poggiale, 2013; Bruggeman and Kooijman, 2007) - it is seeing increasing success in applications to primary producers (e.g., micro-algae, Lorena <i>et al.</i>, 2010), - it has proven very successful when coupled with other models and theories in Ecology, e.g.: coupling with biophysical ecology to obtain process-based species distribution models (Kearney <i>et al.</i>, 2013), coupling with marine ecosystem models to understand changes in species distributions with climate change (Teal <i>et al.</i>, 2012). <p>Additionally, the chapter as it currently stands does not really address the fundamental scientific challenge that hinders progress in modelling biodiversity and ecosystem functioning: the disciplinary divide in ecology between population/community/evolutionary ecology and physiological/ecosystem/functional ecology (Loreau, 2010). By simultaneously and rigorously dealing with mass and energy conservation and entropy production, on the one hand, and fundamental demographic processes like reproduction, mortality and ontogenetic development, DEB provides the best tool for bridging this fundamental disciplinary divide.</p> <p>REFERENCES Baas, J., & Kooijman, S. A. (2015). Sensitivity of animals to chemical compounds links to metabolic rate. <i>Ecotoxicology</i>, 24(3), 657-663. Bruggeman, J., & Kooijman, S. A. (2007). A biodiversity-inspired approach to</p>	Tiago Domingos	Given space constraints the reference to a given theory can not be extended. However, we have now included a reference to DEB theory in the new version of the chapter. Furthermore, the objective of the paper was not primarily to solve the scientific challenge of the current divide mention by the reviewer (that remains), but to provide some (more modest) guidance on the availability and context of biodiversity and ecosystem models available to assess the effects of direct drivers on biodiversity and ecosystems.

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						<p>aquatic ecosystem modeling. <i>Limnology and Oceanography</i>, 52(4), 1533-1544.</p> <p>Kearney, M. R., Simpson, S. J., Raubenheimer, D., & Kooijman, S. A. (2013). Balancing heat, water and nutrients under environmental change: a thermodynamic niche framework. <i>Functional Ecology</i>, 27(4), 950-966.</p> <p>Kooijman, S. A. L. M. (1993). <i>Dynamic energy budgets in biological systems</i>. Cambridge University Press.</p> <p>Kooijman, S. A. L. M. (2000). <i>Dynamic energy and mass budgets in biological systems</i>. Cambridge University Press.</p> <p>Kooijman, S. A. L. M. (2010). <i>Dynamic energy budget theory for metabolic organisation</i>. Cambridge University Press.</p> <p>Llandres, Ana L., G. M. Marques, J. L. Maino, S.A.L.M. Kooijman, M. R. Kearney, J. Casas (2015). A Dynamic Energy Budget for the whole life cycle of holometabolous insects. <i>Ecological Monographs</i> (in press).</p> <p>Loreau, M. (2010). <i>From Populations to Ecosystems: Theoretical Foundations for a New Ecological Synthesis</i>. Princeton University Press.</p> <p>Lorena, A., Marques, G. M., Kooijman, S. A. L. M., & Sousa, T. (2010). Stylized facts in microalgal growth: interpretation in a dynamic energy budget context. <i>Philosophical Transactions of the Royal Society B: Biological Sciences</i>, 365(1557), 3509-3521.</p> <p>Maury, O., & Poggiale, J. C. (2013). From individuals to populations to communities: a dynamic energy budget model of marine ecosystem size-spectrum including life history diversity. <i>Journal of theoretical biology</i>, 324, 52-71.</p> <p>Teal, L. R., Hal, R., Kooten, T., Ruardij, P., & Rijnsdorp, A. D. (2012). Bio-energetics underpins the spatial response of North Sea plaice (<i>Pleuronectes platessa</i> L.) and sole (<i>Solea solea</i> L.) to climate change. <i>Global Change Biology</i>, 18(11), 3291-3305.</p>		
20	4	401	12	401	12	Insert 'although they can never provide complete understanding' after 'representations'	Gary Kass, UK government	Sentence changed
21	4	401	23	401	23	Insert 'validity, specificity' after 'uncertainty'	Gary Kass, UK government	Acknowledged, but the sentence has now be deleted after text reduction.
22	4	401	30	401	30	Insert 'and explored' before 'jointly' [note it's not a simple matter of interpretation']	Gary Kass, UK government	Inserted
23	4	401	31	401	31	Replace 'reflected' with 'inherent'. This section is too positive and needs to reflect the inevitability that uncertainties will remain, despite better data and better models...not least because of stochastic and non-linear effects in ecosystem dynamics. Also, the effort required to produce the data, develop the	Gary Kass, UK government	Changed

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						models and undertake intermodel comparisons is huge and cannot be justified in many (most) cases...		
24	4	401	9	402	30	I feel that the link between your key findings and the overall aim could be stronger. Given the first part of your aim to identify the range of tools available to model biodiversity change, what do you conclude from your inventory in terms of models available and their applicability domain?	Aafke Schipper	See comment 15
25	4	401	17	401	18	'modelling underpins tools': I would say that the models <i>are</i> the tools?	Aafke Schipper	Changed
26	4	401	24	401	30	I don't see how this follows from your inventory of model approaches and I also think that the extent to which policy-makers and stakeholders are to be consulted in the actual modelling process is a debatable issue. I tend to agree that it might be worth to consider policy relevance when defining the scope of an assessment (in particular the selection of the biodiversity endpoint to be modelled), but I would say that the selection and representation of relevant factors and processes to be modelled belong to the domain of the modelers. Please rephrase or better underpin this statement, or consider to leave it out from here and save the stakeholder involvement for the recommendations.	Aafke Schipper	See comment 15
27	4	401	31	401	33	I would say that ways to reduce uncertainty comprise a recommendation rather than a key finding.	Aafke Schipper	We have decided to leave it as key finding because we just want to recognize the importance of uncertainty issues in model building and interpretation of model results.
28	4	401	34	401	35	Which are these main gaps? Please be more specific or else leave out.	Aafke Schipper	Sentence deleted
29	4	401	36	402	2	So do you actually conclude that we should model future biodiversity at the ecosystem level rather than the other organizational levels? If so, why? Also, this conclusion is only poorly related to the key statement in bold at the start of this paragraph.	Aafke Schipper	Sentence deleted
30	4	401	22	401	23	However, there still remain important gaps in the link between biodiversity modelling, planning and policy making due to model complexity, uncertainty, and the lack of available data, systematized data or and knowledge.	Marina Rosales Benites de Franco	Acknowledged and sentence changed.
31	4	401		10	14	Given the complexity of environmental issues, and the fact that models are only representations of reality I would strongly recommend very careful reconsideration of the use terms related to "prediction". Throughout the deliverable there is a worrying overuse of the term "predict". I	Robert Dunford	We have changed prediction to projection in most cases (i.e. referring to biodiversity model outputs in a

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						appreciate that there are many schools of thought on this but I would suggest that it is better form to use the word project. It is not possible to predict the future but it is possible to make projections of the future. I also appreciate that prediction may have more traction with decision makers (and indeed IPBES's aims) but there are dangers associated with projecting a false message of certainty and does not fit with most of the text on uncertainty and predictability e.g. 4.3.2.2 / 4.6.		future temporal dimension). However, prediction is also used when refereeing to models outputs in a more general way.
32	4	401	11	401	11	Why is it important that they are "open systems" at this point?	Axel G. Rossberg	Deleted.
33	4	401	31	401	31	Your heading reads "Uncertainty in ecosystem dynamics is reflected in ecosystem modelling." I agree: the uncertainty is in the dynamics of the ecosystems themselves [Chapters 16-18 in Rossberg, A. G. (2013). Food Webs and Biodiversity: Foundations, Models, Data. Wiley. ISBN 9-780470973-55-4]. Good models simply reproduce this uncertainty. The uncertainty is irreproducible. Unfortunately, this logic is not carried through in the subsequent text. The reader is left with the impression that uncertainty could be reduced through improved modeling, which is not always the case.	Axel G. Rossberg	Acknowledged and changed to avoid the impression that uncertainty can be avoided but rather accounted for.
34	4	401	10	401	23	Check use of term "predict" and "responses".	David Cooper	See comment 31.
35	4	401	34	401	34	"different" perhaps "a range of"	David Cooper	Sentence deleted.
36	4	401				Biodiversity-focused computer models are not usually based on ecological mechanisms and tend to focus on only a few types of species.	Boris Stipernitz	Acknowledged.
37	4	401	13			change one of the options to one way for	UK Government	Changed.
38	4	401	14			delete these	UK Government	Changed.
39	4	401	9	402	30	Key Findings: The listed key findings need to be re-written as: 1) they are too general and without pinpointing to the issues discussed in the chapter – modeling impacts. 2) the findings are not fully supported with the detailed assessment of the chapter.	Yi Huang	Key findings have been now reduced and rewritten to improve focus and relevance.
40	4	401	20	401	21	Should mention process based models here	Franziska Schrodt	Sentence deleted.
41	4	401	25	401	26	Should read: models rely heavily on assumptions about key processes and input data.	Franziska Schrodt	Changed.
42	4	402	6	402	23	There is a bit missing between these two paragraphs related to the fact that modelling depends, not just on data availability and on how complexity of feedbacks across scales are incorporated but on the underpinning need to have robust understanding of ecosystem structure, function and process which must be adequately represented in models - unless looking only at statistical	Gary Kass, UK government	Changed.

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						modelling.		
43	4	402	26	402	26	Insert 'and suitably treat' after 'reduce'	Gary Kass, UK government	Changed.
44	4	402	24	402	30	Is it possible to manage models by creating metamodels (i.e., Models of Models with diverse applications), to avoid any confusion which probably may occur through multi individual models?	Mahmood Yekeh Yazdandoost	Acknowledged. Not included here but mentioned thorough the chapter (I.e. IAMS).
45	4	402	6	402	13	The basic need should be mentioned to establish representative monitoring schemes to gather sufficient data of spatial, structural, and material flows of ecosystems (see page 420, lines 1-4), as well as of the biodiversity value relations to people for modelling and developing scenarios. In general Chapter 4 describes many useful methods and theoretical considerations, but should be complemented by practical examples that illustrate the limits and chances of scenarios based on modelling for practitioners.	Marcus Zisenis	Changed.
46	4	402	31	402	39	Rather than “models”, the focus and wording should be “scenarios based on modelling”, because models of biodiversity and their related values (“ecosystem services”) are generally to complex and unpredictable in time (see page 404, lines 20-28; page 442ff.). Therefore, different scenarios based on models are adequate to support decision-making with an impact on biodiversity. This refers also to the following text of Chapter 4.	Marcus Zisenis	Changed.
47	4	402	5	402	6	“Uncertainty in ecosystem dynamics is reflected in ecosystem modeling”. However, it must not be explained to policy makers as this uncertainty concept might encourage them in rejecting protection efforts devoted to ecosystem services.	Eyüp Yüksel	Acknowledged. The main point on uncertainty is not to avoid communicating it but to account for it and acknowledge the fact that we do not know everything about biological systems and that biological systems are stochastic in nature.
48	4	402	12	402	13	“Long-term observations at the as much as larger scale are therefore essential for improving our understanding of ecological patterns 12 and biodiversity. Insertion of the phrase ” at the as much as larger scale ” is required in many cases so as to emphasis the importance of benefits of local ecosystem’s regulatory importance to global ecosystem dynamics and regulation, i.e. biosphere, namely the ecosystem of our exclusive planet.	Eyüp Yüksel	Acknowledged, but we have decided not to add the suggestion by the comment as we think the scale issue is implicit in the sentence and we are not sure that

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								any scale should be prioritized.
49	4	402	25	402	27	“The scientific community has recognized the importance of 25 developing strategies to address the limitations of current models and reduce uncertainty involved.”. Moreover, strategy-the ecological components of ecosystems-Impacts one-to-one correspondence relations researches should be explored by computer simulations, field experimental or phenological (observational) monitoring, and theoretical studies should also be worked in order to compensate such gaps stressed by the scientific community.	Eyüp Yüksel	Acknowledged.
50	4	402	3	402	3	‘These multiple models’: which models do you actually refer to? (See also earlier remark concerning the results of your model inventory.)	Aafke Schipper	Changed. “Biodiversity and ecosystem functioning models currently available.”
51	4	402	6	402	10	Only the quality or also the quantity of the input data? And do we primarily need more data, or rather a better integration of existing data into publicly available databases (e.g. GBIF)? Further, the need to generate more data is not substantiated by the text in the chapter, which does not discuss input data limitations.	Aafke Schipper	Changed to focus not only on data but on the role of data in the adequate development of modeling approaches. We have also added the importance of compiling the data.
52	4	402	10	402	13	Consider to rephrase to state that data are needed both to parameterize and to test/validate models. Or leave out.	Aafke Schipper	Changed.
53	4	402	14	402	15	Integration of ecosystem models with what? Also, this is a rather bold statement! Where and how in the chapter do you actually prove the successfulness of models that include feedbacks across scales? And which models do actually do that...? The section on feedbacks is rather vague in this respect.	Aafke Schipper	Key finding rewritten.
54	4	402	24	402	30	Please be more specific. Which are these gaps? And which are these research avenues?	Aafke Schipper	Key finding rewritten and sentence deleted.
55	4	402	6	402	13	Is there also a need to mobilize existing data that is not accessible or digitized for one reason or another?	Derek Tittensor	Changed to include data mobilization (compilation) more generally.
56	4	402	6	402	13	For most of these ecosystem assessments and monitoring approaches, the species composition is one crucial parameter. In this context, the “taxonomic impediment” is a special problem for many of the most diverse ecosystems (https://www.cbd.int/gti/problem.shtml). Though this falls mainly in the area of the task force on Knowledge, Information and Data, the modelling community	Jens Mutke	Acknowledged but we think that, albeit treating a critical issue, the statement goes beyond the scope of the

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						should actively support capacity building in the context of biological taxonomy. This is important in the context of this paragraph (“quality of the data available”). Possible wording at the end of this paragraph: “Unfortunately, the number of well-trained specialists for the organism groups and ecosystems studied is still limiting especially for many of the most diverse ecosystems and in the countries of origin.”		present chapter.
57	4	402	14	402	23	“integration of ecosystem models ..” This bold statement is not clear. This KF is important but perhaps not so clearly expressed. It is perhaps particularly important since it deals with feedbacks from BES to drivers, which could be lost given the way the report is structured by chapter.	David Cooper	See comment 53.
58	4	402	6	402	13	Yes, biodiversity and ecosystem modelling depend heavily on the quality of the data available. This is a very important aspect which should be emphasized elsewhere (SPM-Policy Makers). Also, biodiversity and ecosystem modelling depends heavily on the mere existence (quantity) of data. In many regions, data coverage is extremely limited, precluding reliable ecosystem modelling/scenarios (also see previous point).	Christine Michel	Changed to accommodate this comment but also see comment 51.
59	4	402	5			add 'to 'design	UK Government	Changed
60	4	402	6			delete heavily	UK Government	Deleted.
61	4	402	24			require (no s)	UK Government	Changed
62	4	402	32	402	33	I am not sure what this recommendation means, how can this advice be used?	UK Government	Key finding reformulated.
63	4	402	32			delete 'need to be aware of' change to 'embrace and support'	UK Government	Changed
64	4	402	31	404	16	Similar problem in concluding the recommendations. From the assessment text of this chapter, the authors could not be possible to understand why these recommendations raised in this chapter. They are too general, not for this chapter. It should be better to focus the recommendations on what IPBES should do in modeling the “impacts.”, not the general recommendations.	Yi Huang	Key recommendations have been reduced and reformulated after consideration of examples and general discussion across the chapters.
65	4	402	24	402	30	More emphasis on gap in input data availability which is crucial for high performance and reliability of models. Mention potential for integrating airborne/remotely sensed data to complement ground data.	Franziska Schrodt	Acknowledged. Data issues treated in key findings and chapter 8.
66	4	403	1	403	1	Insert ‘limitations’ before ‘and use’	Gary Kass, UK government	Changed
67	4	403	11	403	11	Replace ‘model uncertainty’ with ‘the range of uncertainties involved’ (note:	Gary Kass,	Sentence deleted.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						'model uncertainty' is just one source of uncertainty involved in modelling)	UK government	
68	4	403	12	403	12	Insert ', stakeholders' after 'modellers'	Gary Kass, UK government	Changed
69	4	403	23	403	23	This should be stronger than 'encourage' it should be a required as the basis of good scientific practice.	Gary Kass, UK government	Changed
70	4	403	23	403	30	This should also include the development of improved process models – it cannot rest solely on more and better data. Also, there should be a recommendation relating to the need for IPBES to develop practical guidance on how to characterize, assess, communicate and take account of the full range of uncertainties arising from modelling of biodiversity and ecosystems and in using integrated models .	Gary Kass, UK government	Recommendations on practice guides for IPBES are included in the last two key recommendations
71	4	403	34	403	34	Insert 'development and' before 'integration'	Gary Kass, UK government	Changed
72	4	403	5	403	6	Very doubtful, stakeholders participation in scenario and models without gaining the knowledge of models to be exactly possible. Teaching models to stakeholders and expecting them to learn is another problem which is very time consuming. So applicability of models to the field in each and every country always remain under questions and still we may face gap of needed knowledge to seal the target.	Mahmood Yekeh Yazdandoost	Inclusion of stakeholder participation in scenario and models does not involve always profound knowledge of modeling details but agreements on state variables, objectives and system constraints (see also chapter 2).
73	4	403	5	403	13	A bottom-up network of networks needs to be established on different scale for biodiversity assessments and related values to them ("ecosystem services") of equal decision-making fora of decision-makers, scientists, and other stakeholders, as well as the public directly and indirectly concerned to guarantee, inter alia, an up-to-date modelling and scenario development, as well as timely revision, and last not least, implementation of resulting management decisions (see, for instance, page 406, lines 26-27, and the role of NGOs as equal partners according to UNEP (1992). Agenda 21 – to be involved as partners at "...all levels from policy-making and decision-making to implementation." under the heading "Strengthening the role of non-governmental organizations: partners for sustainable development", instead of the top-down constructed IPBES in current form: Zisenis, M. (2015). The	Marcus Zisenis	In this key recommendation we focus on the need for model development to interact more actively with stakeholders further discussions on links between decision making and biodiversity research are in fact at the core of many IPBES activities.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						International Platform on Biodiversity and Ecosystem Services gets profile. <i>Biodiversity and Conservation</i> 24(1), 199-203)).		
74	4	403	33	403	36	“IPBES should promote forums or joint 33 programs that facilitate the exchange of information, approaches and methodological integration of 34 environmental drivers modelling and ecosystem modelling in areas with potential feedbacks are 35 greater (marine ecosystems).” . Here IPBES have to be careful while structuring forums as in many developing countries, not eminent experts and relevant professionals but the one who speak and write foreign languages very well usually selected to form forum structure (participants, and forum managers) who are coming from irrelevant expertise areas and professions. That’s why like the all bodies of UN and other similar organizations continuously repeating intentions, and some unimportant, irrelevant “results” would be the outputs which never work in actual situations. Notice that in UN, OECD, and EU bodies not real experts but academicians having big foreign language skills are selected to be recruited. As a result the UN bodies and similar international organizations in a way cannot find solutions to the actual ongoing world processes since the ending of the Second World War. My recommendation would be strong recruitment choice of real experts who might have less foreign language skills, to be recruited by the UN, IPBES; UNEP, UNDP etc. in order to find working, real solutions	Eyüp Yüksel	Acknowledged.
75	4	403	14	403	15	Uncertainty is important, but not the most priority. Decision makers focus on the trends and pattern.	Fu Bin	Acknowledged in the the context of modeling outputs (now added).
76	4	403	31	403	33	Feedbak should be involved in, but the assessment boundary must be clear to avoid the cycle between input and output.	Fu Bin	Acknowledged.
77	4	403	31	403	36	This recommendation seems rather vague... Did you actually intend to say that we need feedback models particularly for the marine environment? If so, I would expect one of your key findings to be that feedbacks are important mainly in the marine environment. How and where does this follow from your model inventory? Also, how does this key recommendation relate to the next one where you recommend integrated models including feedbacks also for terrestrial and freshwater systems?	Aafke Schipper	Key recommendation deleted.
78	4	403	37	403	39	I strongly agree with this key recommendation: “ <i>We further recommend IPBES to engage in the active development of guidelines for integrated 37 ecosystem modelling (to be explicitly integrated into the development of regional assessments 38 deliverable 2b)</i> ”.	Marina Rosales Benites de Franco	Acknowledged.
79	4	403	23	403	30	The issue of quality raised in this paragraph includes as well the question of taxonomic bias and reliability of species determinations in ecological studies. Until now, many large scale studies involve mainly vertebrate species. For many of the more diverse groups of organisms, including many plant groups, the knowledge of their taxonomy but as well their ecology is still limiting	Jens Mutke	Acknowledged but suggestion not added because we need it is implicit in the current text.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						especially in tropical ecosystems. Thus, when we aim to encourage long-term monitoring programmes, some capacity building to minimize the shortage of trained taxonomists and curators should be included, as well. Possible wording in line 26 after “ecological patterns”: “, and as well, capacity building activities to minimize the shortage of trained specialists for the organism groups and ecosystems studied.”		
80	4	403	24	403	30	The need for long-term observations to further understanding of ecological patterns, functions and biodiversity is a key point that should be included in the key findings (SPM – Policy Makers).	Christine Michel	Suggestion made.
81	4	403	12	403	13	Can the experts participating in this assessment recommend a mechanism to facilitate this type participation?	Brenda McAfee	This needs to be discussed carefully if the proposal is taken forward.
82	4	403	5			delete strong	UK Government	Changed
83	4	403	9			exercises, (add s)	UK Government	Added
84	4	403	23	403	30	The quality of information is not independent of its use. This recommendation reads as though there is an absolute standard. But this is not the case – it depends on what it is being used for. It does not matter what the exact level of sea level rise is, if it exceeds to coastal flood plain for example. I think this recommendation could more clearly point to <i>relevant and sufficient</i> detail, and some of the literature on optimal monitoring	UK Government	Changed to accommodate the suggestion (“ensure quality chain”).
85	4	403	23			delete 'we encourage, delete' to 'change to' should'	UK Government	Changed
86	4	403	26			change should to will, better fit to match	UK Government	Changed
87	4	403	27			delete strong	UK Government	Changed
88	4	403	35			change to modelling of environmental drivers and ecosystem services (delete second ' modelling'	UK Government	Changed
89	4	403	37			Delete we further recommend, change to IPBES should	UK Government	Changed
90	4	403	23	403	30	Also important to carry over uncertainties e.g. From species distributions, trait data etc. --> important to consider model AND data uncertainty in tandem.	Franziska Schrod	Acknowledged.
91	4	404	21	404	23	While it is true that models ‘can be used to assess and predict’ this is by no means simple, unproblematic or able to deliver accurate and reliable outputs. This sentence is misleading as written and must be accompanied by suitable caveats. (contrast with page 405, lines 3-5)	Gary Kass, UK government	We agree but we think that at this level of the intro the statement can be substantiated with caveats introduced and

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
								discussed later on (i.e. uncertainty)
92	4	404	26	404	28	As above...no model can fully ‘unravel’ patterns and mechanisms; similarly while allowing projection...these will not be wholly accurate or reliable...again, suitable caveats are needed	Gary Kass, UK government	See previous comment 91.
93	4	404	1	404	2	Also demographic.	Mahmood Yekeh Yazdandoost	These are socio-economic in nature.
94	4.1	404	20	404	33	As ecosystems are one level of biodiversity (Article 2 (1) CBD), it would be better to refer either to “ecosystems” or alternatively “biodiversity” as a whole while taking also in account that Chapter 4 itself refers to the functioning of ecosystems, apart from biodiversity. This applies also to the following text of Chapter 4.	Marcus Zisenis	Biodiversity and ecosystems are used in accordance to the IPBES conceptual framework (see chapter 1) and they are not used as synonyms.
95	4	404	3	404	4	Shouldn't a typology of available models follow from your inventory? (See also suggestion below regarding the aim). Also, how does the formation of model comparison groups relate to the recommendation to use a multi-model approach to biodiversity modelling (page 403 line 18-19)? Can these two recommendations be combined? If not, make a clear separation between the two.	Aafke Schipper	The typology introduced in the deliverable is a first step, but authors do not think the question is closed after its publication. eE have also slightly modified this key recommendation to make clear that uncertainty issues are the object of a different key recommendation. We have also reordered key recommendations.
96	4	404	26	404	27	It is stated that ‘The aim is to identify the range of tools available to unravel patterns and mechanisms of biodiversity and ecosystem change, ...’ Given the aim to make an inventory of models available, I find the structure of sections 4.2 and 4.3 confusing and the text in places repetitive or rather redundant. Can sections 4.2 and 4.3 be integrated to a new section 4.2 presenting an overall classification/typology of models, organized from pattern- to process-based at different levels of biological organization? Regarding the levels of organization (section 3), please note that species (4.3.1.3) do not constitute a formal level. So the classification scheme could then look like this (I tried to fill it with the different models, but I may have missed some mentioned in your chapter):	Aafke Schipper	A new table based on the reviewers comments have been now included in the new version of the chapter (table 4.3). However, the structure of the table has been discussed and based on info included in chapter

N ^o	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment																				
						<table border="1"> <thead> <tr> <th>Level of organization</th> <th>Pattern-based (correlative) models</th> <th>Mixed (hybrid) models</th> <th>Process-based (mechanistic) models</th> </tr> </thead> <tbody> <tr> <td>Individual</td> <td>...</td> <td>...</td> <td>...</td> </tr> <tr> <td>Population (single species)</td> <td>SDMs</td> <td>DBEMs</td> <td>Dynamic population models (like used in PVA)</td> </tr> <tr> <td>Community</td> <td>SARs GLOBIO model</td> <td>...</td> <td>Foodweb models Lotka-Volterra</td> </tr> <tr> <td>Ecosystem</td> <td>...</td> <td>...</td> <td>MADINGLEY DGVMs</td> </tr> </tbody> </table> <p>This classification would provide an overall overview and typology of the models, which is now lacking, as well as a guide to structure the text: I would suggest to then organize section 4.2 into an introduction presenting the scheme (4.2.1) followed by four sub-sections describing pattern- and process-based models at each of the four levels of organization (4.2.2 to 4.2.5; largely corresponding with the current section 4.3).</p>	Level of organization	Pattern-based (correlative) models	Mixed (hybrid) models	Process-based (mechanistic) models	Individual	Population (single species)	SDMs	DBEMs	Dynamic population models (like used in PVA)	Community	SARs GLOBIO model	...	Foodweb models Lotka-Volterra	Ecosystem	MADINGLEY DGVMs		5 (table 5.2).
Level of organization	Pattern-based (correlative) models	Mixed (hybrid) models	Process-based (mechanistic) models																									
Individual																									
Population (single species)	SDMs	DBEMs	Dynamic population models (like used in PVA)																									
Community	SARs GLOBIO model	...	Foodweb models Lotka-Volterra																									
Ecosystem	MADINGLEY DGVMs																									
97	4	404	27	404	28	<p>The second part of the aim states ‘... incorporate this knowledge in models allowing the projection of future biodiversity conditions’. First, I feel that this should be phrased differently to better link up with the first part of the aim. (The formulation as is now suggests that the inventory of tools is to be incorporated in models – this doesn’t seem to make much sense as the tools are the models...) Second, I would advise to make the second part of the aim more specific. Judged from your text, isn’t the actual aim to provide an overview of issues that need to be considered when selecting a particular modeling approach for projecting future biodiversity, like the scope of the study and the model’s potential for projection/extrapolation, data requirements, ecological knowledge requirements, spatial scale and uncertainty? Would it be possible to present an overview of these issues in a single section (new section 4.3) with each issue in a separate sub-section? Perhaps the current section 4.3.2 can be combined with the current sections 4.5 and 4.6 and serve as a starting point. Where possible, it would be nice to discuss the issues to consider also in the light of the two axes of the model typology (pattern-process + organizational level). This is now done in Fig. 4.5 for the data and knowledge requirements in relation to pattern- and process-based models; it would be very informative if this graph was extended to include other issues as well. For example, the potential for projection into the future might be larger for process-based than pattern-based models; parameter uncertainty is probably larger for process-based models because they require input parameters that are more difficult to quantify (e.g. survival and</p>	Aafke Schipper	Section 4 completely restructured following the suggestions and discussion between chapter authors and CLAs.																				

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						reproduction rates for process-based population models as opposed to ‘simple’ occurrence records for SDMs). Similar continua may exist along the axes of organization; e.g., appropriate spatial scale may increase from individuals to ecosystem models.		
98	4	404	1	405	8	Based on the above, I would suggest a slightly different structure. As said, I would merge section 4.2 and 4.3 into one new section 4.2 describing the model approaches and classifying them along two axes (see suggested table above). Then I would have a new section 4.3 addressing the issues to consider when selecting a model (including scope/aim, complexity, applicability, uncertainty, etc.), preferably also in relation to the two axes.. I would end with a new section 4.4 to address the overall conclusions and recommendations (possibilities to reduce uncertainty, added value of model comparisons, including biotic feedbacks, relevance of stakeholder involvement).	Aafke Schipper	We have now restructured the chapter to accommodate these comments. We have not included all the suggestion changes as these would have radically changed our chapter but specially 4.2 now reflects much better model typologies according to what is modeled and how it is modeled and 4.3 goes more revising actual models used for different biological organization levels.
99	4	404	18	404	18	(Add new paragraph). IPBES should take into consideration the use of models for understanding ecosystem functions and services based on the perspectives and worldviews of all knowledge systems, and particularly indigenous and knowledge systems (ILK) as a way to effectively incorporate different perspectives of the relationships between nature and nature’s benefits.	Diego Pacheco	This consideration is an interesting one, but it does not apply to chapter 4 that only deals with methods available to assess impacts on biodiversity and ecosystems. Perspectives and word views do affect the ways that decisions are made or how services are quantified but not how biodiversity respond to direct drivers of change.
100	4	404	15			Delete therefor we urge, change to there is a	UK Government	Deleted
101	4	404	23			change the present chapter to this chapter	UK	Changed

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
							Government	
102	4	404	19	405	8	The introduction should more focus on the importance of “modeling impacts” for decision making and management of biodiversity in a context of the IPBES’s conceptual framework. It should have text to describe what are the impacts identified in this chapter, and indicate its objectives/purpose in decision making for biodiversity and ecosystem services management, or should start with the explanation of Fig. 4-1.	Yi Huang	Changed to include (briefly) a reference to decision making and management (described in more detail in chapter 2).
103	4	405	3	405	5	This is rightly described as being of utmost importance (note spelling mistake in text) and is such a fundamental point in any discussion of modelling a n scenarios that it should be made much more prominent in the text – not least in setting context at the start of section 4.1.	Gary Kass, UK government	Acknowledged and implemented in the text subjected to space constraints.
104	4	405				Suggest folding section 4.1.1 and 4.1.2 into section 4.1 and relabelling 4.1 ‘Introduction and conceptual framework’ for consistency with other chapters. For example, see Chapter 2 and 3 which cover links to other chapters in this way. Also, shorten to fit with other chapters.	Derek Tittensor	Changed
105	4	405	1			change ‘the following sections’ to Sections 4.5-7	UK Government	Changed
106	4	405	4			delete outmost, change to passive voice	UK Government	Corrected
107	4	406	24	406	25	Stakeholders must be defined (targeting which group). (Information given in chapter 8).	Mahmood Yekeh Yazdandoost	Stakeholders are defined in chapter 2 (setting the decision context) and are only referred here from a general perspective.
108	4	406				Figure 4.1 and Figure SPM.1, cover similar topics, but are very different visually and in text. Suggest aligning.	Derek Tittensor	Figures based on the IPBES conceptual framework has been now agreed upon the different chapters.
109	4	406	1	406	2	There is the need to incorporate the full picture and not only the some part of the figure.	Diego Pacheco	The whole diagram corresponds to the IPBES conceptual framework. At the beginning of the chapter, our aim is to identify the topics treated in the chapter by zooming to the corresponding section of the figure.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
110	4	406	29	406	29	Including the linkages with the ILK Participatory Mechanism.	Diego Pacheco	This consideration is an interesting one, but it does not apply to chapter 4 that only deals with methods available to assess impacts on biodiversity and ecosystems. ILK Participatory mechanisms are discussed elsewhere (chapter 2).
111	4	406	8		11	change to Many models that can be of use for contributing to the IPBES deliverables, but for widespread adoption of modelling scientific capacity in the use of such modelling techniques must be built. This is a notable issue in many of the IPBES member states and the need for capacity building is discussed in Chapter 7.	UK Government	Sentence deleted
112	4	407	3	407	5	The point should be made that these choices are not straightforward nor are they informed solely by scientific factors...social, institutional, political, financial and practical factors play a large part in constraining any such choices. As such they should be open to debate and decisions made collaboratively.	Gary Kass, UK government	Acknowledged. However, social, institutional, political and financial factors are beyond the scope of the present chapter. However, these factors are introduced and discussed in more depth in chapter 2.
113	4	407	20	407	20	Replace 'The prediction' with 'Predictions'	Gary Kass, UK government	Changed
114	4	407	26	407	26	Replace 'biological component' with 'biophysical components'	Gary Kass, UK government	Changed
115	4	407	35	407	35	Insert 'and between organisms and their abiotic environment' after 'organisms'	Gary Kass, UK government	Changed
116	4.2	407	14	407	16	Yes, bottom-up decision-making for a need to establish monitoring schemes, and models for scenarios to implement common management decisions with impacts on biodiversity and their related values. This refers in particular to non-use and non-monetary values such as beauty of nature and landscapes, which can already not scientifically been based on decisions by solely selected	Marcus Zisenis	Acknowledged.

№	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
117	4.2	407	26	407	27	<p>“experts”, decision-makers or other people in power.</p> <p>“Species richness” is not a validate indicator, because it needs to refer to natural or typical species as biodiversity evaluation criteria related to certain values such as ethical values (see Zisenis, M. (2009). To which extent is the interdisciplinary evaluation approach of the CBD reflected in European and international biodiversity related regulations? <i>Biodiversity and Conservation</i> 18(3): 639-648): The same refers to typical and natural, among other criteria, habitat types and structures such as natural woodland stratifications, instead of “habitat heterogeneity”.</p> <p>For example, if you drain a naturally nutrient poor highmoor bog, nutrients will be mineralized during oxidation and pioneer trees will increase species richness and habitat heterogeneity while pushing away the typical species poor biocoenosis of Sphagnum mosses (deterioration of ethical values and economical loss among other values of CO2 sink ecological functions of peat).</p>	Marcus Zisenis	We agree with the reviewer that species richness may be an indicator that may lead to interpretation problems in some cases. However, this is often the case, and biological indicators should be chosen with this consideration in mind. We wrote the chapter with a general perspective in mind, and stress that the choice of the biological indicator needs to match the decision context (the example you provide illustrates exactly this point).
118	4	407	29	407		<p>Data collection is expensive. The lion’s share of the budget should be allocated to widespread training of the public by mass media insteade of data collection. Only critical, monitoring related selected data should be explored, and benefit-transfer methods should be used more in decision-making. We shoul not convince the policy makers, decision makers, rather we should influence public, the voters in a more strong, striking ways. I do not believe the critical roles of policy-makers and decision-makers so much! This is a habit to believe their role as so much exaggarated. However, the driver role of big consumption, big deteriorating entities, the private sector multi-national companies are the big targets to be influenced by IPBES. The poor, and low level classes in general do not resist against conserving biodiversity, and ecosystem svives at much bigger scales.</p>	Eyüp Yüksel	The issue raised on how to optimally allocate resources is a critical one that is currently beyond the scope of the present chapter and is more explicitly addressed in chapter 8.
119	4	407	22	407		<p>“In the description of any model of this type, the following components 22 should be identified:” In a model, in my opinion, determination or estimation of economic megatrends, conflicts, and wars are more prominent compared to those of biodiversity models.</p>	Eyüp Yüksel	Our intention is not to confront models of different kinds (treated in chapter 3 for instance), but offer insight on how they work and how they can

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
								be used to be used together to better respond to current environmental challenges.
120	4	407	3	407	4	Specify that the present chapter deals with <i>modelling</i> those impacts.	Aafke Schipper	Changed
121	4	407	8	407	14	Also reference showing empirical evidence for linking different biodiversity attributes to ecosystem services in Harrison et al. (2014). Linkages between biodiversity attributes and ecosystem services: A systematic review. <i>Ecosystem Services</i> , 9: 191-203, DOI 10.1016/j.ecoser.2014.05.006i.	Paula A Harrison	Changed
122	4	407	12	407	16	The acknowledgement of the different roles of biodiversity follows an anthropocentric perspective that has ecosystem services, the material and non-material benefits generated by nature, as its main end. In parallel to utilitarian values biodiversity has its own intrinsic value, which is independent of human demand or appreciation and which is difficult or impossible to quantify through modelling, its existence value or evolutionary value to maintain the life in the world.	Marina Rosales Benites de Franco	Existence value is explicitly acknowledged in chapter 5. In these cases, biodiversity models are commonly and directly used to feed into policy.
123	4	407		4		What is the primary purpose of section 4.2 – to say how models are generally constructed – or to suggest how they should be best constructed for IPBES’ aims? If the latter then consider including a section that links to the key recommendations with respect to engagement. i.e. mention up front the importance of coproduction of knowledge when deciding the whats, hows and whys of modelling.	Robert Dunford	The primary purpose of section 4.2 is to explain how models are generally constructed.
124	4	407	25	407	29	Often with state variables one has to be pragmatic and base them on what data is available, while thinking about ideal variables and the costs and feasibility of collecting such data.	UK Government	Acknowledged.
125	4	407	29			add data availability	UK Government	Added
126	4	407	1			The whole assessment of methodologies in modeling impacts is likely a scientific review of the subject. There are basically 2 dimensions needs to be improved in future versions: 1) the classification of modeling tools/methods is well structured. However, it is a more general review of different modeling methods/tools, but lack of analysis on how the tools/methods can be applied to address IPBES’ needs in address the impacts and feedbacks. The whole text is more on what is available, but no in-depth discussion on how each (group) of the tools could be used for the purpose of IPBES. It may be a good idea to structure the chapter in such a way to fully supported by IPBES’ tasks. 2) For	Yi Huang	See comment 15.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						the introduction of methods/tools, it is a more general assessment, but lack of the effectiveness of the key modeling methods. The analysis/assessment should be done to taking the needs from IPBES, not general review. It would be good to have more case studies. One more aspect need to be discussed in the chapter is at what extent each of the tools/methods could be applicable.		
127	4	407	7	407	12	Functional diversity should be mentioned in this instance. Important to understand processes as mentioned e.g. page 409 line 11.	Franziska Schrodt	Added
128	4	407	25	407	29	Again, this should include functional traits of organisms	Franziska Schrodt	Added
129	4	408	4	408	8	This paragraph is correct but it implies that full knowledge of system dynamics is available or possible and its a ,matter of choice or trade-off to what extent a modeller chooses to access this knowledge. In reality, this so far from the truth. basic systems dynamics are not completely understood and this must be reflected in this paragraph	Gary Kass, UK government	Acknowledged and changed.
130	4	408	13	408	13	Replace 'biological' with 'biophysical' (e.g. ocean acidification is a chemical reaction that has biological implications!)	Gary Kass, UK government	Replaced
131	4	408	17	408	17	The phrase ‘; making the model building process very easy’ is highly misleading as the scale of uncertainties and data gaps involved e.g. in SDMs are huge. the sentecne that follows doesn’t make up for this overstatement of ‘ease’	Gary Kass, UK government	Sentence deleted in the restructuring of the chapter.
132	4	408	1	409	2	Why is this part separated from section 4.2.1 (what to model)? It seems to deal with the same question! Also, please consider to restructure section 4.2; see previous comments.	Aafke Schipper	See previous comments 96, 98 on restructuring of section 4.2.
133	4	408	7	408	8	If true, this is a vital notion in the context of modelling future biodiversity and ecosystem change! This seems to suggest that we should actually go for the simpler models if the aim is to make future projections. Please elaborate further and move to appropriate section.	Aafke Schipper	Changed and sentence reformulated.
134	4	408	7			delete There is a trade-off with regard to a models predictive capability involved here, where	UK Government	Changed
135	4	408	10			delete 'key' and 'the nature of'	UK Government	Changed
136	4	408	17			SDMs=?	UK Government	Deleted.
137	4	408	1	408	1	In the “Figure 4.2”. in the climate change components, replace the word Rainfall by “Precipitation”. Rainfall is the atmospheric water falling on the liquid form, while precipitation express better the falling of the atmospheric water under the different forms (liquid, gaseous, solid).	Nkue Nouwezem Daniel Jude	Figure 4.2 has been redrawn and the suggestion incorporated. Please

N ^o	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
								note that climate is here used as an example of driver to illustrate how indicators of this driver can be linked to biodiversity elements.
138	4.2.1	409	4	410	3	Scenarios, based on modelling and empirical data, need to be also developed for the changes of related values of biodiversity according to the Preamble of the CBD.	Marcus Zisenis	Acknowledged. More developed in chapter 1 and 3.
139	4	409	19	409		The pathways of the impact of transportation and foreign trade, globalization on the dissemination of invasive species should be analyzed for each specific region so as to be hampered by the most responsible countries sharing the same borders or seas.	Eyüp Yüksel	Agree. Relationship between indirect and direct drivers is the specific objective of chapter 3 of this deliverable.
140	4	409		409		“In this context, Loreau et al. (2003) highlighted that knowledge of spatial processes across ecosystems is critical to predict the effects of landscape changes on both 40 biodiversity and ecosystem functioning and services.” Here the phrase “across ecosystems” should be strengthened, and clarified by substituting this “across local ecosystems”, or “across ecosystems at the local scale”.	Eyüp Yüksel	Changed.
141	4	409	4			Some overlap with Chapter 3 but summarised and targetted to purpose of this chapter. This is a good illustration for other chapters of how to avoid repetition.	Paula A Harrison	Thanks
142	4	409	22	409	24	This two-fold typology of direct drivers does not seem consistent with Chapter 3. Where would invasives and pollution fit in this? Salafsky et al. 2008 Conserv Biol would be a good citation here.	Thomas Brooks	Reviser for consistency with chapter 3.
143	4	409	36			delete But	UK Government	Changed.
144	4.2.1.2	410	19	411	11	A key point should be mentioned, that the direct and indirect impacts of different drivers can hardly be predicted or quantified due to the complexity of ecosystems and their inherent open system of discontinuous development (see page 420, lines 5-8). Therefore, only scenarios based on modelling can be developed for key indicators such as vegetation type, and related biodiversity values to them, for instance, usability of material timber supply of woodlands as economic value. See pages 120ff. Zisenis, M. et al. (2013). <i>European ecosystems: knowledge on their state and functioning</i> . http://projects.eionet.europa.eu/eea-ecosystem-assessments/library/report_european-ecosystems-state-and-functioning/european_ecosystem_state_functioning_dec-2013	Marcus Zisenis	Acknowledged.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
145	4	410	4	410	17	Aren't the drivers covered in the preceding chapter? Consider to delete.	Aafke Schipper	Deleted.
146	4	410	20	410	21	Outline and link to other chapters should be covered in section 4.1. Please delete.	Aafke Schipper	Deleted.
147	4	410	23	411	11	Please consider to discuss the output (endpoint selection) in relation to the level of organization and to provide the example (Fig. 4.3) in the context of the difference between pattern- and process-based models.	Aafke Schipper	Acknowledged but the main point of this figure is not yet to introduce the difference between pattern (correlative) and process-based models.
148	4	410	12		17	drivers do not list those stated in the MEA, on p105, line 21-22.	UK Government	Section on drivers has been restructured and a detailed list of drivers is now not provided (for further info see chapter 3).
149	4	410	16			A more relevant (and recent) reference here for biodiversity would be Secretariat of the Convention on Biological Diversity (2014) Global Biodiversity Outlook 4., Montréal, 155 pages	UK Government	Section restructured and the need of this ref not considered essential.
150	4	410	23			delete 'notably'	UK Government	Deleted.
151	4.2.3	411	27	412	6	In particular non-use, non-monetary values cannot be assessed and scenarios based on modelling developed without the people concerned, because they are subjective.	Marcus Zisenis	Further consideration on the model's decision context and scenario developments will be found in chapters 2 and 3.
152	4	411	23	411	26	I would remove this table and save the information on the potential benefits for a discussion of the issues to consider when selecting a model (new section 4.3). Further, I would not classify expert knowledge as a model, rather as a source of data and knowledge. Finally, it is unclear what you mean by 'integrated models'. Are these the hybrid models (mix of pattern- and process-based models)? Please specify.	Aafke Schipper	Table removed. Expert based models renamed to expert-based systems. Hybrid models have been now explicitly moved to the previous section and include a mixed of modeling approaches (i.e. models using correlative and process-based).

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
153	4	411	27	414	17	Although I agree that indigenous, local and expert knowledge can provide valuable information in the context of biodiversity assessment and modelling, I do not think that this knowledge can be considered as biodiversity models as such. I suggest removing this information from here and discuss later, for example when discussing input data and knowledge requirements, or save this notion (and condense it) for the recommendations.	Aafke Schipper	As discussed together in Beijing with CLAs of chapters 1 and 5... expert based systems or approaches have been finally included in the typology.
154	4	411	25	411	26	Table 4.1 . I think other potential benefit is improve management and decision making lead the way to sustainable development.	Marina Rosales Benites de Franco	Table removed.
155	4	411		13		<p>There is a lot of critique of science and modelling that comes from the social sciences that would be great to see integrated. Arguments that have been around for a long time (see Wynne, 1992; Latour and Woolgar, 1979 etc.) are rarely seen included in predominantly physical science work. It is great to see more of this in IPBES with specific sections on ILK, uncertainty communication and stakeholder engagement etc.</p> <p>However, I think there is space for more explicit recognition of human agency in the modelling process and the social implications of who decides what to model, who uses the data and where to act. This wouldn't need to be a large section – but it would be a positive, forward thinking and novel contribution.</p> <p>Things to consider: 1) what is being modelled, by whom and the implications of this with respect to agency, power and ultimately where problems are identified and addressed. This applies to both species and humans. (Does the fact that data is more available in the developed world have any influence on the maps we produce? Is this made explicit?)</p> <p>Also, 2) that the environment is complex, and 3) modelling is imperfect and that it is vital that decision makers know this. It should be made explicit that models are just an additional form of knowledge to be put on the decision maker's table along with other data sources. It might also be worth adding to the same section – or to the section on communication that using the wrong model, or misunderstanding a model's purpose can lead to negative outcomes, and that the right model may not yet exist so that an imperfect model used for making decisions must be done so with care, other datasets and ultimately decision makers common sense – so no matter how much sensitivity analysis we do the decisions will always be subjective and we (humanity) need to be ok with this as it is unavoidable. It would be good to make these issues explicit.</p>	Robert Dunford	Acknowledged but most suggestion (ie.e critique from social sciences) could not be accommodated due to lack of space. Also the decision-making context is discussed in detail in chapter 2.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						<p>Hence, I agree strongly that common errors associated with models include overconfidence in communication (Table 4.2, section 4.3.2). To this end I think it is important that the author(s) who wrote the sections that flag this uncertainty (e.g. uncertainty, predictability, communicating model findings) read through the sections on models with a critical eye to make sure these messages come across. Am happy to help if needed.</p> <p>e.g. the first statement:“Ecosystems are indeed too complex to be understood and predicted without formal modelling representations (p401 L12)”. Counterpoint – they are probably too complex to be ‘understood and predicted’ even with models. Models are just another source of knowledge that can be put on the table to help decision makers better understand possible futures. They have advantages, in that we made them so we can (usually) understand why they produce the outputs they do, but we should be very wary about truth/knowledge claims.</p>		
156	4	411		13		4.2.2 would benefit from clearly stating its link to the following sections which discuss the sub-sections it mentions.	Section 4.2	Section 4.2 has been restructured to improve readability.
157	4	411		27		4.2.3 this fits awkwardly here. ILK is a very important consideration and should be flagged but it needs to be treated as a data source rather than a modelling approach. The related modelling approach would be an ‘expert-based system’.	Robert Dunford	Section 4.2 has been restructured to improve readability. Section on ILK has been moved to the end of the section after expert-based systems.
158	4	411	414			Consistency with acronyms IK/ILK	Robert Dunford	Revised.
159	4	411	16			change' . With this in mind, we here adopt' to 'from'	UK Government	Changed
160	4	411	20		21	change to There are additional aspects related to the choice of modelling approach for a given task, notably with 20 regards to the potential benefits of the various modelling types.	UK Government	Deleted
161	4	412	30	413	33	Is IK referring to ILK? Both ILK and IK are used in Lines 30-31 page 413. Terminology should be consistent across the report and with that used in the conceptual framework	Brenda McAfee	Changed
162	4	412	5	412	6	The inclusion of ILK is important, but there is a need to be specific about which gaps it can fill. This is addressed later, so I would either delete this sentence or provide a forward reference e.g. to 4.2.3.2	UK Government	Section restructured
163	4	412	5			delete key	UK Government	Deleted
164	4	412	31			better' than what?	UK	Changed

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
							Government	
165	4	412	31		40	IK- should be in case study text box	UK Government	Since IK is an important and independent approach, we want to keep it as a part of the main section, rather than a box.
166	4	412	4	412	6	It is useful to include ILK into the models, though few examples or concrete ways to incorporated ILK into ecological models are described.	Tohru Nakashizuka	Examples are now provided but can not extended due to space constraints
167	4.2.4	413	35	414	17	<p>Solely or mainly expert driven modelling and scenario development for biodiversity evaluation is the wrong way and not scientifically based, because they can inherently not cover the different knowledge and subjective assessments of different stakeholders, decision-makers, scientists, and the public directly and indirectly concerned. Evaluation of biodiversity and scenarios for management implementation based on different modelling approaches and contents is necessarily a subjective democratic decision of the society, but not depending on selected “experts” by certain groups in power such as the inter-governmental driven IPBES (see Agenda 21 approach already in 1992 above). Experts can take the role of moderators, when they have certain knowledge, techniques of cooperation, and credibility as being appointed by the participatory group of equal partners.</p> <p>A subsection how to organize equal and participatory decision-making for biodiversity assessments and scenarios based on modelling is needed (see, for instance, Ash et al. (eds) (2010) Ecosystems and Human Wellbeing: A Manual for Assessment Practitioners. Island Press, Washington, D.C. http://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/109/original/EcosystemsHumanWellbeing.pdf?1398679213).</p>	Marcus Zisenis	In deliverable 3c there is a whole chapter on decision-making that explicitly deals with the critical issues raised by the reviewer. We refer to this chapter when formulating the decision making and policy context (also chapter 3) in which biodiversity models are developed.
168	4	413	1		10	IK should be in case study text box	UK Government	See comment 165
169	4	413	31			change 'will be especially crucial' to 'useful'	UK Government	Changed
170	4	413	37			change 'may well be' to 'is'	UK Government	Changed
171	4	413	39			delete just as well	UK Government	Changed
172	4	413	40			delete however	UK Government	Changed

N^o	Chap ter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
173	4	413	18	413	20	It seems rather difficult to scale up these local knowledge into regional scale.	Tohru Nakashizuka	Acknowledged.
174	4	413	12	413	13	We can't afford to say with certitude that indigenous are interpreters of changes in the environment. Sure they are good observers but their interpretations is more cultural's (religious) than to be scientific. They are still on the path to scientific interpretation. With data they produce we can trace the evolution of phenomena's More there is the necessity to understand the socio cultural gaps that is been created between generations due to modernization, rural exodus. This situation influence negatively the transmission of tools to observe and acquire local knowledge on biodiversity. Thus threatening facilities to collect primary data.	Nkue Nouwezem Daniel Jude	Acknowledged, but we do not see an objection to leave the text basically as it was.
175	4	414	27	414	31	The distinction between process-based models and mechanistic models is not clear to me. Please provide a more extensive explanation or a referenced definition of each category, without reference to a section elsewhere.	Aafke Schipper	We acknowledge that model typology is complex and prone to discussion over categories. We have tried to improve our discussion on what the categories include (4.2.3). Furthermore, the deliverable has now agreed to use a common basic terminology and model typology (See chapter 1) and we go now (in our chapter in the explicit recognition pf the distinction between process-based and mechanistic models in biology.
176	4	414				The distinction between mechanistic and process-based models as defined in this chapter remains unclear. Process-based models are, in the paragraph from lines 20-25 listed as having parameters with a 'clear ecological interpretation', yet, in the subsequent paragraph, only mechanistic models 'do not use phenomenological approaches for parameterization.' (implying that non-mechanistic process-based models do). There is a link to Section 4.3.1.1 but it is not made any clearer there. Please clarify.	Derek Tittensor	See previous response to comment 175.
177	4	414	419			4.2.5 The model continuum is not just between correlative and process-based approaches. Expert-based systems are part of the "spectrum" too.	Robert Dunford	See also comment 95. We acknowledge that

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						<p>I would like to see more nuance here too – and I’m not sure the spectrum helps.</p> <p>There is a difference between how the model works (statistics, decision tree, box model etc.), its approaches to process (inductive vs deductive) and how variables are quantified (statistical, measurement, expert-based). A process-based model may well have statistical-model-based parameters (or even processes) embedded within it, likewise both will certainly have expert-based information embedded (in terms of the variables included in a regression for example).</p> <p>There are lots of generalisations in these sections that are not flagged as such. The primary difference (inductive vs deductive approach to process) is not made explicit. The basic advantage of statistical models is there is no need for a fundamental understanding of the ecosystem and relationships can be inductively derived from the data. With process-based models there is a deductive process where the process is determined, relationship derived, quantified and modelled. There are both simple and complex statistical and process-based models. Aren’t neural networks statistical...</p> <p>Figure 4.5 is not helpful. It is over simplistic and, if used, needs to clarify, clearly, that it refers to minimum data requirements rather than suggestions for where the models are more appropriate. (i.e. statistical approaches won’t work where there is little data. But both correlative and process-based approaches will work with a lot of data. Agree with the ecological knowledge bars.</p>		model typology is complex (See above). But deliverable has now agree to use a common basic terminology and we go now in more depth into recognizing the distinction between process-based and mechanistic models in some sections (4.2.3) as well as explicitly introduce the basic difference between inductive vs deductive approaches (section 4.2.3).
178	4	414	2			delete in the elicited information and	UK Government	Changed
179	4	414	5			delete however	UK Government	Changed
180	4	414	22			delete here	UK Government	Changed
181	4	415	416			Is “correlation-based” approaches the best term. I prefer “Statistical” as it is more commonly used and is more inclusive w.r.t. non-process-based quantitative models. Chose whichever term has more traction and if evenly split go for the more inclusive and be consistent.	Robert Dunford	See definitions in chapter 1. We kept mainly the term correlative but now acknowledge that term statistical is also used in this context (first paragraph section 4.2.3).
182	4	415	1			Add sensitivity testing to the table- verification?	UK	Acknowledged.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
							Government	
183	4	415	9			In climate change the term 'project' rather than 'predict' is always used there is no statistical predictions associated with the model outputs (usually) I think it would help to use the terminology of “projection” consistently. It also helps when coming to talk about uncertainty. See p415 Line and p422L20 for correct terminology. Indeed there is a mix of use of the two terms in this chapter, with predict predominating. If the decision is taken to keep with “predict “then it needs clearly defining at the outset.	UK Government	We have changed prediction to projection in most cases (i.e. referring to biodiversity model outputs in a future temporal dimension). However, prediction is also used when refereeing to models outputs in a more general way.
184	4	415	2	415	3	Needs more explanation. E.g. What are the little grey boxes between Distribution 1 and Distribution 2?	Franziska Schrodt	Represent biological processes determinant changes in distribution.
185	4	416	1	416	10	I would move the discussion of issues to consider when modelling further down, after the model inventory (see also earlier comments). Further, I would not only present the issues as such, but rather discuss them in the light of the model inventory. So, how do the different models compare on these issues? For example, all models of course require information and all model predictions come with uncertainties; a more relevant question in the current context is how the different models compare in their information needs and sources and magnitude of uncertainty. Should process-based models come with both larger data requirements and larger uncertainties in future projections, then we have a strong argument to prefer pattern-based/correlative models for assessments of future biodiversity.	Aafke Schipper	Table moved further down after introduction of main model types (end of section 4.2.3). We have tried to explicitly deal with issues summarized in the table, but due to space constraints this was not possible to be completed comprehensively or in detail.
186	4	416	Table 4.2			It would be helpful to separate out relevant into issues into these pertinent to correlative and process-based models – by having two columns.	UK Government	We have finally decided not to do that because it is not always easy to derive separate implications for the two ends of the continuum. Some examples are however mentioned in the chapter (i.e. sections 4.2.3.1 and 4.2.3.2).
187	4	416	1	416	1	The table caption is not appropriate. This table shows issues which are inherent to most modelling approaches, it does not compare correlative with possess	Franziska Schrodt	Changed to “Summary of aspects to be

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						based models.		considered during the model building process”
188	4	417	14	417	20	Isn't the appropriate spatial scale also dependent on the response variable? I would think that it changes with the level of biological organization of the response variable, and perhaps even within a level (e.g., within the population level it may change with the species considered). Further, you discuss only correlative models here; how is this for process-based models? Would be could to provide a more extensive description of the scale issue in the overview of issues to consider when selecting an approach.	Aafke Schipper	We are now more explicit on recognizing that the application scale is related to the level of biological organization and response variables used.
189	4	417	22	417	30	Here three different aspects are discussed (spatial resolution, temporal dynamics, endpoint (single species). Please relocate to appropriate sections.	Aafke Schipper	Changed.
190	4	417	32	418	28	Please discuss the potential for future projections in the context of issues to consider when selecting a model (see also earlier comments). Also, I believe that Araújo et al. 2005 (Glob Ecol Biog) and Thuiller et al. 2005 (PNAS) suggest that correlative models (SDMs) perform quite well in temporal projections; might be worth to check these papers.	Aafke Schipper	Changed.
191	4	417				(minor point) whilst it is true that statistical models can't move beyond their training data it for some regional studies statistical models can use wider geographical datasets to extend their applicability beyond their range (e.g. Pearson and Dawson) – hard to do this with a global model though!	Robert Dunford	Acknowledged
192	4	417				Spatial auto-correlation of datasets is often a big problem with these kinds of models. It's worth flagging it.	Robert Dunford	Acknowledged. However, discussion of autorrelation issues is beyond the scope of this chapter. However, issues related to spatial autocorrelation can be found easily in the literature and in some of the reviews /papers cited in the chapter.
193	4	417		38	40	In the correlative models section: “alternative processes based explicitly on mechanisms” – sounds process-based to me. Clarify?	Robert Dunford	Acknowledge and sentence deleted in the new version of the ms. However, we think that this is a good example of why we consider the space between correlative and process-

Nº	Chap ter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
								based a continuum rather than the result of a clear-cut division.
187	4	417	22	417	30	Why will advances in marine correlative modelling require coupling of different trophic levels??? There are very few people trying marine correlative modelling anyway, so how can you know that's the only route to advances. And why should this be so only in marine systems. All this paragraph should say is that what you call "correlative modelling" has not been done much for marine systems, yet, and give a reference. However, please also note that there are thousands of other forms of "correlative modelling", that, for example, do not attempt to model spatial distributions. At some point above you should be more specific about what you mean by this term.	Axel G. Rossberg	Acknowledged and reformulated (moved to section on models of interaction networks, 4.3.1.4.2).
188	4	417	36	417	38	Also, species ranges are often determined according to "expert range size" and ignore sivicultural and other anthropogenically managed distributions which allows species to establish where they might not naturally be able to grow.	Franziska Schrodt	Acknowledged
189	4	418	36	419	19	Why do you discuss process-based models only for the ecosystem level here?	Aafke Schipper	Changed and ecosystems deleted.
190	4	418	20	418	23	While this is likely true, most of the literature seems to suggest that it is statistical correlative models that should not be used to predict to novel conditions, not process-based models. Here it is implicitly implied that this is not the case.	Derek Tittensor	Acknowledged and sentence deleted. We agree that literature suggests that correlative models are in fact less suited for projections (and we acknowledge this explicitly in the section).
191	4	418	16	418	17	Where are these purposes stated?	Axel G. Rossberg	Acknowledged and sentence deleted.
192	4	418	20	418	21	"it should also be clear that the capabilities of process-based models with regard to predicting impact of anthropogenic impacts on biodiversity and ecosystems is uncertain" The class of process-based models is much too broad for such generic statements. I can think of many process-based models which clearly can predict impacts. Even impacts of impacts.	Axel G. Rossberg	Acknowledged and reworded.
193	4	418	30	418	34	Models also (wrongly?) assume that systems are in equilibrium.	Franziska Schrodt	Acknowledged.
194	4	419	14	419	15	No, size is not a good predictor of TL (to understand why, see Chapter 19, of Rossberg, A. G. (2013). Food Webs and Biodiversity: Foundations, Models, Data. Wiley. ISBN 9-780470973-55-4), and Jennings et al. (2001) do not show this. They say size is NOT a good predictor of TL. You don't need this statement here at all. All you need to say is that many predators are size	Axel G. Rossberg	Acknowledged and corrected according to the suggestion.

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						selective (however, see, Naisbit, et al. (2012). Phylogeny versus body size as determinants of food-web structure. <i>Proceedings of the Royal Society B</i> , 279(1741), 3291—3297).		
195	4	419	16	419	17	“... though from a management perspective there may be more interest for species than for size per se.” There is an entire family of size-based indicator used to assess marine community structure, so certainly size per se is of interest, and questions related to these indicators have been addressed using size-based models [e.g. Houle et al. (2012). Assessing the sensitivity and specificity of fish community indicators to management action. <i>Canadian Journal of Fisheries and Aquatic Sciences</i> , 69(6), 1065—1079.]	Axel G. Rossberg	Acknowledged. Reworded to incorporate comment.
196	4	419	19	419	19	The model of Shin and Cury (2001) is size structured in the sense that size matters in the model, but it is not a “box model” with individuals assigned to different size categories, the kind of model you are discussing here. So Shin and Cury (2001) is not the ideal example. How about referring to this instead: Blanchard et al. 2014. Evaluating targets and trade-offs among fisheries and conservation objectives using a multispecies size spectrum model. <i>J Appl Ecol</i> 51, 612–622. doi:10.1111/1365-2664.12238 ? Shin and Cury (2001) belong to the category of individual-based models, of which I am not sure you did cover it at all.	Axel G. Rossberg	Changed.
197	4	419	20	419	20	The section on process-based models is missing the entire category of community assembly models. In assembly models, ecological communities are constructed by iteratively letting randomly selected species invade and simulating population dynamics, usually until an equilibrium between invasions and the resulting extinctions of other species is reached. Contrasting conventional box models, assembly models can resolve communities at species resolution and so describe community-level phenomena more reliably [Rossberg, A. G. (2013). <i>Food Webs and Biodiversity: Foundations, Models, Data</i> . Wiley. ISBN 9-780470973-55-4], even though they do not generate species-by-species representations of actual communities. Community assembly models have traditionally been used to address general theoretical questions of community structure, dynamics, and stability [Post, W. M. and S. L. Pimm, 1983. Community assembly and food web stability. <i>Mathematical Biosciences</i> 64:169–192.]. Only recently realistic assembly models of marine communities were developed and used to model regional time-dependent responses of marine biodiversity to anthropogenic impacts [Shephard et al. (2012). Size-selective fishing drives species composition in the Celtic Sea. <i>ICES Journal of Marine Science</i> , 69(2), 223—234. ; Fung et al. (2013). Why the size structure of marine communities can require decades to recover from fishing. <i>Marine Ecology Progress Series</i> ,	Axel G. Rossberg	Community level models are specifically treated in section 4.3.1.3.

N^o	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						484, 155—171. doi:10.3354/meps10305], and of biodiversity loss on ecosystem functioning and services [Fung et al. (2015). Impact of biodiversity loss on production in complex marine food webs mitigated by prey-release. Nature Communications, 6, 6657].		
198	4	419	25			delete key	UK Government	Changed
199	4	420	13	420	14	“Other processes such as regulation and evolution are critical to the maintenance of 13 biodiversity and ecosystems over time.” Here the expected, usual events /changes) on the surface of the sun should be included to these processes as they alter the ecological, magnetic, and climatic dynamics of the biggest ecosystem biosphere. Notice that biochemical synthesis (see Lehninger’s textbook of Biochemistry), let’s say plant foods synthesis start with the light of sun inside the leafs via photons transfer, called photosynthesis. In other words, space impacts ecosystem services (perhaps, even biodiversity, verification, diversification, mutation of species via altering light energy along with biomass synthesis, e.g. mainly for bacteria, mold, nematodes, plants, blue-green algae, viruses, Aves, Animalia, etc. provided by our world ecosystems.	Eyüp Yüksel	Acknowledged
200	4	420	3	420	3	Add “Risk of collapse” into the box for “Ecosystems” and “Composition” in Table 4.3	Thomas Brooks	Both variables (risk of collapse and extinction) can be assessed using variables already in the table (e.g. abundance).
201	4	420	3	420	3	Add “Extinction risk” into the box for “Species” and “Composition” in Table 4.3.	Thomas Brooks	Both variables (risk of collapse and extinction) can be assessed using variables already in the table (e.g. abundance).
202	4	420	3	420	3	Delete the bottom row from Table 4.3 – “Landscape” is not a level of ecological organization, but rather of the way in which humanity subdivides and characterises space.	Thomas Brooks	“Landscape level” renamed as “ecosystem level” (and “Ecosystem” removed from the previous row)
203	4	420	5	421	30	This entire section is written almost exclusively about ecosystem level components of biodiversity. It should be expanded and restructured to make clear that the remit of IPBES is to address biodiversity broadly, at genetic and species levels as well as at the ecosystem level. Characterising (and thence modelling) each of these levels of ecological organization is important for different decision contexts regarding biodiversity and ecosystem services, a point which has been made repeatedly elsewhere in the draft assessment.	Thomas Brooks	This section addresses the various levels of biological diversity and not just the ecosystem level.
204	4	420	10			If ecological services differ from ecosystem services then a definition should be	Brenda	Changed to “ecosystem

N^o	Chap ter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						provided. Otherwise best to use consistent terminology throughout the report to reduce linguistic uncertainty. Similar example occurs in Chapter 5, p. 508 lines10-12.	McAfee	services”.
205	4	420	5		9	Delete- digressing from modelling	UK Government	We have maintained this section to emphasize the potential characterization of biological levels and associated processes as key element in modeling of biodiversity and ecosystem functioning.
206	4	420	16		28	Delete- digressing from modelling into an essay on energy cycle through biosphere	UK Government	We have maintained this section to emphasize the potential characterization of biological levels and associated processes as key element in modeling of biodiversity and ecosystem functioning.
207	4	421	1		2	Delete- digressing from modelling into an essay on energy cycle through biosphere	UK Government	We have maintained this section to emphasize the potential characterization of biological levels and associated processes as key element in modeling of biodiversity and ecosystem functioning.
208	4	421	22			delete we identify, change to firstly	UK Government	Changed
209	4	421	27			In the second place change to secondly	UK Government	Changed
210	4	421	36	435	26	You could include the PREDICTS model too – this is a comprehensive statistical modelling approach for biodiversity responses to one driver (land use). The methodology can be applied more broadly if there is a known driver and biodiversity metrics of interest though. Hudson, L.N., et al . (2014) The	UK Government	Added.

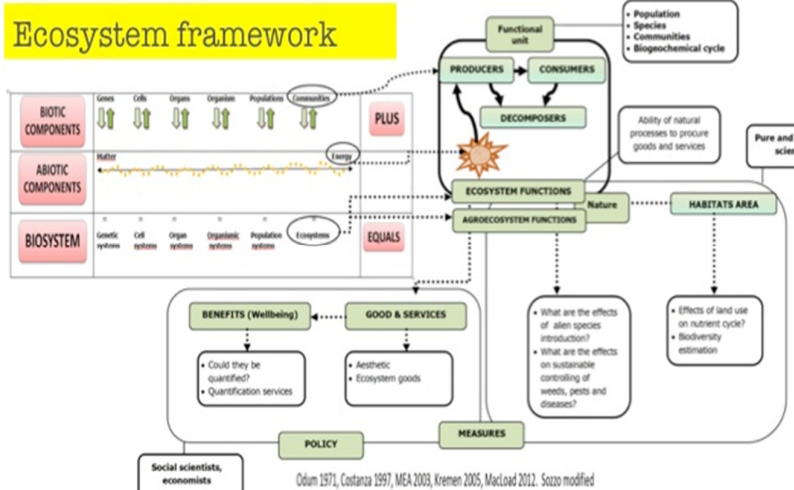
№	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						PREDICTS database: a global database of how local terrestrial biodiversity responds to human impacts. Ecology and Evolution, 4, 4701-4735. Newbold, T., & Purvis, A. (2015) Global land-use impacts on local terrestrial biodiversity. Nature.		
211	4	421	23	421	23	Maybe have to explain "traits" here?	Franziska Schrodt	Reworded to biological traits.
212	4	422	1	422	1	'from genes to the globe': I would not mix levels of biological organization with spatial extent.	Aafke Schipper	Changed to ecosystems.
213	4	423	7	423	10	"For example, models have explored the process of evolution to a new or altered environment in the face of migration from the rest of the species range (Gomulkiewicz et al. 1999). Such models can inform policy decisions about the maintenance of gene flow and migration corridors." Here the alternative or absolute ways to enhance and sustain evolution such as keeping corridors constant knowledge models, and the techniques, strategies for practical implementation of such directive evolutionary protection mechanisms should be clarified as well, and listed to be submitted related, responsible governments, local managements, and NGOs by the IPBES Working Groups and the IPBES Secretariat. FAO can work on Crop Wild Relatives (CWRs) located in natural habitats conservation for this. Particularly non-protected areas under cessation or interruption of normal evolutionary processes must be projected onto global programmes just like climate change mitigation efforts.	Eyüp Yüksel	Acknowledged. But beyond the possibilities of the chapter in terms of scope and space.
214	4	423	19	423	20	"Many evolutionary models focus on genetic changes within a single species. Clearly, it is useful to clarify what might happen in simplified scenarios before adding the complexity of species interactions." In addition to "What may happen?", "Which Ecosystem Services (ESS) would be affected most" should also be analyzed within the context of such scientific studies so as to be used efficiently, in an applicable easy-to-understand, and easy-to-implement way by the countries through linking them to present, and alternative (opportunity cost) policies.	Eyüp Yüksel	Acknowledged. ESS services discussion is the objective of chapter 5.
215	4	423	30			add 'what are selection processes and life strategies?'	UK Government	Added.
216	4	425	1	425	10	Populations move. Research of investigating which movements or which kind of movements are due to natural poulation dynamics acquired by evolution, and which componernts of factors causing movements beyon evolution due environmental interfering factors or to which extent the movements are interrupted by undesired climatic and environmental anthropogenic factors should be differentiated to make this topic applicable concretely for governments and nature conservationists. Not only island ecology, but also continental movements could also be analised to clarify a backbone of the main movement types to be used by IPBES in due course. Here, large herbivores and in particular bird poulation large sacel, long distance migrations and epidemic	Eyüp Yüksel	Acknowledged. But beyond the possibilities of the chapter in terms of scope and space.

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						diseases could be discussed and spatially elaborated on the earth in terms of lost and win of ecosystem services IPBES mostly involved, whether regulatory or provisional. "Specialized pathogens also might constrain diversification if rates of host switching were to increase in proportion to the diversity of hosts and their pathogens." (Ricklefs, 2009).		
217	4	425	15			"model suites such as BIOMOD" are only useful in the situation of presence only data, if there is a presence only model included. Model suites or ensemble modelling is more generally applied to overcome some of the uncertainty coming from the models	UK Government	Acknowledged. But in the level of detail on specific SDM types has been greatly reduced and the reference to BIOMOD deleted.
218	4	425	41	425	41	"Artificial intelligence" should be "machine learning". This category includes many other SDMs, such as e.g. Random forests.	Franziska Schrodt	See comment 217
219	4	426	31	427	21	How does Box 4.1 relate to the main text? What is the purpose of presenting this case study?	Aafke Schipper	Boxes with examples have been now deleted.
220	4	426	5			Cross-reference chapter 2 in this section	Paula A Harrison	We did not find the place to make the requested cross-reference (chapter 2 on decision making) in this section. Sorry.
221	4	426	31	426	31	Add scientific name <i>Lynx pardinus</i> and cite assessment Rodriguez & Calzada (2015) http://www.iucnredlist.org/details/full/12520/0 .	Thomas Brooks	Boxes with examples have been now deleted.
222	4	426	14	426	15	All other SDMs can be used if pseudo-absences are generated which is straight forward and implemented in many software applications (e.g. R)	Franziska Schrodt	See comment 217
223	4	426	1	426	3	also, SDMs rely heavily on good input data in form of species presence (absence) which is currently not available for many target species.	Franziska Schrodt	Acknowledged (see also 4.2.3.1).
224	4	428	5	428	5	Did you consider including the GLOBIO model within this category?	Aafke Schipper	Added.
225	4	428	4	428	4	Add a Section 4.3.1.3.2 on "Species extinction risk". This should discuss the IUCN Red List Categories and Criteria, which have rigorous scientific underpinning (Mace & Lande 1991 Conserv Biol, Akçakaya et al. 2001 Conserv Biol, de Grammont & Cuarón 2006 Conserv Biol, Mace et al. 2008 Conserv Biol), clear application at national levels (Gardenfors et al. 2001 Conserv Biol, Miller et al. 2007 Conserv Biol, Zamin et al. 2010 Conserv Biol), and numerous applications for decision support in policy and practice (Rodrigues et al. 2001 TREE) and indicator mobilisation (Butchart et al. 2004 PLoS Biol, Butchart et al. 2005 Phil Trans R Soc Lond B, Hoffmann et al. 2010 Science, Butchart et al. 2012 PLoS ONE), and which has been applied to assess extinction risk for >70,000 species (with repeat assessments spanning the last	Thomas Brooks	We consider these applications of biodiversity models and have not been included in the present version of the chapter.

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						<p>three decades for many of these). One of the Red List criteria (the “E criterion”) is based on extinction models (e.g., PVA) directly, while the other four are based on threshold approaches. (Box 6.1 in Chapter 6 gives a good example of why this approach is so important to reflect here.)</p> <p>Carlo Rondinini (CLA Chapter 6) or Resit Akcakaya (CLA Chapter 8) are both experts in the field; either of them would easily be able to provide such text; or I would be happy to do so.</p>		
226	4	430	20	430	20	For the purposes of IPBES, it may be worth adding here applications to predict BEF relations: Fung et al. (2015). Impact of biodiversity loss on production in complex marine food webs mitigated by prey-release. Nature Communications, 6, 6657.	Axel G. Rosenberg	Added.
227	4	430	22	430	43	<p>4.3.1. Species traits approaches: to provide an example for non terrestrial environments see a nice recent work on traits for Benthic community on ESP Science of the Total Environment 506-507 (2015) 594–603 Integrating the provision of ecosystem services and trawl fisheries for the management of the marine environment</p> <p>Alba Muntadas, Silvia de Juan, Montserrat Demestre</p>	Sandra Luque	Acknowledged but not possible to include due to space constraints.
228	4	430	22	43		A general comment is that this chapter provides an excellent review of modelling approaches organised by the nature of the model. But it does not really address how to decide what is appropriate for any particular issue of concern. It is more like a text book than a guide for users. There is a good general overview of how to link response and effect traits in Diaz et al (2013) Functional traits, the phylogeny of function, and ecosystem service vulnerability. Ecology and Evolution, 3, 2958-2975.	UK Government	Acknowledged. We have tried to improve the chapter structure to facilitate potential guidance on biodiversity model understanding.
229	4	431	22	431	23	Note that these lines repeat lines 8-9 on the same page.	Aafke Schipper	Repetition deleted.
230	4	431	26	432	17	It would be helpful to describe some examples of such hybrid models, as the current text is a bit abstract.	Aafke Schipper	Examples already cited but space does not allow detailed description.
231	4	431	43	432	2	But are occupancy models actually hybrid models...? I would think that models of occupancy or habitat suitability belong to the pattern-based/correlative models.	Aafke Schipper	Deleted in the new version to save space. However, the original sentence referred occupancy models from the metapopulation literature (process-based like).

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
232	4.3.1.4.4	431	2	431	23	It is important to mention that the slope of the species-area relationship is highly dependent on the ecosystem (Tab. 1 in Kier et al. 2005 J. Biogeography), the group of organisms (Patiño et al. 2014 Global Ecol. Biogeogr), heterogeneity of the landscape, and even the scale of the study (Triantis et al 2012).	Jens Mutke	Acknowledged.
233	4.3.1.4.4	431	8	431	23	Lines 8-9 are repeated in lines 22-23.	Jens Mutke	Changed
234	4	431	1	431	23	Also important to note work done to validate projections from application of SARs, e.g., Pimm & Askins 1995 PNAS, Pimm et al. 1996 Science, Brooks et al. 1997 Conserv Biol, Brooks et al. 2002 Conserv Biol.	Thomas Brooks	Acknowledged.
235	4	431	24	431	24	I think that a section is missing between Sections 4.3.1.4 and 4.3.1.5 on ecosystem level approaches. This should include a paragraph to discuss the emerging Categories and Criteria for the Red List of Ecosystems, citing in particular Keith et al. (2013) PLoS ONE, as well as the Boitani et al. (2014) Conserv Lett critique of this.	Thomas Brooks	We consider these applications of biodiversity models and have not been included in the present version of the chapter.
236	4	431	25	432	17	Another set of work which should be reflected in Chapter 4, and would likely fit best here in Section 4.3.1.5, is the identification of sites contributing significantly to the global persistence of biodiversity, or “key biodiversity areas” (Eken et al. 2004 BioScience). This encompasses numerous widely-used approaches such as Important Bird Areas (e.g., Butchart et al. 2012 PLoS ONE) and Alliance for Zero Extinction sites (Ricketts et al. 2005 PNAS). Again, this work can utilise both threshold-based approaches and comprehensively quantitative irreplaceability modelling. A global standard uniting such approaches is currently being finalised by IUCN (see http://www.kbaconsultation.org).	Thomas Brooks	Acknowledged. But this proposed section not clearly within the scope of the chapter. Such a section could be interpreted more like an application of biodiversity models in a particular decision context (protected areas)
237	4	432	4	432	17	Paragraph is exact, but how many countries have the capacity to perform this task? Beside software, massive training and monitoring on performance is needed.	Mahmood Yekeh Yazdandoost	Acknowledged and reflected in key findings and recommendations.
238	4	432	4	432	17	Here I get a bit lost. How is this list of model approaches related to the topic of this section? Are these all hybrid models? If so, would be good to explain and specify how pattern and process are actually combined/integrated in these models.	Aafke Schipper	These are just examples of models integrated in hybrid approaches including references to hybrid model applications.
239	4	432	19	433	24	- Why are the DGVMs discussed in a text box only? - Did you consider including the MADINGLEY model in this category?	Aafke Schipper	Changed and discussed in the text “Madingley” now incorporated in the table 4.3.
240	4	432	26	436	2	I wonder whether IAMs should actually be included in this model inventory,	Aafke	Acknowledged.

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						given that current IAMs are not designed to model biodiversity (page 433 lines 9-10) and given that the biotic component of IAMs is typically represented by a DGVM, while DGVMs are already described in the preceding section. Wouldn't it be more appropriate to consider IAMs as a source of input data (i.e., future levels of environmental drivers)? Or (briefly) describe IAMs in the recommendations section, as they have the potential for biodiversity components other than DGVMs to be included?	Schipper	However this issue was discussed at the author's meeting in Beijing with CLAs from chapter 6 and the section has been slightly corrected but maintained in chapter 4.
241	4	432	20	432	41	Should be interesting to mention the recent effort of the DGVM community to improve representation of biodiversity and plasticity of functional traits. See for example Verhenjen et al. 2013, Sakscewski et al 2015.....	Nicolas Viovy	Acknowledged but space did not allow the inclusion of further detail on this topic.
242	4	432	20	433	24	Should also discuss disadvantages of DGVMs, e.g. Overly simplistic PFTs which result in misrepresentation of large vegetated areas especially in the tropics (only 2 tropical PFTs when there are more than 6 kind of savannas recognised alone).	Franziska Schrodt	Acknowledged but space did not allow the inclusion of further detail on this topic.
243	4.3.1.7.	433	26	2	436	A practical concrete example would be helpful how the integrative modelling of different demands on and values of biodiversity has or could lead to "balanced trade-offs" of biodiversity and ecosystem functioning in the future according to different scenarios.	Marcus Zisenis	Noted. However due to lack of space (since the chapter is far longer than the desired length, unable to include a reference
244	4	433	26	436	2	Section on IAMs needs integrating with other similar descriptions in preceding chapters. This is a good overview and figure (4.10) which would probably be better introduced in chapter 3 and this section could just focus on how IAMs model natural vegetation and cross-reference chapter 3 for the general description.	Paula A Harrison	Noted, we feel (after conversations with CLAs from chapter 6) that IAMs fits well in this chapter, since we list all the modeling approaches.
245	4	433	15	433	19	DGVMs have been also widely used (as it was probably their first aim) to study feedback between vegetation and climate on past climate (last glaciation, mid holocene (green sahara, see results from PMIP for instance)	Nicolas Viovy	Accepted. Text added
246	4.3.1.6	433	1	433	2	Another structure of biophysical dimension see framework	Sara Sozzo	Noted. However due to lack of space (since the chapter is far longer than the desired length, unable to include an additional ecosystem framework

№	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						 <p>Ecosystem framework</p> <p>The diagram illustrates the flow from genetic systems to functional units. It is divided into three main horizontal sections: BIOTIC COMPONENTS (Genes, Cells, Organs, Organisms, Populations, Communities), ABIOTIC COMPONENTS (Water, Energy), and BIOSYSTEM (Genetic systems, Cell systems, Organ systems, Organisms systems, Population systems, Ecosystems). A central box labeled 'PLUS' connects the biotic and abiotic components to the 'Functional unit' (Producers, Consumers, Decomposers). Below this, 'ECOSYSTEM FUNCTIONS' and 'AGROECOSYSTEM FUNCTIONS' are shown, leading to 'GOOD & SERVICES' and 'BENEFITS (Wellbeing)'. The diagram also includes 'HABITATS AREA' and 'MEASURES'. A box at the bottom left mentions 'Social scientists, economists'. Citations at the bottom: Odum 1971, Costanza 1997, MEA 2003, Kremen 2005, MacLeod 2012, Sozzo modified.</p>		
247	4	434		9	11	<p>“IAMs could potentially be a valuable tool for modelling biodiversity dynamics under different drivers; however, current IAMs are not developed for this application”</p> <p>The focus here seems to be very much on global modelling. If this is the intention it should be made explicit. There are regional examples that address some of the issues raised. E.g. our own work with the CLIMSAVE model at a European scale addresses the impacts of both climatic and socio-economic change on biodiversity and other ecosystem attributes and services. (see. ◦Harrison, P.A., Dunford, R., Savin, C., Rounsevell, M.D.A., Holman, A.S., Kebede, A.S. and Stuch, B. (2015) Cross-sectoral impacts of climate change and socio-economic change for multiple, European land- and water-based sectors. <i>Climatic Change</i>, 128(3-4).)</p>	Robert Dunford	Accepted. Text modified.
248	4	434	29	434	36	<p>A good example of an IAM is the CLIMSAVE IAP, albeit just for Europe. It not only integrates sectoral models but also has feedbacks and can be used to explore the impacts of selected adaptation options. There was a Special Issue of <i>Climatic Change</i>, 128(3) and many of the papers are relevant e.g. An overview is in Harrison, P.A., Holman, I.P. and Berry, P.M. (2015) Assessing cross-sectoral climate change impacts, vulnerability and adaptation: an introduction to the CLIMSAVE project. <i>Climatic Change</i>, 128(3-4): 153-167.</p>	UK Government	Accepted. The text and the reference added
249	4.3.2.2.	437	24	437	25	<p>Some explaining words would be needed that the future development of biodiversity (nature and landscapes) depend on the subjective decision of the public how they want it, apart from uncertainties of the real development. It is</p>	Marcus Zisenis	These consideration form part of the decision context of the

N ^o	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						not a question to be solved by natural sciences or “experts”. This common decision needs to be included as guidelines of different scenarios based on modelling. For instance, Central Europe consists almost entirely of cultural landscapes, which have developed human land-use dependant ecosystems, habitats, and species as cultural followers.		deliverable introduced in chapter 2.
250	4	437	16	437	17	If accurate models do not exist, the question is raised why we are putting so much effort in developing them... Perhaps phrase a little differently to make the statement less bold?	Aafke Schipper	Reworded to accommodate the comment.
251	4	437	29	437	33	Perhaps better save this for the recommendations section?	Aafke Schipper	Decided to keep in this section.
252	4	437	28	438	5	Could be indicated that MIP project, by providing to a wide community a set of coherent simulations, also stimulated a large number of scientific studies using these simulations but not directly related to their intercomparison A good example is the TRENDY project in the frame of the global carbon project that conducted to numerous studies publishes including some in Nature and Science	Nicolas Viovy	Acknowledged. But space constraints did not allow to expand on the CMIP related topics.
253	4	437	15			4.3.2.2 Heading - see comment on use of predictability for p415 L9	UK Government	Acknowledged.
254	4	438	13	438	14	Why is comparison with validation data no formal test of model performance? What would be a better test? Further, why would models that perform equally well in fitting a test set lead to different policy implications? Would be good to better explain/underpin these statements.	Aafke Schipper	Statements deleted.
255	4	438	16	438	16	<i>‘As an example’</i> : an example of what? Not the preceding sentence I guess? Please specify.	Aafke Schipper	As an example of a model validation exercise.
256	4	438	28	439	4	I would move this part to the recommendations section.	Aafke Schipper	Discussed but finally decision was made to leave it in this section.
257	4	439	7	441	32	Although this section makes an interesting read, the purpose of this (rather long...) overview of examples of biotic feedbacks is not quite clear. To highlight the relevance of biotic feedbacks, a short paragraph with a set of appropriate references could suffice. In the context of this chapter, I would expect biotic feedbacks to be discussed in relation to the inventory of model approaches. Do any of the models you described before account for biotic feedbacks? If not, why not? Which models are most suited to possibly incorporate feedbacks? Does that depend on the type of model (pattern-process) or on the endpoint (level of organization)? If there are currently hardly any models that incorporate biotic feedbacks while there’s evidence that feedbacks strongly modify responses, then I would integrate this section in the recommendations section later on.	Aafke Schipper	Agreed. The last paragraph completely re-written The comment noted for taking this to the recommendation section
258	4	439				Perhaps swap section 4.4 and 4.5 to improve flow of ideas. This would flow	Shane	Discussed among

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						better from the methodological focus of 4.3. (Modelling approaches). Currently 4.4 (Modelling biodiversity feedbacks and interaction) contains fairly detailed ecological information for consideration which would fit in nicely after attention a more general consideration of model complexity issues (currently 4.5).	Orchard	authors but decided against restructuring
259	4	439				Note sub-heading 4.4.1 is not needed. It could be incorporated within the section title if desired eg “Modelling feedbacks and interactions between biodiversity, the human systems and non-human environment”. Another option might be to combine sections 4.4 and 4.5 eg 4.4 Model complexity > 4.4.1 Handling increased complexity; 4.4.2 Modelling feedbacks and interactions.	Shane Orchard	Accepted
260	4	439	9	439	26	The paragraphe is related to interaction between biodiversity an environnement but the example cited (i.e dieback of tropical forest or increase of forest cover in boreal zone) is in fact related to biome shift and not change in biodiversity ?	Nicolas Viovy	Noted, comment not relevant to the paragraph.
261	4	441	27	441	27	Why is Burton 1993 not in the reference list?	Aafke Schipper	Noted, Unable to locate the appropriate reference, thus DELETED
262	4	441	34	441	38	Please specify the feedback mechanism(s) modelled here. How do the biota feedback on the environment?	Aafke Schipper	Agreed. The last paragraph completely re-written to include this suggestion
263	4	442	3	442	5	The sentence is not an accurate representation of the content of the cited article. More correct would be something like “The high inherent complexity of ecological and societal systems presents considerable challenges for predicting future responses of biodiversity and ecosystems to direct drivers (Petchey et al 2015).”	Owen Petchey	
264	4	442	3	442	5	I found this text to be quite poorly representing the scientific literature. Perhaps something more like: “One of these challenges is formulating models of appropriate complexity. On the one hand, highly complex models can represent more the processes that occur in reality, and thereby have the potential to make more accurate predictions than less complex and thereby realistic models (cite Evans, M.R., Grimm, V., Johst, K., Knuuttila, T., de Langhe, R., Lessells, C.M., Merz, M., O’Malley, M. a, Orzack, S.H., Weisberg, M., Wilkinson, D.J., Wolkenhauer, O. & Benton, T.G. (2013) Do simple models lead to generality in ecology? Trends in Ecology & Evolution, 28, 578–583.). On the other hand, complex models can be much more sensitive (i.e., small uncertainties in the model can create large uncertainty in predictions) than simple ones. Balancing model realism with certainty in predictions (i.e., predictive capability) is a key	Owen Petchey	Suggestion incorporated.

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						area for model development, and can greatly benefit from careful, explicit definition of the purpose of a model and criteria for when the model is good enough to be useful. Making these definitions will require input from stakeholder and policy. Strategies for dealing with model complexity follow.”		
265	4	442	36	442	37	The text states that three general strategies will be described, but as far as I can see, there are only two.	Owen Petchey	Changed
266	4	442	35	442	37	I would advise some general text about formulating models that are as simple as possible, while still meeting stakeholder and policy needs, and therefore including in the "Handling of complexity" specification of model output requirements by stakeholders, and testing of models of different complexity (or even type, e.g., process-based versus correlative) against this requirements. The simplest models that meets the stakeholder requirements is the one to use.	Owen Petchey	Concern added.
267	4.5.1.	442	34	444	20	A practical example would be helpful to allow better following the considerations.	Marcus Zisenis	Space limitation have made this impossible.
268	4	442	11	442	14	This is an important notion! How general is this finding? Is this the result of a particular case study or a common phenomenon?	Aafke Schipper	Changed to indicate generality.
269	4	442	1	444	20	As said before, I would integrate this section in a new section discussing the various issues to consider in model development/selection. Also, this section relies heavily on SDMs, while the issue of complexity applies to the other models as well.	Aafke Schipper	After careful consideration we have finally decided to keep the section on model complexity although we have tried to decrease its reliance on SDMs examples.
270	4	442	36	442	37	Isn't the vital issue how to define the optimal level of complexity rather than just limiting complexity? Besides, you discuss two rather than three strategies.	Aafke Schipper	Correct by saying two rather than three .
271	4	442	1	442	18	I am not totally agree with the arguments given in this paragraph. I think this is not the complexity of processes and the number of parameters which is important. This is the sensitivity of model to these parameters and how it varies from one vegetation to another. a simple parameterization can in fact mask the underlying processes and been decoupled from biological process. This can be also challenging to communicate because they are not related to known processes and in some case cannot be compared to observation. A good example is the representation of photosynthesis in vegetation models. It was progressively replaced from empirical relationships to the complex Farquhar model. In principle there is more parameters but in fact most of them are mostly similar among species because model is very generic. Then there is no more varying parameters than in a more empirical model and it can be compared to direct measurements and not calibrated from indirect observations. Moreover it	Nicolas Viovy	Acknowledged. However, due to space constraints we decided not to include this discussion in the section.

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						allows to take into account between the non linear feedback between drivers (temperature, co2) whereas empirical models consider a decoupling between the drivers.		
272	4	443	7	443	7	Reference should be to Box 4.3	Aafke Schipper	Changed
273	4	443	27	444	2	I don't see how this paragraph relates to the central topic of this section. What are the implications of movement and biotic interactions in terms of optimizing model complexity?	Aafke Schipper	Section deleted.
	4	443	36	443	38	Numerical and theoretical studies find that, due to biotic interactions within communities, equilibrium population sizes of species are highly sensitive to pressures [you call this "impacts"?] and so inherently difficult to predict [Yodzis, P., 1988. The indeterminacy of ecological interactions as perceived through perturbation experiments. Ecology 69, 508–515; Section 18.1.3 in Rossberg, A. G. (2013). Food Webs and Biodiversity: Foundations, Models, Data. Wiley. ISBN 9-780470973-55-4].	Axel G. Rossberg	Acknowledged.
274	4	443	27	444	2	These two paragraphs are not about handling complexity but rather represent elements that could/should be built into models and which can contribute to complexity. They are touched on elsewhere in the chapter and the text should be moved there.	UK Government	See previous comment 272
275	4	444	23	448		I would integrate this section in a new section discussing the various issues to consider in model development/selection (similar to the previous section).	Aafke Schipper	Suggestion noted. However due to lack of space unable add new content
276	4	444	33	444	37	This example is poorly related to the preceding statement.	Aafke Schipper	The paragraph below is added to this paragraph and that solves this confusion
277	4	444	39	445	12	Do the examples listed here reflect uncertainty, model complexity or both? And why do you refer only to IAMs here? I think it is important to start off the discussion of uncertainty in model predictions by distinguishing model uncertainty and parameter uncertainty and explaining the trade-offs between uncertainty and complexity. I'm not an expert on uncertainty assessment, but I would expect that increased complexity may reduce model uncertainty by including more processes/factors, while this may increase the influence of parameter uncertainty because it requires more input data. Would be good to make explicit such trade-offs.	Aafke Schipper	Agreed. The paragraph modified
278	4	444		25		Agree very much with the first para here. It might be worth adding that environmental complexity is an emergent property of the environment – it's not just that our models are limited in what they can do its that the environment is incredibly complex and interconnected.	Robert Dunford	Agreed. Text added

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
279	4	444	23	449	39	Section 4.6 Accounting for uncertainty This section is very important, as it relates directly to the level of confidence in the models and their predictions. The section is succinct and well-written. I recommend including (e.g. in Section 4.6.2) a comment on the need for identification of key bifurcation points and decision nodes in models and scenarios, and the need to monitor the system as it approaches these nodes to verify system behaviour. More generally, model and scenario uncertainty can be reduced by monitoring the system and, if needed, making adjustment to the model, i.e. the process of data assimilation . This latter term does not seem to appear in this report, but it should be an important component of modelling dynamic systems over time to help reduce uncertainty in model outputs.	Ian Perry	Agreed. Text added
280	4.6.1.	445	14	448	41	The practical consequences of different sources of uncertainty should be made more clear, last not least of inherent dynamic open ecosystems and related (subjective) values of them itself. A practical example would be helpful to predict in different scenarios based on modelling certain limited indicators such as groundwater recharge of cities depending on the degree of soil sealing and direct and indirect biodiversity values (ecosystem services) of them.	Marcus Zisenis	Noted. However due to lack of space unable add new content
281	4	445	16	448	40	I wonder whether communication uncertainty, lack of clarity and outcome uncertainty are actually relevant to consider here, as these are not directly related to the uncertainty of the model outcomes. I would suggest leaving out these three issues (and the figure). Further, as said earlier, I would start off the discussion by distinguishing parameter uncertainty (resulting from natural variability and observation error) and model uncertainty (resulting from structural complexity), as these have different implications and inherent trade-offs.	Aafke Schipper	Suggestion noted. Text modified as per the suggestion
282	4	445	22			General point (not just chapter 4): The sections on uncertainty need to use more consistent terminology and structure. One option would be to only focus in chapters 3, 4 and 5 on very specific aspects of uncertainty of relevance to the chapter, then bring the wider discussion and all the different elements of uncertainty across all types of models and scenarios together in chapter 6. This might avoid some repetition and inconsistency. A similar statement could be made about the sections in each chapter on communication.	Paula A Harrison	Suggestion noted
283	4	445				4.6.1 These are not all the aspects of uncertainty to be considered in ecosystem modelling, particularly in a context that includes integrated assessment modelling. Model uncertainty and scenario uncertainty should be addressed.	Robert Dunford	Agreed. Text added
284	4	445				We have done some novel work looking into understanding model uncertainty in a European scale integrated assessment model that provides species distribution outputs that may be helpful here. We used a mixed-method approach to uncertainty assessment that combines formal numerical approaches, modeller interviews and network analysis are combined to provide a holistic uncertainty assessment that considers both quantifiable and un-quantifiable	Robert Dunford	Text added

N ^o	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						uncertainty. The paper focuses on both scenario and model uncertainty. (see Dunford et al., 2014 °Dunford, R., Harrison, P.A. and Rounsevell, M.D.A. (2014) Exploring scenario and model uncertainty in cross-sectoral integrated assessment approaches to climate change impacts. Climatic Change. DOI 10.1007/s10584-014-1211-3)		
285	4	445	23	445	23	and within individuals! E.g. Characteristics/traits are generally measured at one point in time and in one are of the organism (e.g. in the case of foliage traits, on sun exported top canopy leaves), yet, it is well known that many traits vary widely within one organism at one point in time and within one organism at different times.	Franziska Schrodt	Agreed. Text added
286	4	446	27	446	28	This is debatable: I don't think that stochastic influences prevent us from adequately estimating parameters as we could account for stochasticity by quantifying parameters as frequency distributions rather than single values.	Aafke Schipper	Noted. However since we feel the sentence is technically correct as it reads: "However, given stochastic elements present, we never have perfect estimates of underlying parameters and processes."
287	4	446	33	447	9	As said before, these phenomena do not represent sources of uncertainty in model outcomes, so I would leave out this part. The relevance of adequate communication with stakeholders is better addressed elsewhere.	Aafke Schipper	Agreed. The section is removed
288	4	446	29	446	31	Furthermore, given that models are our conceptual abstractions of the real world, even the basic structure of the model is uncertain. In addition, there will always be some uncertainty in our data sources, which may propagate through the risk model. The nature variables and its integrated process do not be exactly since they are not exactly since the ecosystem has a resilience behavior and flexibility to answer stochastic processes.	Marina Rosales Benites de Franco	Noted. Text added
289	4	446	33	446	37	In other sections, suggestions for overcoming problems have been suggested. Could this be done here? Have now read on and suggest you reference 4.6.3	UK Government	Suggestion noted, limited space to add more text
290	4	447	11	447	23	Does this apply to ecosystem models only? Is uncertainty in larger in the output of ecosystem models compared to models of lower levels of biological organization?	Aafke Schipper	Yes. As the complexity increases it has a trade-off in terms of uncertainty
291	4	447	21	447	23	Less attention compared to what? And why would this apply to forest ecosystems only?	Aafke Schipper	Agreed. Text deleted
292	4	447	25	448	40	Why are these descriptions in separate text boxes? I would suggest to provide a more integrated description of the sources and magnitude of uncertainty in the different models types, not only DGVMs and SDMs but also other models.	Aafke Schipper	Agree. But due to space limitation we provide box only for the DGVM as an

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
								example
293	4	447				Box 4.4 has a lot of text, and could do with an illustrative diagram.	Derek Tittensor	Noted. However other comments suggest to keep this box. Agreed and text reduced
294	4	448	1	448	2	What does this imply for uncertainty in the predictions?	Aafke Schipper	Noted. Text deleted
295	4	448	11	448	14	I would save recommendations for a separate section.	Aafke Schipper	Noted, limited space in recommendation section
296	4	448	16	448	23	This does not concern DGVMs.	Aafke Schipper	Agree. The text removed
297	4	448	34	448	35	This sentence seems to repeat the ideas in the previous sentence..	UK Government	Agree. The text removed
298	4	449	1	449		Perhaps this is better moved to a recommendations section? Also, some of the approaches mentioned (stochastic simulations, sensitivity analysis) do not actually reduce uncertainty but merely quantify it. Further, I would be more specific about the exact recommendations; many of them are rather vaguely formulated. Also, some more underpinning with references would be good. See more specific comments below.	Aafke Schipper	Agreed, but limited space in recommendation section.
299	4	449	3	449	4	I do not understand how defining the aim of the study may reduce model uncertainty...	Aafke Schipper	Agreed. Text deleted
300		449	4	449	6	Similarly, I do not understand how defining model performance measures (like which? AUC, R ² ?) help reduce uncertainty.	Aafke Schipper	Noted. Text deleted
301	4	449	6	449	12	This is a bit vague. Do you actually advocate stochastic model simulations/monte carlo approaches? Please specify	Aafke Schipper	Noted. This section doesn't deal with stochastic model simulations
302	4	449	12	449	13	Sure it is important to tailor a model to the aim of the study (and identify the corresponding optimum level of complexity), but how may this reduce uncertainty?	Aafke Schipper	Noted. Text deleted
303	4	449	20	449	22	But doesn't extrapolation beyond the training data (applicability domain) come with additional uncertainties?	Aafke Schipper	Noted. Text deleted
304	4	449	22	449	24	How exactly is this done; what exactly forms the basis to quantify the plausibility of different models? Please be more concrete (and add references if possible).	Aafke Schipper	Noted. Text deleted
305	4	449	28	449	29	I don't understand this. Why wouldn't it be appropriate to average model outcomes over different models if the outcome distribution per model is other than unimodal?	Aafke Schipper	Noted. Text deleted
306	4	449		449	30	A comparison is not a combination, I would say...	Aafke	Agree. Text modified

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
							Schipper	
307	4	449	31		33	But does this actually reduce uncertainty?	Aafke Schipper	It helps in better representation of the uncertainty and uncertainty reduction as well
308	4	449	35	449	39	This relates to communication of the results rather than reducing uncertainty. Please delete.	Aafke Schipper	Noted. Text deleted
309	4	450	17	450	17	Insert 'e.g. how might a reduction in uncertainty affect the decisions to be made?' after 'context'	Gary Kass, UK government	Agree. Text added
310	4	450	30	450	30	Insert ' , how' after 'uncertainty' [note: the mode of communication is also very important: e.g. face to face, through an intermediary, visually, verbally, etc...]	Gary Kass, UK government	Agreed. Text added
311	4.6.3.	450	1	451	15	The degree of uncertainty of different scenarios based on modelling depends on what the community wants also to tolerate scientifically. This subsection is still focused on what "experts" decide in developing scenarios based on models and communicating their top-down decision, instead of moderating a decision of equal partners of proposed priorities and models of scenarios.	Marcus Zisenis	Agreed. Text added towards end of the section
312	4	450	1	452	7	I would merge communication about uncertainty and communication about the models in general into one paragraph in the recommendations section. Also, I would condense it a bit; the relevance of transparency in the communication and the importance of tailoring the communication to the goal of the study and the target audience seem so obvious that it can be said in much fewer words than is done now. When it comes to the actual recommendations, please clarify how the PDI approach relates to the ODD protocol. Are these mutually exclusive? If so, which is to be preferred? Or complementary – then how can they be combined?	Aafke Schipper	The section on ODD has been now integrated into the discussion about complexity and discussion around how to deal with it and communicate it in biodiversity models.
313	4	450	20	450	24	This concerns the quantification rather than the communication of uncertainty.	Aafke Schipper	Agreed. Text deleted
314	4	450	2	451	15	Many statements without references in this section 4.6.3. Please add references.	Yann Clough	Text reduced due to limited space and the section is largely about communication and many references may not be required
315	4	451	1	451	15	Include here or as a new paragraph, something on 'how' uncertainty might usefully be communicated. e.g. the use of numbers, words or graphics. Set out the various pros and cons of these approaches. Discuss also the modes of communication e.g. through face-to-face dialogue, working through intermediaries (knowledge brokers or translators) or producing written	Gary Kass, UK government	Noted. However due to limit of space unable to add extra text

Nº	Chap ter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
						broiefngs...again, there are pros and cons here		
316	4	451	42	452	7	This paragraph has no relation at all with communicating research results and has no central topic either. Please delete or relocate the bits of information to the appropriate sections.	Aafke Schipper	The section on ODD has been now integrated into the discussion about complexity and discussion around how to deal with it and communicate it in biodiversity models.
317	4.7	451	30	451	30	The abbreviation SDM is used with two different meanings in this Assessment (chapter 2.4.1, p234ff: ‘Structured Decision Making’; all other chapters ‘Species distribution models’)	Jens Mutke	SDM is now used to refer to species distribution models only.
318	4	452	25	452	29	I suggest this text instead: "Petchey et al. (2015) have introduced a road map for ecological predictability research (it applies equally to research about the predictability of any complex system). The roadmap describes the feedbacks and interactions among fundamental research in which the models are based, the data feeding such models, and the use of model outputs that operate in the process of making models that can make accurate and useful predictions. These feedbacks and interactions council for an integrated approach towards making models that meet the predictive requirements of stakeholders and policy (Figure 4.14)."	Owen Petchey	Changed.
319	4.8.	452	10	453	22	The conclusions section is too short and should be a major part of Chapter 4 after discussing chances and limits of scenarios based on “Modelling impact of drivers on biodiversity and ecosystem functioning”, including practical examples.	Marcus Zisenis	Expanded but limited to space constraints.
320	4	452	14	452	14	Do not mingle levels of organization with spatial extent (‘from individuals to global level’).	Aafke Schipper	Changed.
321	4	452	16	452	16	This is a bold and rather important statement; please motivate. Also, isn’t this gap one of the very reasons for performing the current study, or in other words, shouldn’t it be highlighted in the introduction rather than the concluding section? Further, doesn’t the current study fill at least part of the gap by providing an overview of the variety of biodiversity models and providing some guidelines/considerations for model development and selection?	Aafke Schipper	Changed.
322	4	452	12	453	12	Mention importance of capacity building and integration of novel data sources (such as remotely sensed data) and techniques (such as multi-species distribution models) and integrating forward thinking experts in these fieds in the IPBES process?	Franziska Schrodt	These issues are explicitly discussed and addressed in chapter 7 and 8.
323	4	453	9	453	10	‘limitations to be developed’?	Aafke Schipper	Changed

Nº	Chapter	From page	From line	Till page	Till line	Comment	Reviewer Full Name	What was done with the comment
324	4	453	14	453	15	I don't understand this sentence...	Aafke Schipper	Changed
325	4	453	14	453	22	I think we need to explain the stakeholders the models has its confidence interval (a range of values so defined that there is a specified probability that the value of a parameter lies within it) and the decision makers need to know this parameters to choose the better decision.	Marina Rosales Benites de Franco	Treated in more detail in chapter 2.

Thierry Overdorf R1. Paragraph 4.3.1.1 Species level modeling. Besides evaluating species distribution there are also attempts to incorporate species densities. in the modeling process. These types of models seem promising to me and should be at least mentioned in this chapter. See the recent review made by Ehrlen & Morris 2015 – Ecology Letters 18, 303-314.
ADDED.