

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Individual Peer Reviewer Comments on OMB's Proposed *Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis*

Peer Reviewers:

John Battles
Michael Beck
Emily Bernhardt
Ankur Desai
Robert Johnston
Catherine Kling
Stephen Polasky
Lisa Wainger

Prepared for:

Executive Office of the President, Office of Management and Budget
Office of Information and Regulatory Affairs
725 17th Street, NW
Washington, DC 20503

Prepared by:

ICF International
1902 Reston Metro Plaza
Reston, VA 20190

Contract No. GS-21F-0029W / 11316022A0010EOP

Task Order 11316022F0025OMB

November 17, 2023

External Peer Review on OMB’s Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Table of Contents

Introduction..... 3
Charge to Peer Reviewers of the Proposed Guidance..... 4
Individual Peer Reviewer Comments: John Battles..... 6
Individual Peer Reviewer Comments: Michael W. Beck 12
Individual Peer Reviewer Comments: Emily S. Bernhardt 16
Individual Peer Reviewer Comments: Ankur Desai 22
Individual Peer Reviewer Comments: Robert J. Johnston..... 26
Individual Peer Reviewer Comments: Cathy Kling..... 47
Individual Peer Reviewer Comments: Stephen Polasky 53
Individual Peer Reviewer Comments: Lisa A. Wainger..... 61

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Introduction

On August 2, 2023, the Office of Information and Regulatory Affairs (OIRA) – part of the Office of Management and Budget (OMB) – released a draft of the Federal government's first-ever guidance on accounting for ecosystem services in benefit-cost analysis, available at <https://www.whitehouse.gov/wp-content/uploads/2023/08/DraftESGuidance.pdf>. Public comments on the guidance were solicited via a separate notice. In addition, the draft guidance was peer reviewed in accordance with OMB's Final Information Quality Bulletin for Peer Review (the Bulletin) and the Regulatory Right-to-Know Act. This document provides the peer review comments submitted by each of the eight peer reviewers.

Charge to Peer Reviewers of the Proposed Guidance

Please review the draft *Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis* (available at <https://www.whitehouse.gov/wp-content/uploads/2023/08/DraftESGuidance.pdf>). Peer reviewers may also consult any public comments on the draft Guidance.¹

The reviewers are asked to draft their individual reports in response to the questions posed below, consistent with each reviewer's experience and areas of expertise. Whereas peer reviewers are welcome to comment on any aspects of the draft guidance, this list of topics cover some of the notable components of this guidance:

- (1) an ecosystem service definition for the purpose of federal agency benefit-cost analyses;
- (2) identifying possible ecosystem service effects from regulatory changes;
- (3) recommended steps for considering and assessing ecosystem services;
- (4) scoping analyses;
- (5) monetization methods; and
- (6) accounting for uncertainty.

Questions:

1. Please review the proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis. Peer reviewers may also consult any public comments on the draft proposed guidance.¹ The reviewers are asked to draft their individual reports in response to the questions posed below, consistent with each reviewer's experience and areas of expertise.
2. Peer reviewers are welcome to comment on any aspects of the proposed guidance, including addressing questions raised in the accompanying Federal Register Notice, but we provide some particular questions of interest below.
3. Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).
4. Please note any important omissions.
5. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.
6. Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

¹ Docket number: OMB-2022-0016, available at www.regulations.gov.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

7. Does the document provide clear and useful guidance for both governmental and nongovernmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.
8. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?
9. Are there important valuation methods that should be mentioned, including for non-use values?
10. Are there other important references or ecosystem services resources that should be included in the references?
11. Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?
12. Should any elements be removed?

We welcome additional recommendations for ensuring that the guidance and associated methodologies are supported by the theoretical and empirical peer-reviewed academic literature in relevant disciplines.

Individual Peer Reviewer Comments: John Battles

Overview: The ambition of the draft Guidance is laudable. The value of ecosystem services must be part of the equation for evaluating the impact of federal regulations. And this Guidance provides much useful advice to consider when conducting this valuation. However the scope of the Guidance, i.e., providing a general framework to value ecosystem services for every possible federal regulation, is daunting. The best approach will be very context dependent. Our understanding of the ecosystem dynamics varies depending on the ecosystem and the nature of the changes related by the regulation. Most of the Guidance assumes that these regulatory-induced changes can be reasonably well anticipated. Thus much of the instruction focuses on how to quantify the ecosystem service consequences. When the rules under consideration are narrow in scope (e.g., title reform in Appendix III) or narrow in scale (local housing grants in Appendix III), the causal pathways can be charted with confidence. But these pathways become more difficult to chart when the scope and/or scale of the rule increases (e.g., Appendix IV). This Guidance generally ignores these scaling challenges.

Adding to the complexity of anticipating ecosystem dynamics are the ongoing changes in climate. While there is uncertainty in the precise magnitude of changes, the trajectory is very well established. During the next twenty years, the climate will get warmer everywhere, will get drier in most places, and will get less predictable with more extreme events. These changes are known and must be included.

There are some good examples in the ecosystem science literature that outline approaches to chart causal pathways. For a narrower regulation, Syphard et al. (2013) illustrates an analysis of the changes in fire risk to homes under different land use planning scenarios in southern California. For more far-reaching rules (e.g., management of DoD lands), Patch et al. (2020) document in detail the kind of ecosystem modeling needed to inform an ecosystem service valuation. Importantly, Patch et al. (2020) explicitly consider the consequences of a changing climate.

Strengths

1. There is a strong foundation for a responsible approach to valuing ecosystem services.
2. The advice to rely on conceptual models to frame the analysis and communicate the process is very well supported by best scientific practice.
3. Key terms are clearly defined.

Weaknesses

1. The complexities introduced by a changing climate are underestimated. This underestimate is part of a larger problem of assuming we can reliably predict ecosystem dynamics.
2. The specific examples included in the appendices are not well thought out.
3. Uncertainty is a much bigger challenge than acknowledged.

Response (in italics) to list of topics

- (1) an ecosystem service definition for the purpose of federal agency benefit-cost analyses;

I thought this definition was clearly described and actionable.

- (2) identifying possible ecosystem service effects from regulatory changes;

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Figure 1 and Table 2 are extremely useful rubrics for thinking about ecosystem service valuation. A more comprehensive approach is included in Appendix I but I found it much less useful.

- (3) recommended steps for considering and assessing ecosystem services;

As explained elsewhere, the Guidance assumes we can reliably predict the consequences of rules on ecosystem structure and function and that the primary challenge is monetizing these changes. I do not think this is a valid assumption.

- (4) scoping analyses;

Forgive me but I am not sure what is meant here. No comment.

- (5) monetization methods; and

These methods are not described in any detail. A few specifics are mentioned as asides or tips but I did not see a how-to. The examples worked in Appendix III are hard to follow.

- (6) accounting for uncertainty

Accounting for uncertainty is an incredibly important and difficult charge. The pace of global change only makes it more difficult. The task must be approached with humility. We are going to be wrong. The goal is to limit the errors as much as possible.

We empiricists wrestle with identifying and reporting uncertainty in our ecosystem studies (Yanai et al. 2018). A formal statistical propagation of errors can overwhelm the signal of change with potential noise. So we try to identify the major causes of uncertainty and design studies to minimize them. However this is a relatively new emphasis in ecosystem ecology. Many of the existing models we use to anticipate ecosystem dynamics in response to a disturbance (aka a regulatory change) do not account for the uncertainty in the data used to calibrate and validate the models. We are improving this data-model assimilation (Dietze et al. 2013) but progress is slow for the full suite of ecosystem responses. Grêt-Regamey et al. (2013) provide an example of how to incorporate uncertainty into management for ecosystem service; their results are sobering.

The synthesis paper by Doak et al. (2018) documents the ubiquity of ecological surprises. From their survey of 58 field ecologists, all respondents reported that during their career they had observed an ecosystem response that was not predicted nor reasonably anticipated. These surprises constitute observed changes in the opposite direction from predictions or observed magnitudes of change that exceeded the range of predicted responses. In other words, the surprises would greatly impact the delivery of ecosystem services. The prevalence of these surprises is a testimony to our ignorance and/or the pace of change. And yet, we must try to not only predict the ecosystem responses but also quantify their impact on human welfare. Thus my recommendation for humility particularly when the regulation is large in scope or scale.

On the topic of uncertainty, I also want to note the need to understand how to reliably apply models developed for one ecosystem to another ecosystem or to novel conditions. In practice, ecosystem models built for one application are applied to another with no formal evaluation if such a transfer is warranted. As Yates et al. (2018) note, there is a huge upside in terms of time and effort to transferring existing models, but we currently lack the means to ensure reliability. Thus the common practice of ad hoc transfers introduces another dimension of uncertainty.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

My objective, although tangent to the task at hand, is a note of caution to economic colleagues and policy makers. Our understanding of ecosystem dynamics is rife with uncertainties that are not always clearly acknowledged.

Response (in italics) to Questions

1. Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).

The phrasing of this question illustrates my main point. There is an implicit assumption that the regulatory agency will be able to reliably chart the impact on the ecosystem of a proposed rule. Thus the primary challenge is the economic valuation of predictable ecosystem services. While I deeply respect the expertise of the agencies I work with (USFS and NPS), neither currently have the capacity to routinely consider even the direct impacts (sensu Seidl et al. 2017) of climate change on ecosystem dynamics. I understand that we must start somewhere and make estimates on limited knowledge. However, the need to have reliable ecosystem models as well as robust economic ones should be noted.

2. Please note any important omissions.

The Guidance would benefit from a glossary of terms. For a document intended as a primer for a wide audience, all technical terms (i.e., jargon) should be defined.

As explained above, the challenges of a changing climate are not fully acknowledged. Even regulations with as little as ten-year event horizons need to consider the unavoidable, certain changes in climate. It cannot be a mere afterthought given climate's pervasive impacts on ecosystem structure and function (Pecl et al. 2017, McDowell et al. 2020).

3. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.

The repeated warnings about double counting ecosystem services were a concern from an ecosystem dynamics perspective. Ecology, by definition, focuses on the interdependence among organisms and their environments. I am not sure how the double counting rules would apply and worry that the caution against double counting may ignore potential ecosystem services. For example, consider a land-use rule that promotes species diversity in a public grassland by reducing livestock grazing. There are at least three intertwined ecosystem consequences: 1) species diversity is maintained (direct impact); 2) rare/threatened species are protected (indirect impact); and 3) carbon storage is increased (interactive impact since increased diversity tends to increase primary productivity). Would valuing all three of these services be considered double counting the benefit of promoting species diversity?

The double counting concern also includes the valuation of reducing greenhouse gas emissions (GHG). It is really hard NOT to double count the benefit of reducing GHGs given the all-encompassing definition in the GHG box.

I recommend explaining more precisely the concern with double counting with detailed guidance about when and where it applies. The admonition seems focused on economic valuation. If so, make that clear and be specific about how to count (or not count) interdependent ecosystem services.

4. Are categorizations consistent with the science and useful for practitioners? Please comment on

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

important ways the categorizations might be improved.

The conceptual model (Fig. 1) provides a useful workflow. Its application in Table 2 reinforces its utility with the details in the columns illustrating how to categorize changes. Table 2 links the conceptual model and the categories defined in the text. It is an excellent foundation for this Guidance. However, this foundation must be consistently deployed. For the inexperienced user (like me), the Human Welfare Endpoints in the table in Appendix I do not directly track the categories in the text. So it took some deduction to realize that "non-use values" = "Passive Use Values." Although minor lapses in terminology, they inject a disproportionate amount of confusion. In general, the Guidance would be improved by being super careful to have all the parts closely aligned.

Aside: The appendices are not as helpful as they could be. Unlike the main body of the text, they are not as carefully crafted. For example, not all the tables, figures, and equations have a label and caption. Nor are all the terms described. Appendix III is a particularly dire example. Figures, terms, and equations are not defined or explained. It is impossible to closely follow these examples and thus they defeat the purpose of their inclusion.

5. Does the document provide clear and useful guidance for both governmental and non- governmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

My sense is that the Guidance is a victim of its ambition. It strives to incorporate every possible application for both "governmental and non- governmental practitioners." It includes essential information (e.g., defining terms and illustrating the overall process). It sometimes dives into more specific issues (e.g., box on GHGs, some details on monetizing services, and information in the appendices) but does not provide a step-by-step approach. Given the scope of the Guidance, providing step-by-step advice is an overwhelming goal. So I suggest that the Guidance narrows its scope to providing an overview of the process (already included) with some key watch-outs (e.g., double counting; GHGs) and recommendations (e.g., value of a conceptual model). I would repurpose the appendix to provide fewer examples (e.g., conceptual models) or simpler examples (ecosystem service valuations) that are more fully described.

6. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

The Patch et al. (2020) report on ecosystem valuation for the DoD is a good example that explicitly includes climate change in its assessment. But it is not a simple example. It was a comprehensive analysis and the document is long. It does have an effective executive summary that runs 11 pages.

Syphard et al. (2013) provide a narrower example of modeling the impact of land-use policies on wildfire and the risks posed to housing. But the ecosystem service values are not quantified.

Weiskop et al. (2020) is another example of including climate change in an ecosystem service assessment. It outlines the complexity in terms of maintaining biodiversity.

7. Are there important valuation methods that should be mentioned, including for non-use values?

No comment. Not my expertise.

8. Are there other important references or ecosystem services resources that should be included in the references?

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

As briefly mentioned in the Guidance, the potential for non-linear ecosystem responses to regulatory changes pose a particular challenge for valuation. We expect step-changes and tipping points but lack the understanding to reliably predict them. Evidence to date also suggests that non-linear responses are an increasing risk given trends in global change agents (e.g., a warming climate, ubiquitous air pollution, and invasive species spread). Smith et al. (2009) provide a useful framework for thinking about these hierarchical ecosystem dynamics in the context of chronic nutrient deposition but their framework applies to other chronic stressors (e.g., a warming climate or the spread of an invasive disease) on ecosystem dynamics.

9. Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?

Chapin et al. (2003) is a great example of using conceptual models to frame and analytical models to quantify the impact of policy changes on ecosystem dynamics and subsequent effects on human welfare. It does not however directly quantify the human welfare benefits.

10. Should any elements be removed?

As noted, the appendices are generally unhelpful. So removing them would be one solution. There is also a fair bit of repetition in the text. For example, the warning about double counting appears several times. So removing this repetition would improve readability.

References

- Chapin III, F.S., Rupp, T.S., Starfield, A.M., DeWilde, L.O., Zavaleta, E.S., Fresco, N., Henkelman, J. and McGuire, A.D., 2003. Planning for resilience: modeling change in human–fire interactions in the Alaskan boreal forest. *Frontiers in Ecology and the Environment*, 1(5), pp.255-261.
- Dietze, M.C., Lebauer, D.S. and Kooper, R.O.B., 2013. On improving the communication between models and data. *Plant, Cell & Environment*, 36(9), pp.1575-1585.
- Doak, D.F., Estes, J.A., Halpern, B.S., Jacob, U., Lindberg, D.R., Lovvorn, J., Monson, D.H., Tinker, M.T., Williams, T.M., Wootton, J.T. and Carroll, I., 2008. Understanding and predicting ecological dynamics: are major surprises inevitable. *Ecology*, 89(4), pp.952-961.
- Grêt-Regamey, A., Brunner, S.H., Altwegg, J. and Bebi, P., 2013. Facing uncertainty in ecosystem services-based resource management. *Journal of environmental management*, 127, pp.S145-S154.
- McDowell, N.G., Allen, C.D., Anderson-Teixeira, K., Aukema, B.H., Bond-Lamberty, B., Chini, L., Clark, J.S., Dietze, M., Grossiord, C., Hanbury-Brown, A. and Hurtt, G.C., 2020. Pervasive shifts in forest dynamics in a changing world. *Science*, 368(6494), p.eaaz9463.
- Patch, B., McDowell, N.G., Prasad, R., Moore, M.L., Tan, Z. and Hurteau, M.D., 2020. Value and Resiliency of Ecosystem Services on Department of Defense Lands.
- Pecl, G.T., Araújo, M.B., Bell, J.D., Blanchard, J., Bonebrake, T.C., Chen, I.C., Clark, T.D., Colwell, R.K., Danielsen, F., Evengård, B. and Falconi, L., 2017. Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science*, 355(6332), p.eaai9214.
- Seidl, R., Thom, D., Kautz, M., Martin-Benito, D., Peltoniemi, M., Vacchiano, G., Wild, J., Ascoli, D.,

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Petr, M., Honkaniemi, J. and Lexer, M.J., 2017. Forest disturbances under climate change. *Nature climate change*, 7(6), pp.395-402.

Smith, M.D., Knapp, A.K. and Collins, S.L., 2009. A framework for assessing ecosystem dynamics in response to chronic resource alterations induced by global change. *Ecology*, 90(12), pp.3279-3289.

Syphard, A.D., Bar Massada, A., Butsic, V. and Keeley, J.E., 2013. Land use planning and wildfire: development policies influence future probability of housing loss. *PloS one*, 8(8), p.e71708.

Weiskopf, S.R., Rubenstein, M.A., Crozier, L.G., Gaichas, S., Griffis, R., Halofsky, J.E., Hyde, K.J., Morelli, T.L., Morisette, J.T., Muñoz, R.C. and Pershing, A.J., 2020. Climate change effects on biodiversity, ecosystems, ecosystem services, and natural resource management in the United States. *Science of the Total Environment*, 733, p.137782.

Yanai, R.D., See, C.R. and Campbell, J.L., 2018. Current practices in reporting uncertainty in ecosystem ecology. *Ecosystems*, 21, pp.971-981.

Yates, K.L., Bouchet, P.J., Caley, M.J., Mengersen, K., Randin, C.F., Parnell, S., Fielding, A.H., Bamford, A.J., Ban, S., Barbosa, A.M. and Dormann, C.F., 2018. Outstanding challenges in the transferability of ecological models. *Trends in ecology & evolution*, 33(10), pp.790-802.

Individual Peer Reviewer Comments: Michael W. Beck

Q2: General Comments (“Peer reviewers are welcome to comment on any aspects of the proposed guidance”)

The *Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis* (hereafter “Guidance”) is a key element in the roadmap for further consideration of ecosystem services by federal agencies. The main aim of such guidance should be to make it clearer and easier to appropriately account for ecosystem services (ES) in federal decision-making including Benefit-Cost Analyses (BCAs). The Guidance does not yet achieve that aim.

At present, the Guidance focuses on the complexity of the task of including ecosystem services in decision making. Much of the Guidance describes: (i) the myriad, complex pathways by which ecosystem services might affect decisions; (ii) how ES vary spatially and may require different ‘service sheds’ for valuing each service; (iii) how ES vary temporally; and (iv) the importance of quantitatively assessing uncertainty in ES. That is, the Guidance focuses mainly on the complexity of the BCA task (for any benefit from ES or otherwise) and may inadvertently make the case for why federal practitioners should be cautious about considering ecosystem services.

Overall, I think it would be best to more practical in the advice, illustrate why it is important to consider ecosystem services, and to draw from or at least cite some of the practical work by agencies and others to incorporate ecosystem services in decision making. The Guidance makes it appear as if it will be incredibly challenging to further include ecosystem services in decisions, which is not really the case. The inclusion of ecosystem services is for the most part no more challenging than the inclusion of any other factor in decision-making.

Q3: “.. comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations”

Some key recommendations that were overlooked or could be clearer include:

- Some ecosystem services can and have been be well defined and valued;
- Ecosystem services must be accounted for (in BCAs) to improve decision-making and to develop more cost-effective decisions;
- Some services have enormous benefits and often it will be possible to vastly improve a given federal decision-making process (e.g., BCA) by assessing just a few (e.g., 1-3) services with high to very high (social, cultural, or economic) values;
- It is helpful to elucidate the many services that might be relevant to a policy or project but only a few need to be assessed within a BCA;
- Only a few services will have significant impact at the level of changing/modifying a decision;
- Incorporating ecosystem services and their economic and social benefits will help ensure that the natural resources of the US are used not just for short-term monetary benefit but also for the broader and longer benefit of all Americans;
- Numerous federal agencies including USFWS, USACE, FEMA and others have already been incorporating the value of services; this work should be expanded.

Q4: “..note any important omissions.”

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Simplified examples of how ecosystem services have been directly included in BCAs by agencies would be helpful. The main examples offered are conceptual in Appendix II, which indicate numerous and complex relationships among factors and services in spaghetti diagrams.

Q5: *“Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.”*

Overall the Guidance does a reasonable job of reflecting the science with a few significant issues that are highlighted by other reviewers. The Guidance does a poor job of providing advice that is actionable; see Q2 General comments above. Improving the scientific definitions of concepts will likely not help substantively in providing more actionable advice. For example, there is a long and frequent consideration of concepts such as assets, stocks and flows. These are important concepts but an even more robust conceptual understanding of them is not likely what impedes consideration of ecosystem services in decisions.

Q6. *“Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.”*

The categorizations are generally consistent with science but likely only partly useful to practitioners. Sections III and IV on “Which aspects of human welfare can be affected by ecosystem-service changes?” and “Does your rule involve ecosystem services?” provide too many examples that are lightly described in a phrase or two when it likely would be more instructive to have more depth on fewer examples. The paragraph examples in section III such as **“Constructing, operating, maintaining, or removing infrastructure can change access to ecosystem services”** at first appear to offer this depth, but each paragraph is mostly an ensemble of single sentence examples. Most of the examples in this section could be moved to an appendix, and it would be better to more thoroughly walk through how a handful of services such as floodplain protection, recreation, water purification and carbon sequestration can affect decision-making.

Q7. *“Does the document provide clear and useful guidance for both governmental and non-governmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.”*

The greatest weakness in the Guidance is that it does not provide much clear direction for practitioners. Practitioners not already familiar with the valuation of ecosystem services will have a hard time figuring out where to start or how to proceed. The most important aspect of the Guidance should be Section VI, but this starts by identifying complexities. For example Step 1 is “Ensure that the scope (i.e., time and spatial scale) of the analysis is sufficiently broad to reflect important ecosystem services in the baseline and across alternatives”, which sets the tone for all the direction that follows. The explanation here focuses on complexity and how difficult it will be to consider Ecosystem Services.

The topic sentences for each paragraph in Step 1 (bulleted below) would give pause to even an expert seasoned in service valuation.

- “Analysts should use appropriate baselines and regulatory alternatives that reflect ecosystem-service considerations.”
- “The scope of the analysis includes its spatial scale, which can be determined by the “extent of the market” or ecosystem “serviceshed.”

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- “It is important that the analytical timeline selected for analysis is not arbitrarily short or driven by any one specific flow of benefits and costs.”
- “As noted in that Circular A-4 section on uncertainty, specifying key analytical assumptions is important.”
- “At this step (and others), pause to consider whether additional alternatives merit formal assessment, given the evidence you have gathered, including evidence related to the role of natural assets or environmental conditions.”

The direction (and paragraphs) of Step 1 should be focused on how to practically get started not the complexity. Most of the examples highlight complexity when they could also indicate how the problem can be simplified. For example, the spaghetti diagram examples in appendix II appear to indicate that this problem of including ES in decision making can only be characterized by an overwhelming number of boxes and arrows. However, what is not stated in any of these conceptual examples is that there are just a handful of services such as coastal protection, water purification, recreation and fish production at the center of any of each of these examples. Indeed, it seems likely that only a handful of services were used to inform the decisions in these examples.

Q8: *Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?*

- van Zanten, B., K. Arkema, T. Swannack. 2021. Benefits and Costs of NNBF in Bridges, T. S., J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder, and R. K. Mohan, [International Guidelines on Natural and Nature-Based Features for Flood Risk Management](#). Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Bridges, T. S., J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder, and R. K. Mohan, eds. 2021. [Overview: International Guidelines on Natural and Nature-Based Features for Flood Risk Management](#). Vicksburg, MS, U.S. Army Engineer Research and Development Center.
- Stovall AE, M.W. Beck, C Storlazzi, J Hayes, J Reilly, J Koss, D Bausch. 2022. [Coral Reef Restoration for Risk Reduction \(CR4\): A Guide to Project Design and Proposal Development](#). US Coral Reef Task Force.
- FEMA 2021. [FEMA Hazus Success Story Mapping the Risk Reduction Benefits of Coral Reef Conservation](#). FEMA, Washington DC.
- Beck, M. W., N. Heck, S. Narayan, P. Menéndez, B. Reguero, S. Bitterwolf, S. Torres-Ortega, G.-M. Lange, K. Pfliegner, V. McNulty, I. J. Losada. 2022. [Return on Investment for Mangrove and Reef Flood Protection](#). Ecosystem Services 56:101440.

Q9: *“Are there important valuation methods that should be mentioned, including for non-use values?”*

While there are more valuation methods that could be considered, the addition of more detail on valuation methods and concepts is not likely to help practitioners get started.

Q10: *“Are there other important references or ecosystem services resources that should be included in the references?”*

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- World Bank. 2016. [Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs](#). M.W. Beck & G-M. Lange, editors, World Bank, Washington, DC.
- Lange, G-M, M. W. Beck, V. Lam, P. Menéndez, R. Sumaila. 2021. [Blue natural capital: mangroves and fisheries](#) in G. M. Lange et al. (eds). *Changing Wealth of Nations 2021: Managing Assets for the Future*. World Bank.
- Reguero, B., C. D. Storlazzi, A. E. Gibbs, J. B. Shope, A. D. Cole, K. A. Cumming, M. W. Beck. 2021. [The Value of U.S. Coral Reefs for Flood Risk Reduction](#). *Nature Sustainability* 4:688-698
- Storlazzi, C.D., Reguero, B.G., Cole, A.D., Lowe, E., Shope, J.A., Gibbs, A.E., Nickel, B.A., McCall, R.T., van Dongeren, A.R., Beck, M.W. 2019. [Rigorously valuing the role of U.S. coral reefs in coastal hazard risk reduction](#). U.S. Geological Survey Open-File Report 2019-1027, 42 pp.
- Storlazzi, C.D., Reguero, B.G., Cumming, K.A., Cole, A., Shope, J., Gaido, C., Viehman, T., Nickel, B., Beck, M.W. 2021. [Rigorously valuing the coastal hazard risks reduction provided by coral reef restoration in Florida and Puerto Rico](#). USGS Open-File Report 2021-1054.

Q11: *“Should any elements be removed?”*

As noted in the answer to earlier Qs, there should be fewer ‘single sentence’ examples and a handful of slightly more detailed examples.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Individual Peer Reviewer Comments: Emily S. Bernhardt

I preface my comments by assuming that the goal of any guidance should be incremental improvements in policy and policy implementation over time. I applaud the intent behind this guidance. It is a worthy goal to incorporate an accounting for the impacts of new policy or policy implementation on natural capital and ecosystem services. Meeting this goal requires new ways of thinking and accounting for the environmental impacts of regulatory decisions. It is both an important and difficult challenge to assign value to the key environmental services of clean water, clean air, recreational access, aesthetic and spiritual fulfillment, and cultural traditions that are often threatened by resource extraction and development. Some federal agencies have well-established approaches and in-house expertise for making these assessments, while others are being asked to take environmental services into account for the first time. Clear recommendations for how to implement such assessments are necessary, particularly for those agencies that have not traditionally included environmental impacts in their cost-benefit analyses. I am glad to see that OMB is confronting this challenge and I recognize that any attempt to craft guidance for the complicated work of accounting for ecosystem service impacts of policy will be extremely difficult.

That said, I feel this guidance is poorly targeted and organized to accomplish such an important goal. The document lists a wide variety of examples that describe how various policies can alter ecosystem services, yet it provides too little clear guidance about how a regulator might effectively consider the environmental impacts of the policy they are charged with drafting or implementing. This document seems better designed to confuse and intimidate the regulator rather than inform and empower them, and I found it extremely hard to navigate.

The guidance document is not explicit about the policy or regulatory gap that is intended to fill. The entire exercise would benefit from leading off with an exceptionally clear articulation of the document's goal. Why are Circulars A4 and A94 insufficient? How does this exercise enhance or expand beyond NEPA requirements or traditional RIA procedures?

Similarly, the document would benefit from clearly stating the overarching goals of incorporating ecosystem service valuation into policy analysis. What is the hierarchy of goals? Is it to sustain and enhance the provisioning of ecosystem services? Is it instead to minimize harm to or reduction in ecosystem services? How important is it to minimize the inequality of who pays and who benefits from the ecosystem impacts of new policies? Or is it merely to be transparent about the impact of new policy on ecosystems and ecosystem services to guide decision making?

I assume the authors intended to encourage and guide regulators in evaluating the impact of a new policy or a policy change on ecosystem services. My primary concern is that the expectations set by this guidance document are so broad and nebulous that no report could ever satisfactorily accomplish the stated intent. Under this guidance, any evaluation would be subject to critique for not being sufficiently thorough. This does not seem likely to improve the implementation of policy.

The guidance document is long on examples and short on general principles. It should be the reverse. What are the principles on which ecosystem service impact assessments must be based? What critical questions must be asked and answered to satisfy the intent of the guidance? How does one make critical

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

decisions about the spatial and temporal scale of an appropriate assessment? What expertise is required to decide upon the quantitative and qualitative values that are incorporated into an assessment? I would like to see the list of questions that currently appear on p. 22 show up much earlier in the document and be separated from the examples accompanying them.

The hard truth about ecosystem service assessments is that it is hard to quantify the vast majority of them. In the absence of empirically based quantitative data for most services it becomes all too easy to rely too much on those services for which monetary values have been assigned. As a result, very important services receive too little or no attention. This is particularly likely to be true when assessments are conducted by agency staff with no prior experience.

In my own experience as an expert in river and wetland restoration and mitigation¹, I have seen agencies produce accounting structures that have no basis in the literature. In the most egregious example of ecosystem service valuation, I have yet been involved in, constructed channels on reclaimed mine surfaces that never hold water were routinely determined to be of greater value than the natural headwater streams they were built to replace. In this use case, physical structures were allowed to serve as proxies for biodiversity, water quantity and water quality services without any empirical evidence to justify such links. In a more widespread example, newly constructed wetlands are regularly assumed to provide the same ecosystem services as those lost when a long-established wetland is filled or drained. This is an assumption that is demonstrably false for many ecosystem services (such as carbon sequestration or biodiversity support).

Experience with issues like these leads me to doubt that untrained agency staff can determine appropriate assessment criteria for environmental cost-benefit analysis without extremely clear principles and guiding questions. In the absence of such expertise, it is far too easy for corporate interests to provide assessment information that is favorable to their economic interests. Good intentions without clear instructions and expert support are susceptible to abuse and there are plenty of examples of such abuses in modern environmental management.

To summarize my overarching points. An effective guidance document should: clearly state the intended purpose and goals; articulate a set of guiding principles to govern all such ecosystem service assessments; and, provide sufficient clarity about the requirements of each step of such an assessment process that a regulator can confidently demonstrate that the step has been completed.

I respond to the specific questions of the charge below, though I will note that most of my reactions and constructive critique of the document could not be captured in these answers.:

¹ Bernhardt, E. S., and M. A. Palmer. 2011. The environmental costs of mountaintop mining valley fill operations for aquatic ecosystems of the Central Appalachians. Pages 39–57 in R. S. Ostfeld and W. H. Schlesinger, editors. YEAR IN ECOLOGY AND CONSERVATION BIOLOGY. / Palmer, M.A., E S. Bernhardt, et al. 2005. Standards for ecologically successful river restoration. The Journal of Applied Ecology 42:208–217. / Palmer, M. A., H. L. Menninger, and E. Bernhardt. 2010. River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice? Freshwater biology 55:205–222.

Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).

This guidance document relies primarily on major conceptual and synthetic publications that describe ecosystem services and argue for their incorporation into policy and management. The authors have done a good job of citing the most high-impact papers in this area.

There is far less inclusion of reports and papers describing the implementation or mechanics of ecosystem service valuation. The guidance would be considerably enriched by providing a few carefully chosen summaries of exemplary ecosystem service valuation implementation efforts. This is done to some extent in the appendix, but I would strongly recommend highlighting these examples in the main text rather than the current long lists of examples that take up the bulk of the text.

Please note any important omissions.

A major omission in the document is a frontispiece that clearly explains the purpose and intent of this guidance. The authors should very clearly articulate why separate guidance is needed for environmental or ecosystem service benefits, and why this is a necessary addition to regulatory impact assessments.

There is far too little attention to cultural, spiritual, and heritage values in the guidance - yet these can be the dominant value of an ecosystem for many of its inhabitants or users, particularly true for marginalized groups. The relative emphasis of the guidance on 'recreational' benefits relative to these harder-to-quantify cultural/heritage values makes an implicit if unintentional statement that devalues these ecosystem services. There are important equity implications of not adequately addressing the need to incorporate hard-to-quantify but often priority values of sacred sites, ancestral lands, and longstanding cultural traditions connected to landscapes.

The guidance document omits some very important references to national and international guidance that is directly relevant to this issue. Chief among them

CEQ's Principles, Requirements, and Guidelines (PR&G) for Federal Investments in Water Resources².

The IPBES Values Assessment (released in 2022)³ describes the inclusion of multiple forms of value (both monetary and non-monetary representations of value) in a valuation process.

Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved

I did not find fault with the definitions provided in the guidance.

² <https://obamawhitehouse.archives.gov/administration/eop/ceq/initiatives/PandG>

³ <https://www.ipbes.net/the-values-assessment>

Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

I do not understand this question as phrased.

Does the document provide clear and useful guidance for both governmental and nongovernmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

On page 34, 2nd full paragraph along with footnotes 70 and 71 are an example where the guidance suggests that 'farm gate value', because it is 'easily measurable' should be considered in preference to any assessment of the value of the water consumed in the production of the crop. Yet given the many factors that influence crop prices, would it not be better to place value on the water resource? By this accounting won't we devalue the ecosystem service (water) while over-valuing whatever it takes to enable the maximum production of a crop? Would it not be 'more valuable' to produce a crop with maximally efficient water use? If we don't consider both water and crop yield, are we truly doing an ecosystem service valuation?

I applaud and support the public comment submitted by Moritz Drupp and colleagues in which they recommend: *"Building on a rich body of economic literature, we recommend that federal agencies should rely on relative price change adjustments for non-market ecosystem services. Crucially this results in an (upward) adjustment of future WTP estimates from ecosystem services. We recommend specific and easily operationalizable guidance for such implementation."* Their carefully written comment provides clear documentation and justification (along with many appropriate references) for making this extremely important adjustment in cost-benefit analyses. I encourage the authors to carefully consider this constructive suggestion.

In his public comment, Professor John Loomis wrote *"...it may also be worthwhile to remind the reader to "beware of shortcuts". The preference for shortcuts at this stage may result in what one of my land management agency colleagues remarked about short-cutting analysis in their agency "we never have time to right, but we always have time to do it over and over again due to court lawsuits"."* I strongly support this recommendation, as cursory attention to ecosystem service evaluation that is not grounded in the best information, may be less useful than no analysis at all and will certainly undermine confidence in the agencies responsible, making them subject to complaints and legal action.

Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

It would be nice to have the examples provided in the appendix incorporated into the main text with a clear description of the approach or challenge they illustrate. Within the appendix itself perhaps they could be organized by common challenges in benefit-cost analyses so that there is a bit more effort to help the reader understand the purpose of the selected examples.

External Peer Review on OMB’s Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

I would like to see more examples of effective incorporation of non-quantitative values in these benefit-cost analyses.

In a public comment, Dr. Rochelle Gould suggested the guidance “*could include examples of situations in which non-quantitative characterizations of values have been influential. The Hawaii North Shore analysis using InVEST software provides one example⁴—in this case, intergenerational and cultural values emerged in discussion-based interactions that comprised part of the decision-making process, along with model results.*”

Are there important valuation methods that should be mentioned, including for non-use values?

I am alert to an overemphasis on the magnitude of the change, often referred to by regulators involved in mitigation efforts as ‘lift’, as opposed to the absolute extent of service provisioning of the ecosystem in question. Making measurable improvements to an extremely degraded ecosystem so that it is less degraded may not provide nearly as much sustainable ecosystem service benefit as merely minor improvements in a minimally degraded ecosystem. Flipping this, degradation in an already heavily degraded ecosystem will cause less loss of services than the same action in a more protected, minimally managed ecosystem. If we focus too much attention on lift of degraded systems, we do too little to protect and mitigate impacts to relatively intact ecosystems. This becomes particularly important when we consider the application of this guidance to restoration and mitigation efforts.

Are there other important references or ecosystem services resources that should be included in the references?

This guidance would be substantially improved if it was linked with a clearinghouse of ecosystem service valuation resources and data tables. It would make sense to provide a list of high-quality resources in section 3. Just to name a few.

EnviroAtlas⁵.

Environmental Valuation Reference Inventory⁶

The Economics of Ecosystems and Biodiversity (TEEB) ⁷

Ecosystem Services Valuation Database (ESVD)⁸

Blue Value Online database⁹

Social Values for Ecosystem Services (SolVES)¹⁰

Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?

⁴ Goldstein et al. 2012, <https://www.pnas.org/doi/full/10.1073/pnas.1201040109>

⁵ <https://www.epa.gov/enviroatlas>

⁶ <https://evri.ca/en>

⁷ <https://teebweb.org/>

⁸ <https://www.esvd.net/>

⁹ <https://coast.noaa.gov/digitalcoast/tools/gecoserv.html>

¹⁰ <https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/social-values-ecosystem>

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

I don't think the guidance needs more examples - it would be better to make sure that the examples chosen illustrate important points or provide guidance on common challenges. Rather than collecting examples, it would be better to decide on what points should be illustrated through the examples and curate a careful and high-quality set that is connected to those points.

Should any elements be removed?

The repeated and somewhat inconsistent warnings about double counting need to be carefully reviewed and sometimes eliminated from the guidance. It is appropriate that we avoid counting the same ecosystem service benefit in two separate categories - BUT there are many cases in which the same action provides unique services in multiple categories and such actions should be encouraged. For example, if a restoration project enhances recreational access, reduces greenhouse gas emissions, and provides excess nutrient abatement, then that implementation should be worth considerably more than a project that provides only a single service.

The guidance references to greenhouse gases struck me as particularly unhelpful and inconsistent and should be carefully evaluated to ensure clarity and consistency.

I find Appendix I to be unhelpful. It essentially suggests that nearly every type of policy will have impacts (of uncertain sign and magnitude) on nearly every ecosystem service. It flattens complexity in a way that is not particularly helpful or clear. It creates the illusion of a clear dichotomy for many actions when the reality will nearly always be more nuanced. For example, green space creation is treated as only positive, but I know of examples here in Durham, NC where mature unmanaged forests were removed to create the green space of baseball fields and of neighborhoods where the construction of a new city park led to increases in property values that forced long-time residents and renters to relocate away from a tightly knit community.

Individual Peer Reviewer Comments: Ankur Desai

Benefit-Cost Analysis is an important component of the federal rule-making and review process. The updates in the recent OMB Circular A-4 provided additional details and updates for best practices in cost estimation, managing imperfect information, accounting for baseline assumptions, and scope. These are welcome additions to scoping the range of decisions one might make in any type of analysis.

Here, draft guidance has been developed for “Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis”, where further detailed guidance is provided on how ecosystem services should be included in benefit-cost analysis. The overall intention to incorporate these into benefit-cost analysis is welcome. Versions of this are already part of several agencies and having singular guidance that can be applied across agencies should help make the process more uniform and applied more broadly to all decisions where ecosystem services can be enhanced or harmed by regulatory action.

Ecosystem services stress tests all the mechanisms of benefit-cost analysis on A-4 including definition of baseline, temporal and spatial scopes, dealing with imperfect information, difficult to quantify preferences, applying appropriate benefits transfer analyses, and estimating uncertainty. Thus, it is warranted that separate guidance is provided.

I commend the OMB in attempted to address these factors in a single document, with detailed examples, a set of steps to apply, and lengthy tables of services, impacts, decisions. However, that thoroughness comes at a cost of readability. I appreciate the challenge of having a single document that meets the needs of audiences that are both already well seasoned in ecosystem service benefit-cost analysis, including many federal agencies that manage natural resources, and those for whom these types of ecosystem services are a new consideration.

A general recommendation here is to consider how to streamline this document, with a few suggestions:

- A table of terms and definitions
- Greater deference/reference to existing documented approaches for ecosystem service assessment including from federal agencies, major international assessment bodies, and other nations with existing implementation processes
- Introduce each step/concept (e.g., double counting) once, in a section, and to not repeat multiple times
- Have examples consolidated into appendix, perhaps reduced in number of these to key examples that focus on the most important decisions needed to make (scope, benefit estimation, monetization, equity consideration) while expanding the breadth and alternate scenarios within the examples, including analysis of distributional effects and greenhouse gas accounting
- Greater separation of what is an “ecosystem service” from “human welfare”. As it stands multiple tables/sections mix and match (see Table 1, many of the ecosystem services mentioned are not necessarily services)

I should situate my expertise here. I am climate scientist who is an expert on ecosystem-atmosphere interactions including greenhouse gas exchanges. I work with several partners on carbon sequestration estimation and land management. My expertise in the specifics of benefit-cost analysis and their applications by federal agencies is limited and I defer to the other reviewers to apply a more thorough lens on the specific language, terms, and limits. Here are my specific responses to the questions posed to the panel.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

1. Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).

As far as I can tell, the document is thoroughly sourced, though given the fast-evolving nature of the discipline, there is likely more literature by the minute on ecosystem service assessment. It does appear that literature post-2010 is relatively scant along with a lack of consideration of the history of prior and ongoing processes. There are existing and prior guidance documents on benefit-cost analysis for ecosystem services that may to reference and compare, for example FEMA policy 108-024-02, "Ecosystem Service Benefits in Benefit-Cost Analysis" or the ecosystem service decision support tools from the Environmental Protect Agency: <https://www.epa.gov/eco-research/ecosystem-services-research> or existing approaches used by the Army Corps of Engineers and others.

2. Please note any important omissions.

Given the relative novelty of the Social Cost of Carbon (SCC), some more guidance on its use in the examples and in the monetization would be useful. In particular, in what ways do embedded impacts to ecosystems in SCC lead to possible double counting? In what ways, does SCC miss other ecosystem service changes from greenhouse gas emission/sequestration (e.g., role of lifecycle analyses for natural resource extraction)

As an outsider, I was a little surprised to see the lack of a link to well-established processes in environmental impact analysis that goes with NEPA for permitting and regulatory actions and its relationship to ecosystem service benefit-cost analysis. Perhaps they are very different processes, but it might be useful to clarify the difference in how those are implemented, especially for natural resource agencies. At least one public comment also brought this up.

Examples lack consideration of distributional impacts, an important component of A.4. I respect that A.4 provides some guidance here. Here, the use of the environmental justice screening and mapping tools from the EPA are called out and likely the central tool needed for ecosystem service distributional impacts, but how to use them are not really presented. Clarity on estimating distributional impacts was a frequent request in the public comments.

Without a doubt, there is significant uncertainty in many of the steps to estimating the ecosystem service benefit or cost, from defining the "serviceshed", delineating the effect, assuming the marginal impacts are linear/additive, whether to account for "tipping points", selecting the appropriate model for benefits transfer estimation, determining what are plausible sources of uncertainty to include (i.e., the ones that impact relative ranking of policy preferences). Uncertainty analysis is presented in Step 3d, but this needs a larger calling out. There is a risk that this type of analysis is setting an analysis up for failure, either in that one could come up with opposing guidance based on selection of criteria, or that one could become overwhelmed with accounting for every source of uncertainty. For ecosystem services and climate change, probabilistic thinking has to be infused in every step along with a sense of what is "good enough" and what is "defensible". As a scientist, I like to think in terms of alternative hypotheses, and whether a preponderance of evidence leans toward supporting or falsifying one or several hypothesis over others, taking into account the possibility that sampling uncertainty may lead to some results by chance or with different effect size than across the entire population. I don't expect the writers here to redefine core concepts in benefit-cost analysis. Maybe what's needed is an upfront and center top-line summary of the core steps and the core principles of each, before diving into details, at the beginning of VI.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

3. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.

Another issue brought up is the role of fixed versus shifting baselines. As noted in details for Step 1, baselines (at some level, the “counterfactual case”) should reflect “a reasonable forecast of relevant system dynamics.” When it comes to ecosystem services, I don’t see how this can ever not include climate change. I recommend this be mentioned explicitly. Lack of baseline shift consideration in some carbon offset schemes has been a major source of criticism of their estimates of net sequestration benefit (additionality).

The serviceshed concept is defined as an “area in which a specific ecosystem service accrues to a specific group of people” – this seems like a process that could use more definition or example. Does each ecosystem service first need to define a separate serviceshed?

I don’t understand why the guidance chooses to completely move away from defined published typologies of ecosystem services in regulating/provisioning/culture/supporting or material/non-material are not given, as noted in footnote 2. These typologies are widely used in the science and moving away from them is one reason aspects like Table 1 appear muddled in mixing ecosystem services from human welfare aspects. I’d recommend at least using that typology when discussing ecosystem services throughout.

4. Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

I see a common theme in the public comments from practitioners of concern about knowing “what is good enough” and “how to be timely”? Obviously, some level of judgement is required and experts may have a good handle on it. For a novice practitioner or agency new to ecosystem service assessment, it may quickly become overwhelming or extraordinary lengthy to consider all the factors. Delineation of scope, what to prioritize across services, space, and time should be addressed more concretely, perhaps as frequently asked questions?

Benefits transfer, the art of estimating the costs or preferences of one activity based on a reported stated or revealed preferences from a related activity that may vary in scope, marginal effect, and onward, is likely to be applied quite liberally here. A few wordy examples are provided but not a core set of principles.

In the nature-based climate solutions or carbon offset market literature, a lot of focus is made on additionality over baseline and accounting for leakage. I can see how the framework accounts for the former. How is leakage – the likelihood that some activity in one location that limits some economic activity (perhaps to provide an ecosystem service benefit) just increases the economic activity in another location? Is that the same as transfers?

To what extent does aggregation account for trade-offs?

5. Does the document provide clear and useful guidance for both governmental and non-governmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

See my notes above on delineating the audience of experts who need consolidated instructions and those who benefit from details, literature, and examples. The narrative as written goes into numerous asides

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

throughout that for expert readers are well-known or repeated (e.g., double counting), while for novice readers, may benefit from defining terms, using call-out boxes.

6. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

Perhaps relevant, but there is rich literature on lifecycle analysis when it comes to tracing carbon sequestration and impacts, and some of those will be useful for greenhouse related ecosystem services, and in some cases more useful than a social cost of carbon metric (e.g., forest harvest, production of goods, regrowth, accounting for future disturbance rates). An example of one: White, M.K., Gower, S.T., Ahl, D., 2005. Life cycle inventories of roundwood production in northern Wisconsin: Inputs into an industrial forest carbon budget. *Forest Ecology and Management*, 219, 1, 13-28, <https://doi.org/10.1016/j.foreco.2005.08.039> or Klein, D., Wolf, C., Schulz, C. *et al.* 20 years of life cycle assessment (LCA) in the forestry sector: state of the art and a methodical proposal for the LCA of forest production. *Int J Life Cycle Assess* **20**, 556–575 (2015). <https://doi.org/10.1007/s11367-015-0847-1>

7. Are there important valuation methods that should be mentioned, including for non-use values?

I do not have expertise here.

8. Are there other important references or ecosystem services resources that should be included in the references?

-

9. Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?

-

10. Should any elements be removed?

It is possible that fewer but more worked out examples, with potential alternate pathways within the same example (what if? Scenarios) might be more impactful.

Individual Peer Reviewer Comments: Robert J. Johnston

Introduction and Overview

I commend the Office of Information and Regulatory Affairs (OIRA) and Office of Management and Budget (OMB) for developing the draft *Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis*. Guidance of this type is important to ensure that federal agencies apply valid approaches to incorporate changes in environmental and ecosystem services within benefit-cost analyses, consistent with guidance in Circulars A-4 and A-94. The draft guidance document is intended to be consistent with, and to clarify guidance provided in these existing circulars for analyses that involve significant changes to environmental conditions and ecosystem services.

Following the nomenclature used within the document, the remainder of this review utilizes the shorthand phrase “ecosystem services” to encompass the broader category of welfare-relevant environmental effects and ecosystem services. The rationale for this grouping within the guidance document is the difficulty in unambiguously delineating welfare-relevant “ecosystem service” changes, narrowly defined, from “environmental” changes. The core theory and methods for economic analysis are invariant to whether a change happens to be labeled “ecosystem service” or “environmental,” and one can encounter similar biophysical changes under each of these two descriptions in the literature.¹

Although the draft guidance provides a wealth of useful information to support assessment of ecosystem service changes, the combined focus on environmental effects and ecosystem services within the guidance appears to have led to reduced emphasis on some of the dimensions that pose challenges to benefit-cost analyses involving *ecosystem services*, more narrowly defined, and that can contribute to errors within this type of work. This comment foreshadows a general theme in this review that clearer and more rigorous attention is needed to the theory, methods and accompanying literature that support validity and reliability in ecosystem services analysis. For example, greater attention is required to the primary steps necessary to transition from models and measures of ecological processes (the ecological domain) to models and measures of ecosystem services and accompanying welfare (the human domain). The draft guidance would also be improved by reduced emphasis on informal, illustrative examples and greater emphasis on rigorous and generalizable guidance, grounded in a clearly communicated framework for ecosystem services analysis. In addition, there are errors and omissions in the guidance that should be addressed (both implicit and explicit), for example related to valuation methods.

The draft guidance allows for an array of different situations under which ecosystem services analysis might occur, under the general purview of “assessing environmental and ecosystem services in benefit-cost analysis.” The guidance hence allows considerable latitude in how these analyses might proceed (e.g., based on data availability, the types of services under consideration, the diversity of economic outcomes that might be of interest beyond well-defined welfare measures to support benefit-cost analysis, etc.). Although flexibility of this type is necessary, it also contributes to ambiguity in multiple areas of the draft guidance. The draft guidance could be improved via additional attention to precision, while maintaining flexibility needed for different types of applications.

These observations lead to the general recommendation that the draft guidance would be enhanced by greater precision regarding concepts, theory and methods that support validity in ecosystem services analysis. Further details on this general recommendation are provided under responses to the peer review questions below. The review is organized by peer review question. The first two “questions” are deleted, as these were not specific questions but rather general instructions to review and comment on the proposed guidance.

¹ For example, similar if not identical water-quality changes can emerge due to natural ecological processes or wastewater treatment in manmade facilities.

Response to Peer Review Questions

- 1. Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).***
- 2. Please note any important omissions.***

Questions #1 and #2 address the extent to which the recommendations in the draft guidance are supported by the leading theoretical and empirical peer-reviewed academic literature and whether there are important omissions that should be considered. Because these two questions are closely related, they are answered jointly.

There are multiple areas in which the guidance could be improved by a stronger foundation in the theoretical and empirical peer-reviewed literature. There are also a few areas in which the guidance is at least implicitly inconsistent with the established literature. Benefit-cost analysis involving changes to environmental conditions (or environmental effects) has proceeded for decades under Circulars A-4 and A-94, as required by Executive Orders such as 12866. Methods for this type of analysis are well developed (see, e.g., Bockstael and McConnell 2010; Freeman et al. 2014; US EPA 2014; Champ et al. 2017), and the literature provides contemporary guidance for the theory and empirical methods applicable to this type of work (e.g., targeted guidance for valuation methods in Johnston et al. 2017, 2021, Lupi et al. 2020, and Bishop et al. 2020). Although some of this work is acknowledged and the importance of following best practices (in general) is mentioned, much of the guidance provided by this past work for environmental and ecosystem services valuation has not been acknowledged or integrated into the draft guidance.

For example, the draft guidance (p. 26) explains briefly that “Hedonic pricing methods are frequently used to understand how ecosystems services or natural assets capitalize into other goods that bundle many services, such as real estate value,” citing Bishop et al. (2020), but does not acknowledge key questions or recommendations of best practice that might apply when seeking to apply hedonic methods to ecosystem service valuation (or even explain that the cited article outlines best practices at all). As another example, no mention is given to best practices for the estimation of recreation demand and value (Lupi et al. 2020). Although it is not possible for draft guidance such as this to comprehensively review best practices for all possible techniques, the peer reviewed literature that describes consensus best practices should (at a minimum) be identified, and the draft guidance should acknowledge and at least briefly describe key elements of this best practice that are particularly salient for ecosystem service applications.

In some cases, obsolete citations (or incorrectly dated?) are provided to the literature. For example, Freeman, Herriges and Kling (2003) is cited in the draft guidance instead of Freeman et al. (2014). The correct reference to the older book is Freeman (2003), with no co-authors, whereas the citation to the newer text is Freeman et al. (2014). Regardless, this difference is not trivial, as the literature advanced between 2003 and 2014 with regard to theory and methods supporting environmental and ecosystem services valuation. I also recommend that the draft guidance consider directly applicable guidance documents that are already provided by federal agencies, including US EPA's Guidelines for Preparing Economic Analyses (US EPA 2014). This US EPA document provides extensive guidance for benefit-cost analysis involving environmental and ecosystem service changes of precisely the type covered by the present draft guidance.

Providing Guidance Specific to Ecosystem Services Valuation

The fact that this guidance has been written to supplement the information in Circulars A-4 and A-94 implies that OIRA and OMB believe that these extant circulars provide insufficient guidance for benefit-

External Peer Review on OMB’s Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

cost analyses involving ecosystem service changes, such that additional guidance is warranted. Yet how does *ecosystem services* analysis differ from more traditional environmental benefit-cost analysis, such that further guidance is needed? The answer to this question can help inform the key elements that should be covered, rigorously and thoroughly, in a guidance document of this type.

Compared to traditional economic valuation of market and non-market benefits related to environmental changes, an ecosystem services perspective implies direct attention to the contributions of ecosystem structures and functions to human welfare. Hence, ecosystem services analyses typically give greater emphasis to the ecological processes through which ecosystem services are produced. As described by Johnston (2022), “...*ecosystem services analysis often seeks to trace ... values back through systems of human and ecological production to (a) isolate the values provided by natural systems, and (b) understand how changes in these natural systems affect the provision of valued services. Although the applicable methods for economic analysis may be similar if not identical (e.g., methods for non-market valuation), ecosystem services analysis requires additional steps to identify, quantify and disentangle services provided by ecosystem functions.*”

A foundation of ecosystem services analysis is the translation of models and information on ecological processes into forms that are useful for understanding welfare impacts to people. As such, ecosystem services analysis often requires analysts to characterize complex interactions through which ecosystems directly and indirectly influence human welfare. Moreover, valuation of market and non-market goods and services produced using ecosystem services as inputs is not necessarily the same as valuation of the ecosystem services that produce those goods and services.

This orientation of ecosystem services analysis—seeking to characterize how benefits and costs are related to *ecological systems*—is among the primary reasons why further guidance is needed for ecosystem services analysis, beyond companion information already in Circulars A-4 and A-94. For example, rigorous understanding of the pathways through which changes to ecosystems impact human welfare is required to avoid double-counting. There can be related questions over how final ecosystem services are best quantified (e.g., what biophysical indicators to use)—these questions are also important for analyses that quantify but do not monetize the changes (Johnston and Russell 2011; Olander et al. 2018). Whether these outcomes are denoted “final ecosystem services,” “linking indicators,” “ecological endpoints,” “benefit-relevant indicators,” or something else (cf. Brown et al. 2007, Johnston and Russell 2011, Boyd and Krupnick 2013, Boyd et al. 2016, 2023, Olander et al. 2018), they have a central role in ecosystem services analysis—serving as the well-defined nexus between ecological and human domains. Failure to correctly identify final ecosystem services or distinguish them from intermediate ecological processes can also lead to multiple errors in ecosystem services analysis (Brown et al. 2007, Johnston and Russell 2011; Boyd and Krupnick 2013).² Although not unique to ecosystem services analysis, there can also be important questions about the extent to which certain types of final ecosystem services, such as those related to “culturally valued experiences” (p. 6), can be quantified or monetized. There can also be questions over the difference between ecosystem services and various types of goods and services produced at least in part through those services, leading to questions over “what should be valued” to assess the benefits of ecosystem services.

The guidance does not provide sufficient clarity on general principles, theory, and methods related to topics and questions such as these. The peer reviewed literature provides extensive guidance for ecosystem services analysis, addressing topics such as the underlying theory, development of the integrated frameworks to support ecosystem services analysis, measurement of ecosystem services and benefit-relevant indicators to populate these frameworks, development of causal chains or means-ends diagrams to

² Moreover, in many cases, the same outcome can serve as both a final and intermediate ecosystem service—for example a water quality improvement that is both valued directly and supports increased recreational fish catch (Johnston and Russell 2011; Boyd and Krupnick 2013).

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

structure the analysis, rigorous methods that can be utilized to distinguish intermediate from final services and ameliorate associated problems of double-counting, and applicable market and non-market valuation methods, among others.³ Much of the systematic insight provided by the literature has been given inadequate attention or communicated primarily via informal examples.

The response to peer-review question #5 identifies some key areas where greater guidance is warranted, focusing on the transition from models and measures of ecological systems to models and measures of human systems that is required for valid ecosystem services analysis. Additional omissions are noted in the following subsections.

Sources of Information on Ecosystem Services and Ecosystem Service Values

Agencies and individuals without experience with ecosystem service valuation may lack information on topics such as ecosystem services that might be important to consider in different types of settings and the empirical measures that are best suited to quantify these services. The need for basic information of this type is implied by multiple sections of the draft guidance, which provide information on topics such as “which aspects of human welfare can be affected by ecosystem-service changes” (p. 3) and “does your rule involve ecosystem services” (p. 7). The draft guidance relies primarily on brief and informal examples to convey this information.

Rather than rely on informal examples, the guidance could instead refer readers to existing publications that provide more thorough and systematic insight on the range of different types of ecosystem service changes that can occur in different settings. For example, US EPA has created the “National Ecosystem Services Classification System (NESCOCS)” (Newcomer Johnson et al 2020, US EPA 2015) and the “Final Ecosystem Goods and Services Classification System” (Landers and Nahlik 2013). Extant work (including peer-reviewed literature and federal agency documents) also discusses final ecosystem services that can be provided by specific types of ecosystems, such as coral reefs (Santavy et al. 2021), among many others. Other work reviews empirical measures that are well suited to quantify final ecosystem services associated with particular types of uses and values (e.g., Boyd et al. 2016, 2023). Some of this work has been cited in the draft guidance for other purposes, but does not appear to be acknowledged as a source of information on the types of ecosystem services that can be relevant within different settings. Whether or not OIRA/OMB agrees that the above cited documents are the best options for providing information on ecosystem services within particular types of systems (there might be other and better literature that could be cited), it would be useful to provide sources for this type of information, beyond the informal examples in the text.

Benefit Transfer Methods for Ecosystem Services Valuation

Another set of omissions and misstatements relates to the role of benefit transfer in ecosystem services valuation. Large-scale, applied ecosystem service valuation by federal agencies almost universally requires benefit transfer (Newbold et al. 2018; Johnston and Bauer 2020). The draft guidance considers benefit transfer briefly (one paragraph) on pages 29-30 and discusses some of the common shortcomings encountered in ecosystem services benefit transfers, but this paragraph falls short of the type of explicit guidance needed to help develop and apply these transfers in a valid and credible manner. This paragraph also confounds multiple distinct topics related to ecosystem-services benefit transfers, including (1) the type of transfer method to apply, e.g., unit value versus function versus meta-function, (2) accommodating effects of scope and geographical scale in benefit transfers, (3) incorporating effects of contextual factors

³ See, for example, Boyd and Banzhaf (2007), Brown et al. (2007), Fisher et al. (2008, 2009), Dale and Polasky (2007), Polasky and Segerson (2009), Tallis and Polasky (2009), Bateman et al. (2011), Johnston and Russell (2011), Wainger and Mazzotta (2011), Boyd et al. (2016, 2023), Boyd and Krupnick (2013), Olander et al. (2017, 2018) and Johnston (2022). A comprehensive summary of relevant concepts and methods is provided in the Federal Resource Management and Ecosystem Services Guidebook, <https://nespguidebook.com/>, accessed October 25, 2023.

External Peer Review on OMB’s Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

such as site conditions and available substitutes, (4) the validity of area-based benefit transfers, and (5) effects of primary study validity (i.e., primary study measurement errors; Johnston et al. 2021). Although these appear to be grouped (inappropriately) as part of a general discussion concerning the invalidity of area-based transfers, each of these topics relates to a distinct issue covered by the peer reviewed literature⁴ and for which consensus guidance for benefit transfers is provided in Johnston et al. (2021). Each of these important topics should be addressed independently and systematically (even if briefly), referencing current sources and guidance in the literature. If there is insufficient room in the guidance document for careful treatment of these topics, then they can be identified explicitly and references to the relevant literature provided.

As another example of insufficient information on benefit transfer methods, the draft guidance (p. 30) informs the reader to “Consider whether meta-analyses may help aggregate and synthesize benefit-transfer methods and estimates for particular ecosystem services.” However, no information is provided on *why* meta-analysis should be “considered,” or why such as synthesis and aggregation can be useful to promote more accurate benefit predictions. This information may be found in multiple sources in the literature, as summarized in Section 4.4 of Johnston et al. (2018). Work such as Kaul et al. (2013) provides empirical evidence that data synthesis methods (combining data from more than one study) reduces benefit-transfer errors. The same sentence in the draft guidance implies, incorrectly, that meta-regression analysis may be used to “synthesize benefit-transfer methods,” which is inaccurate as written. When used to support ecosystem services benefit transfer, meta-analyses generally synthesize the results of prior valuation studies on the ecosystem service of interest (they do not synthesize benefit transfer *methods*).

The draft guidance follows with a statement that benefit-function transfer is often preferred to benefit-point transfer, because function transfer has a greater capacity to adjust value predictions “for natural, built, and social system characteristics of the resource of interest.” This is accurate but fails to make explicit one of the key advantages of function transfers for ecosystem services analysis—a capacity to account for effects of scope (i.e., the magnitude of the ecosystem service change) and scale (i.e., the extent of the spatial area over which the change occurs) on the values provided by ecosystem service changes.

As explained by Johnston et al. (2021), the ability of function transfers to adjust study-site value estimates according to observable differences between study and policy contexts can promote accuracy. Among these differences, there may be considerable differences between the scope and scale of the ecosystem service changes for which values were estimated by original primary studies and the scope and scale of changes for which values are needed to support a given benefit-cost analysis. There have also been many methodological abuses (at least from the perspective of welfare theory) related to the treatment of scope and scale within benefit transfers. For example, as described by Johnston and Wainger (2015), some past ecosystem services analyses have sought to predict values for large-scale ecosystem service changes (or entire global ecosystems) by “scaling up” unit values produced by primary studies that consider small-scale, localized changes. It is widely acknowledged that extensive, unadjusted scaling up of per unit benefit estimates in this way sacrifices validity, for example because it fails to account for economic principles such as the diminishing marginal utility that often apply to ecosystem service changes (Bockstael et al. 2000). Among the advantages of function-based transfers—and particularly data synthesis methods such as meta-regression analysis—is a greater capacity to account for the effects of scope and scale on ecosystem service value, and thereby promote more valid and reliable predictions of value. Although the draft guidance alludes to this topic briefly (for example using the example of diminishing marginal utility of beach acres and discussing related-but-not-identical problems with area-based transfers), the frequent misuse of scaling within ecosystem services benefit transfer (see Johnston and Wainger 2015; Johnston et al. 2021 for a discussion) suggests that more explicit guidance is needed to preclude the use of invalid methods within ecosystem service benefit transfers.

⁴ See, for example, reviews in Richardson et al. (2015) and Johnston et al. (2018).

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

There are also misleading statements in the draft guidance regarding benefit transfers. Consider, for example, the following two sentences on page 30: *“In addition, as already noted, values generated by WTP studies may also vary due to context-specific aspects of the study design, including any survey instruments. For these reasons, area-based benefit transfer may not be a robust method for benefit transfer in ecosystem-service analysis for an RIA.”* These two sentences imply direct causality between two issues that have no relationship whatsoever (and least that I can ascertain). The first sentence seems to be a poorly supported criticism of stated preference studies, incorrectly labeled as “WTP studies.”⁵ More specifically, this sentence seems to be alluding to the effect of methodological covariates on primary study welfare estimates that emerge from stated preference valuation. Approaches to address these effects are reviewed in the literature and recommended procedures exist (see Johnston et al. 2006; Moeltner et al. 2007; Stapler and Johnston 2009; and Boyle and Wooldridge 2018). These methods have no direct relationship to the transfer of area-based welfare measures—the validity of which is affected by dimensions such as the effects of scope, geographical scale and the number of affected beneficiaries on the social value of ecosystem service changes (see discussion above). The literature provides guidance for accommodating these effects when implementing ecosystem-services benefit transfers (see, e.g., Johnston and Wainger 2015).

Benefit transfer is also alluded to indirectly on page 28 (but not named explicitly), with the paragraph that begins, *“Analysts considering how best to monetize particular services should first look for existing data that may be relevant to the question at hand, including market and non-market data...”* However, the paragraph that follows again confounds multiple distinct topics related to valid benefit estimation, such as (1) the conceptual / theoretical difference between National Flood Insurance Program (NFIP) claims and welfare change (i.e., that NFIP claims do not represent a well-defined welfare measure), (2) the magnitude of prior estimates of WTP, derived from stated preference studies, (3) benefit-aggregation issues due to factors such as differences in the number of households affected, quality and quantity of wetland affected, and other contributing factors that are not directly relate to the theoretical difference between insurance claims and welfare measures, (4) transfer effects, and (5) avoidance of double-counting when measuring both damage costs and WTP. Given this confounded treatment of distinct methodological topics, it is not clear what systematic guidance or insight can be gleaned from this paragraph, other than a recognition that NFIP flood-claim information is poorly suited to ecosystem services benefit transfer.

A related inconsistency in the draft guidance lies in the fact that the NFIP claims information provided by this paragraph (p. 28) is presented in terms of average claims reduction per acre of wetland. This is an area-based measure (i.e., NFIP claims reduced per acre). However, page 30 then argues (correctly) that constant area-based measures of value should not, in general, be used to support benefit transfers, because “the effect of an area change on a given ecosystem service can seldom be translated directly between contexts” (p. 30). So, page 28 explains how area-based NFIP claims information might be used to provide insight into ecosystem service values, followed by an argument on page 30 that area-based measures should not be used. Given the confounded messages and inconsistencies in these two paragraphs, I suggest the NFIP illustration on page 28 be deleted. At a minimum, the inconsistency between these two paragraphs should be explained.

In summary, the draft guidance does not yet provide sufficient guidance on benefit-transfer methods that are likely to applied by federal agencies and confuses unrelated challenges for benefit estimation. To address this, I recommend more extensive and rigorous discussion of ecosystem services benefit transfer that closely adheres to guidance in the peer reviewed literature. Among these revisions, I suggest that the draft guidance provide an independent section on methods for ecosystem services benefit transfer, focusing

⁵ There is no category of studies denoted “WTP studies” in the environmental economics literature. WTP is a theoretical construct representing a particular type of welfare measure that can be estimated or approximated by many different types of market and non-market techniques. Misguided terminology is also found on page 28, which refers to “a WTP valuation,” seemingly again as a reference to stated preference methods.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

on key questions and challenges that can arise in the type of large-scale transfers that are required of federal agencies, e.g., under Executive Order 12866 (Newbold et al. 2018; Wheeler 2015). Because benefit transfers are almost certain to be the primary approach used by agencies for ecosystem services valuation under the proposed guidance, more explicit (and accurate) information is required on these methods, grounded in conditions for validity and reliability described in the peer reviewed literature. As a starting point, the recent article of Johnston et al. (2021) provides methodological guidance for benefit transfers. The handbook of Johnston et al. (2015) provides information on these methods, including multiple chapters on methods for ecosystem service benefit transfers. Additional, guidance for ecosystem services benefit transfers, along with examples, is provided by Plummer (2009), Johnston and Wainger (2015), Richardson et al. (2015), Johnston and Bauer (2020), and Ferrini et al. (2015). Particular attention is required to steps and validity in large-scale benefit transfers, for example as discussed by Johnston and Bauer (2020), Ferrini et al. (2015) and Johnston and Wainger (2015).

3. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.

The validity of benefit-cost analysis involving ecosystem services requires a systematic understanding of the concepts and relationships that allow valid measures of value (or quantification of ecosystem services) to be derived (see, e.g., Brown et al. 2007, Segerson and Polasky 2009, Bateman et al. 2011). For example, understanding of welfare theory as applied to ecosystem services analysis is required to determine whether different types of monetary measures reflect theoretically valid measures of ecosystem service value and the extent to which different value measures can be aggregated (or not) within benefit-cost analysis. Similar conceptual understanding is required to determine which biophysical indicators represent suitable metrics for ecosystem service quantification, for example considering distinctions between final ecosystem services and intermediate ecosystem processes (Johnston and Russell 2011; Olander et al. 2018; Boyd et al. 2016, 2023). The draft guidance often speaks to concepts and relationships such as these in a general or colloquial sense that lacks clarity and fails to reflect the more precise definitions in the peer-reviewed literature. Some concepts remain undefined in precise terms.

Some examples of informal or ambiguous concept definitions are minor in terms of implied practice. For example, nonuse values are described in the guidance as “values generated without the beneficiary taking action.” Another somewhat puzzling definition is found in footnote 24: “Economists often categorize benefits as non-use values when an individual forgoes current benefits by not consuming a good or service in the current period.” I am not aware of any formal definition of nonuse values that requires an individual to forgo current benefits. At a minimum, this statement should be clarified.

First, note that these definitions are distinct from the definition provided in Circular A-4. It is not clear why this guidance and A-4 should apply inconsistent definitions of the same concept. Second, although there have been multiple competing definitions of nonuse values proposed in the literature (Carson et al. 1999; Freeman et al. 2014), the definitions used here are neither particularly useful nor precise. For example, multiple types of values that are typically considered use values (e.g., values lost due to mortality caused by air pollution exposure) do not require an individual to “take action.” Rather than rely on an informal definition such as this, I recommend that the guidance adopt a more rigorous definition (which acknowledging that there have been many different attempts to define nonuse values). For example, Carson et al (1999) defines passive-use values instrumentally as “those portions of total value ... that are

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

unobtainable using indirect measurement techniques which rely on observed market behavior.” Alternatively, the guidance could adopt the definition applied in Circular A-4 for consistency.⁶

The above example is not particularly important for practice, as nonuse values cannot be measured empirically as a distinct component of benefits, at least in a theoretically defensible manner (Carson et al. 1999). Instead, nonuse values are incorporated implicitly in estimates of total WTP. However, other areas in which clarity is lacking are directly relevant for the procedures used to quantify and value ecosystem services. For example, concepts such as “final” and “intermediate” ecosystem services are mentioned repeatedly within the draft guidance but are not defined formally. Poorly defined terminology is also used when describing different types of valuation methods (e.g., “WTP studies,” which has no clear definition in the literature) and categories of valuation methods (e.g., in Table 3 – see discussion below).⁷ Terms in the draft guidance such as “welfare outcome” (p. 34) and “human welfare endpoints” (Appendix I table heading) are poorly defined and inconsistent with standard nomenclature in the economics literature.⁸ Lack of conceptual clarity in areas such as these can contribute to errors in ecosystem services analysis. For example, a failure to clearly understand the distinctions between intermediate ecosystem processes and final ecosystem services can lead to errors in the estimation and aggregation of benefits (e.g., Brown et al. 2007; Dale and Polasky 2007; Fisher et al. 2008, 2009; Johnston and Russell 2011; Boyd and Krupnick 2013).

Rather than provide precise conceptual definitions, much of the draft guidance document is devoted to informal examples covering topics such as the ways in which ecosystem services can influence human welfare (pp. 4-7), ways that different types of governmental rules or actions can influence ecosystem services (pp. 7-8, 10-13), illustrative linkages between biophysical changes and human welfare (pp. 14-17), and others. The Appendices (38 pages in total) are devoted to similar examples. These examples are neither rigorous nor conceptually consistent and sometimes detract from an understanding of key concepts.

Consider the examples on pages 4-7, illustrating aspects of human welfare that can be affected by ecosystem-service changes. These examples present discuss a myriad of ways that environmental and ecosystem service changes can influence people. Some of the examples consider impacts on human health and mortality due to environmental changes (e.g., “polluted air can cause or exacerbate respiratory and

⁶ Poorly defined terminology of this type is used throughout the draft guidance. Consider the terms “nonuse values” and “passive-use values.” Both of these terms are used in the draft guidance, but the guidance provides neither clear definitions nor a rigorous explanation of the relationship between the two. In some instances, the text implies that the two concepts might be identical (e.g., page 6, “In cases of passive-use or non-use values, services can still be generated even during periods of human inaction.”). However, in other cases the text implies that they are distinct (e.g., page 6, “In such cases, the passive use-value may provide only a lower bound to the non-use value.”) Note that Carson et al. (1999) provide a formal definition of “passive-use value,” given the observational ambiguity of motivation-based definitions implied by the more common term “nonuse value.” However, in the current version of the draft guidance it is not clear whose definitions of these terms are assumed or what those definitions might be.

⁷ The draft guidance alludes to this distinction, for example on page 34: “including the values of processes that occur along the causal chain from a system change to a welfare outcome (e.g., valuing an intermediate service and the associated final service) can lead to double-counting.” However, nowhere in the draft guidance are clear conceptual definitions, associated methods or related literature provided to help practitioners understand how to distinguish between “processes that occur along the causal chain” and the “welfare outcome.” It is also unclear what is implied by the “welfare outcome” in this sentence—is this the monetary welfare measure or the final ecosystem service change?

⁸ For example, the table in Appendix I lists conceptually inconsistent constructs such as “Property Value,” “Production,” “Mental Health” and “Passive Use Values” as “Human Welfare Endpoints.” The first of these (Property Value) is a price observed in markets, or sometimes an assessed value. The second (Production) is a process that transforms inputs into valued goods and services. The third (Mental Health) is a human condition for which changes can be linked to welfare effects. The fourth (Passive Use Values) is a welfare measure. Given this conceptual inconsistency, it is unclear what definition of “Human Welfare Endpoints” is implied, and no definition is provided. This term appears nowhere else in the draft guidance.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

other severe diseases”), but do not consider the associated welfare effects. Others address economic consequences or impacts of these changes that might or might not be considered well-defined welfare impacts, depending on the circumstance (e.g., avoided costs due to illness, “losses and damages” due to flooding). Still other examples discuss well-defined welfare effects that can emerge due to ecosystem service changes (e.g., changes in nonuse values), or market impacts through which welfare effects can be derived (e.g., changes in property values or firm profitability). And other examples provide a vague notion of benefit, e.g., “outdoor recreation, including hunting, fishing, hiking, swimming, boating, camping, playing, and wildlife viewing, are important forms of leisure that many people value.” These examples convey the general idea that changes to ecosystem services and environmental conditions influence humans in a myriad of ways, but do not do so in a conceptually consistent manner that supports rigorous understanding of how these effects should be incorporated within an ecosystem services analysis.

Conceptual consistencies such as those described above are common in the draft guidance. Consider the examples provided under the subsection, “Does your rule involve ecosystem services?” (pp. 7-8). Table 1 claims to show “a sample (non-exhaustive) list of ecosystem services affected.” However, contents of the table include an inconsistent mix of intermediate ecosystem processes (e.g., biological resource productivity for timber), final ecosystem services (e.g., flood risk reduction), and causal impacts on unspecified services (e.g., “greenhouse gas effects on various services”). Other examples are not ecosystem services themselves but rather access to services (e.g., “ability to access sacred sites”). For readers unfamiliar with ecosystem services analysis, these illustrations are unlikely to support a clear understanding of how ecosystem services are defined or how they might be measured to support benefit-cost analysis.

Inconsistent treatment of concepts within these examples can lead to confusion on the methods that should be used for ecosystem services analysis, including uncertainty regarding “what to model or measure” when seeking to quantify or value ecosystem services, and whether different monetary metrics reflect (or do not) well-defined welfare measures suitable for direct use within benefit-cost analysis. To answer questions such as these, there is a large and growing literature devoted to integrated concepts and methods for ecosystem services valuation.⁹ The draft guidance would be improved by the use of concepts and definitions consistent with this literature, grounded in a clear conceptual framework for understanding ecosystem services (see additional discussion of this topic below).

More informative examples could also be used. A clearer and more systematic set of examples might begin with an illustrative federal action (e.g., regulations to protect wetlands), describe one or more changes in ecosystem structure or function that might result (e.g., greater areas of functioning wetlands), describe resulting effects on final, welfare-relevant ecosystem services (e.g., larger populations of wetland-dependent birds), then describe the well-defined welfare measure that could be estimated, as applicable (e.g., increased use values due to recreation, where recreational demand is conditional on these bird populations). From that point, one could illustrate the type of valuation methods that could be applied to assess relevant benefits. A rigorous, parallel set of examples of this type could help better convey the framework that underpins ecosystem services analysis, beyond the broad idea that “ecosystems affect people in many different ways” It could also help users of the guidance understand the constructs that would be described, quantified or monetized.

⁹ Examples include Boyd and Banzhaf (2007), Brown et al. (2007), Fisher et al. (2008, 2009), Dale and Polasky (2007), Plummer (2009), Polasky and Segerson (2009), Tallis and Polasky (2009), Bateman et al. (2011), Johnston and Russell (2011), Wainger and Mazzotta (2011), Richardson et al. (2015), Johnston and Wainger (2015), Boyd et al. (2016, 2023), Boyd and Krupnick (2013), Olander et al. (2017, 2018) and Johnston (2022).

4. Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

The lack of conceptual clarity described under the response to peer-review question #3 above simultaneously implies lack of consistent categorization—for example distinguishing intermediate ecological processes from final ecosystem services, or final ecosystem services from welfare effects, among others. Because each of these concepts imply a corresponding set of conceptual categories for ecosystem services analysis, it is not possible to disentangle the concepts from the implied categories. To avoid redundancy, however, the response to peer review question #4 focuses solely on topics that are not discussed above.

Categorization Values and Valuation Methods

Throughout the draft guidance, but particularly in the section on monetization (pp. 26-31), both implied and explicit categorizations of values and valuation methods are inconsistent with the peer reviewed literature, and many of these categorizations are misleading. Consider Table 3 as an example, where the first column presents a conceptually inconsistent combination of “valuation methods and estimates.” There are multiple inconsistencies with this categorization. First, the table seems to confound the methods that are used (e.g., revealed preference, stated preference) with the type of values that are measured using those techniques (e.g., direct use, indirect use). It is not clear why a separate category is defined for “revealed or stated preference or health utility”—this entire category refers to a type of value (values for health-risk reduction), not a type of valuation method. A “value of statistical life” (VSL) is a value that simply represents a standardized, unit-value benefit transfer, that also relates to values of health-risk reductions (Johnston et al. 2021). The VSL is a type of value not a valuation method (VSLs may be estimated via multiple approaches, including revealed preference methods, stated preference methods, meta-analyses that combine prior primary estimates, etc.). See, for example, Appendix B in US EPA’s Guidance for Preparing Economic Analyses (2014). The “value of statistical life years” is not generally accepted as a valuation approach for risk reductions. Finally, the “social cost of greenhouse gases” also reflects a standardized value, usually produced via an integrated assessment model.

Other inconsistencies in Table 3 are found in the second column, which implicitly confounds different types of economic values, economic impacts, ecosystem services and other outcomes. For example, “recreation income” is an economic impact with no direct link to well-defined welfare measures. “Real estate value” is an observed market price (for real estate) that may be used to derive measures of value, for example via hedonic methods. “Agriculture” is a type of activity. Reduction in “physical health risks” is a measure of a final ecosystem service. The final column then lists “greenhouse gas effects on multiple services,” which focuses on the cause of the change rather than the value to be estimated. Like the first column, the second column detracts from a clear understanding of how ecosystem service values can be categorized and measured.

This categorization of values and methods may lead to confusion over distinctions between the type of welfare measures to be estimated and the methods used to estimate them. It is also unnecessary. The literature provides many examples of clearer and more consistent typologies of valuation methods that simultaneously illustrate the types of values that can be estimated. More consistent and informative categorizations of methods for ecosystem services valuation are provided by Bateman et al. (2011), Holland et al. (2010, chapter 4), Johnston (2022), and the Federal Resource Management and Ecosystem Services Guidebook, <https://nespguidebook.com/>, among many others. An alternative but also more consistent organization of values and valuation methods is provided by US EPA’s Guidance for Preparing Economic Analyses (2014, Table 7.1). Rather than “reinvent the wheel” in a conceptually inconsistent manner, I suggest that the guidance adopt or closely adapt one of these (or similar) valuation typologies.

External Peer Review on OMB’s Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Conceptual Categories within Causal Pathways

Inconsistent categorization is also implied by the examples of causal chains and pathways provided in the draft guidance, primarily although not solely in the appendices. This critique applies in multiple areas, including the verbal descriptions of pathways in Appendix I and illustrative conceptual models in Appendix II. As a precursor to this comment, I note that the guidance is intended to be “generally applicable to benefit-cost analyses that are consistent with both OMB Circular A-4 and A-94” (p. 1). This stated objective implies that the presented or implied categories (e.g., of types of economic effects, ecological processes versus final ecosystem services) should be consistent with those relevant to valid estimation of benefits and costs, consistent with neoclassical welfare theory.

The provided examples and causal chains do not support clear understanding of conceptual categories that support valid benefit-cost analysis. Two areas of implied categorical inconsistency (or at least ambiguity) are found in (1) the “economic effects” or endpoints shown in the different causal chain examples in Appendix II, and (2) the “possible causal pathways” in Appendix I.

Consider the illustrative conceptual models shown on pages xx – xxviii. In many cases it is unclear what the various boxes are intended to show or how these diagrams relate to conceptual categories consistent with benefit-cost analysis. Consider the second example, (p. xxi). The final column presents a conceptually inconsistent combination of outcomes such as “property & shoreline protection,” “human health,” “revenue” and “jobs”—each of which would have a different role (or lack of a role) within benefit-cost analysis. For example, revenues and jobs are economic impacts rather than welfare measures, and “property & shoreline protection” is a general conceptualization of an ecosystem service for which values could be estimated. The illustrated causal chain on page xxiii includes a column entitled “economic effects” that includes a myriad of inconsistent economic measures, some of which are economic impacts, others of which are welfare effects and others of which are undefined (e.g., “burden of disease”). The example on page xxvii includes a final column entitled “value” that includes a conceptually inconsistent set of different elements, few of which would be considered well-defined “values” or welfare effects for purposes of benefit-cost analysis. For example, it is not clear why “PES and Carbon Offset schemes” are included under a heading of “value,” or how “tourism/ecotourism” is to be interpreted within this context.

Similar inconsistencies are found within the “possible causal pathways” illustrated in the Appendix I table. For example, some of these causal chains terminate with effects on environmental conditions (e.g., reduced greenhouse gases), others terminate with health risk reductions, others terminate with ambiguously specified economic effects or values (e.g., “multiple indirect losses”). For those unfamiliar with ecosystem services or benefit-cost analysis, these illustrations are unlikely to clarify how different types of biophysical and economic measures are categorized and understood within formal frameworks for benefit-cost analysis.

Steps in Ecosystem Services Analysis

Circular A-4 provides a set of steps for regulatory analysis that also apply to analysis of benefits and costs due to environmental and ecosystem service changes. Because the draft guidance is designed to accompany and supplement guidance in Circular A-4 (and the same analytical steps apply), redesigning an alternative set of steps for ecosystem services analysis seems to confuse rather than clarify the process.

The general steps outlined in Circular A-4 include the following:

- evaluating the need for the regulatory action;
- defining the baseline;
- identifying a range of regulatory alternatives;
- estimating the benefits, costs, and transfers of each regulatory alternative; and
- summarizing the regulatory analysis.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

The same steps apply to regulatory analysis involving ecosystem services. To add clarity on the ways these steps are accomplished for analyses that involve ecosystem services, one can easily add subheadings to each of these steps as needed. Redefining the steps (as done in the draft guidance) is unnecessary and confounds multiple distinct procedures. For example, the description of Step 1 seems to confound establishing the scope of the analysis with establishing the baseline and the regulatory alternatives to be considered. These are related, but determining baselines and regulatory alternatives is not a subcomponent of determining the spatial and temporal scope of the analysis.

At least one of the suggested steps confounds the procedural steps in an ecosystem services analysis with recommendations on how those steps should be accomplished. Step 1 in the draft guidance is explained as “ensure that the scope (i.e., time and spatial scale) of the analysis is sufficiently broad to reflect important ecosystem services in the baseline and across alternatives.” This confounds the procedural step (i.e., define the scope of the analysis) with guidance on how that step should be accomplished (i.e., in a way that is sufficiently broad to reflect important ecosystem services in the baseline and across alternatives).

In addition, the level of detail presented under each of the steps does not appear to match the extent to which guidance is needed in each area. Consider Step 1. Circular A-4 already provides direct and relatively extensive guidance on developing the spatial and temporal scope of the analysis, so that much of the information in this section is redundant with material already in A-4. In contrast, Step 2 is immensely important for ecosystem services analysis and includes some of the most challenging questions for this type of analysis, with many topics that are not covered in Circulars A-4 or 94. However, less than four pages of guidance are devoted to this crucial topic. Many of the comments included above relate to the need for more rigorous guidance under Step 2.

Overall, I recommend removing the currently proposed steps and restructuring the guidance to match the steps in Circular A-4 (which also apply here), then adding additional information to each step to clarify how each one applies to ecosystem services analysis. If no further information on a particular step is required beyond that already in A-4, then this can be stated directly.

5. Does the document provide clear and useful guidance for both governmental and non-governmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

The draft guidance provides useful information to help guide benefit-cost analysis involving ecosystem services. However, as discussed above, the utility and clarity of the guidance are reduced by informal presentations of theory, concepts and methods. There are multiple areas in which more informative guidance could be provided. As a precursor to this comment, it is important to acknowledge that the peer-reviewed literature on ecosystem services valuation (at least that consistent with the principles of economic benefit-cost analysis) is grounded in broadly accepted, consensus framework for ecosystem services analysis, with accompanying theory and empirical methods. This framework is implicit in the proposed guidance but is not communicated clearly and systematically. Instead, as mentioned above, the guidance is oriented around a set of rather loosely structured, conversational questions (e.g., “Which aspects of human welfare can be affected by ecosystem-service questions?”; “Does your rule involve ecosystem services?”), with answers framed around loose illustrative examples rather than clear and generalizable concepts. This approach stands in contrast to more systematic guidance such as that found in Circular A-4.

There are multiple areas in which more systematic guidance would be helpful. Many of these are already discussed in responses to peer review questions #1 through #4 above. A key example is the translation from an ecology framing (ecosystem functions) to ecosystem services framing, including the identification and measurement of well-defined ecosystem services that are amenable to value estimation. Citations provided

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

above provide guidance for these key steps. More informative presentation of valuation methods, grounded in the peer reviewed literature, is also warranted. This topic is discussed elsewhere in this review.

The draft guidance also provides somewhat confusing insight into the relationship between ecosystem service beneficiaries and the extent of the market for an ecosystem services analysis, and these topics are covered in two different steps of the suggested process. Note that, conceptually, the economic extent of the market is defined by the location of beneficiaries – those individuals whose welfare is affected an ecosystem service change (Smith 1993). However, the draft guidance suggests that the “extent of the market” should be selected in Step 1, whereas identification of beneficiaries is discussed under Step 2. Of course, there can be a distinction between the economic extent of the market and the accounting or political extent of the market that determines “whose benefits count” for a legally mandated benefit-cost analysis (Loomis 2000). Nonetheless, it makes little sense to identify potential beneficiaries under Step 2, only after one has determined the extent of the market for the analysis in Step 1. I recommend that the draft guidance be revised to provide conceptually consistent advice on how these two related determinations are made jointly within an ecosystem services analysis.

The guidance also provides a seemingly misdirected set of suggestions for resources that are most applicable when determining ecosystem service beneficiaries. For example, to identify “the groups of people likely to experience expected changes in ecosystem services,” (p. 23) the draft guidance suggests the use of environmental justice databases and screening tools. Tools of this type are useful for many important purposes, but are not designed to identify ecosystem service beneficiaries. The guidance in this area seems to confound two important but conceptually distinct topics—identifying communities of concern (e.g., underserved communities) and identifying ecosystem service beneficiaries. Those conducting ecosystem services analysis should certainly consider beneficiaries who reside in underserved communities, but ecosystem service beneficiary groups are not restricted to these communities.

Finally, the draft guidance seems to coningle actions that affect ecosystem services and actions that influence the preferences for those services. In general, ecosystem services analysis considers actions that change ecosystems in ways that influence human welfare. Associated methods for welfare analysis presume that preferences are constant in the short run (although they might change over long periods). Seemingly contrary to this approach, the draft guidance also includes multiple examples of actions that change underlying preferences, not ecosystems. An example is found on page 13, “many conservation campaigns aim to increase awareness of endangered species and increase the population that holds an existence value for those species.” Measuring welfare effects of this type (due to actions that provide information intended to change preferences) requires that one consider theory and methods related to the welfare economics of information (Just et al. 2004, chapter 11), none of which is covered in the draft guidance, and which are distinct from standard methods for ecosystem services valuation. Either more complete guidance should be provided into how changes of this type are incorporated within welfare theoretic benefit-cost analysis or these examples should be omitted.

6. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

As noted elsewhere in this review, the draft guidance is too heavily reliant on illustrative and sometimes inconsistent examples of ecosystem services. Rather than rely on additional examples, the guidance could instead refer readers to existing publications that provide more thorough and systematic insight on the range of different types of ecosystem service changes that can occur in different settings. See my response to peer review questions #1 and #2 above.

7. Are there important valuation methods that should be mentioned, including for non-use values?

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Applicable approaches for ecosystem services valuation are well established and described in the literature. However, there are deficiencies in the categorization and description of these methods in the draft guidance, as discussed in responses to peer review questions #4 and #10. To rectify some of these shortcomings, I suggest that the guidance adopt or closely adapt an existing valuation typology from the literature. One can look to established valuation references such as Freeman et al. (2014), US EPA (2014), Champ et al. (2017) and Hanley and Barbier (2009) for an overview of the primary valuation methods applicable to changes in environmental conditions and ecosystem services. As noted above, I recommend greater attention to benefit transfer, as this is likely to be the primary approach applied for ecosystem services valuation under this guidance.

I also recommend that the draft guidance provide more valid information on contemporary stated preference methods, consistent with the peer reviewed literature (Johnston et al. 2017b), including deletion of the unwarranted negative commentary on page 29 (see my response to peer review question #10 below). With regard to non-use values, it is widely established that stated preference methods (including discrete choice experiments) “are the only available means to estimate non-use (also called nonuse or passive-use) values, or use values associated with changes that fall outside the range of current markets or observed conditions” (Johnston et al. 2017b). Consistent with the literature, the draft guidance should make clear stated preference methods (or benefit transfers of information from prior stated preference studies) are the only valid approach to estimating nonuse values.

8. Are there other important references or ecosystem services resources that should be included in the references?

Responses to the other peer review questions identify a broad range of references and ecosystem services resources that could be included. In addition, it could be useful to provide citations to high quality integrated assessments that demonstrate applications of different types of ecosystem services and environmental valuation. There are many examples in the peer reviewed literature, including (for example) multiple articles in a recent special section of the *Proceedings of the National Academy of Sciences* devoted to water quality benefits (e.g., Johnston et al. 2023; Lupi et al. 2023; see summary in Bateman et al. 2023). Other articles cited above provide useful information, examples and guidance for key procedures such as ecosystem services measurement and quantification (e.g., Boyd et al. 2016, 2023, Olander et al. 2018).

There are also existing models and resources that can be directly used or adapted to support ecosystem services benefit transfer, including multiple high-quality meta-analyses designed for general application. Johnston et al. (2018) provide a review and evaluation of newer meta-analyses in the valuation literature, some of which are suitable for applied valuation. Recent examples include the meta-analyses of Moeltner et al. (2023), Johnston et al. (2017a, 2019), and Newbold et al. (2018b) designed to support estimation of water quality benefits. Johnston and Bauer (2020) provide a step-by-step illustration of how meta-analyses of this type can be applied for policy evaluation. US EPA has also developed a prototype *BenSPLASH* model for water quality valuation, based on a similar underlying meta-analysis (Corona et al. 2020).

It might also be useful to provide information on existing valuation databases that can sometimes provide data to help support ecosystem service benefit transfers, such as the Environmental Valuation Reference Inventory (<https://evri.ca/en>). Although there are limitations in the insight that can be provided by typologies, classification systems, reviews and databases such as these (Johnston et al. 2018), they can nonetheless serve as a starting point to understand the services provided by particular ecosystems, available value estimates for these services and the types of empirical measures that can be used to quantify services that may be important in different settings.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

At the same time, care must be taken when using information derived from valuation databases, and I would not recommend that all possible databases be listed. For example, many value estimates provided within the ecosystem services valuation database (Van der Ploeg and de Groot 2010), developed for the Economics of Ecosystems and Biodiversity project, have been characterized as “flawed in ways that would [make] their use in benefit transfer highly suspect” (Blomqvist and Simpson 2017).

9. *Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?*

Rather than adding new examples, I suggest a *reduction* in the number of illustrative examples in the appendix. Instead of adding additional brief examples (and risking further inconsistencies in the examples that are provided), I suggest the development of a few, much more detailed examples that clearly and consistently convey key concepts, methods and frameworks for the incorporation of ecosystem service changes within benefit-cost analysis. The current mix of examples serves to convey the (already obvious) concept that ecosystem changes have a myriad of direct and indirect effects on people, but fails to provide generalizable insight into how these changes are conceptualized, categorized and measured to support ecosystem-services valuation and benefit-cost analysis.

10. *Should any elements be removed?*

As noted above, I suggest removal of most of the examples in Appendices I and II. As currently included, these examples fail to clarify the concepts, categories and frameworks necessary to support valid incorporation of ecosystem service changes within benefit-cost analysis. Similarly, the examples in Sections III and IV lack the precision and consistency necessary to support valid ecosystem services analysis. I recommend removal of most of these examples. In their place, I recommend development of a small number of thorough, precise and rigorous examples that convey consistent, generalizable principles consistent with benefit-cost analysis.

There is also redundancy within the draft guidance that could be reduced. For example, there is repetition of the distinctions between natural capital and ecosystem services. The guidance repeatedly mentions the importance of measuring values for changes in ecosystem services rather than for complete ecosystems. There is also repetition regarding the potential relevance of greenhouse gasses within ecosystem services analysis—this redundancy does not add clarity to the draft guidance. These are just a few examples. In general, I recommend that the document be reviewed to eliminate redundancy.

Footnote 24 provides an uninformative perspective on nonuse values that confounds multiple issues, including (1) the concept or definition of nonuse value, (2) challenges for estimating these values, (3) indirect evidence that nonuse values might exist, such as cases in which individuals are observed to forgo consumption of a good or service, presumably in order to obtain an ongoing flow of nonuse or other benefits that would result by not consuming that good or service, (4) possible relationships between non-use and passive-use values, and (4) the possibility of individuals taking management actions. Other statements in this footnote have little to do with nonuse values, such as “*Individuals are sometimes willing to forgo other benefits, such as lower product prices, in order to secure public ecosystem services. However, market failures can prevent individuals from doing so. Regulation can help correct some of these market failures.*” This discussion fails to clarify the concept of nonuse values or how they can be estimated. I recommend that this footnote be deleted, or at a minimum heavily revised.

There are also multiple unsupported comments throughout the draft guidance that seem to have little purpose beyond casting vague and unwarranted doubt on the validity of stated preference methods. All broadly established, primary-data valuation techniques have advantages and disadvantages. With this in

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

mind, it is unclear why the draft guidance targets stated preference methods alone for criticism. An example is the statement on page 30: *“In addition, as already noted, values generated by WTP studies may also vary due to context-specific aspects of the study design, including any survey instruments.”* Another example is found on page 29: *“Because survey respondents are sometimes asked to value goods and services that are not traded directly in the market, their elicited responses may suffer from many deficiencies that are noted in the economics literature. Household respondents may not know the full extent of the ecosystem services that they currently derive from wetlands or they may not know how to monetize values. In cases in which the survey instruments do not describe all of a wetland’s attributes or the services of interest, the valuations provided by households may be lower than if such information were provided and understood.”* No similar emphasis is given to potential shortcomings or biases that can occur when using revealed preference valuation methods. These comments are also misleading – for example implying that stated preference methods somehow directly ask respondents to “monetize values,” which is not the case for stated preference methods that follow best practices (Johnston et al. 2017b). These statements also seem to criticize stated preferences methods using examples of poorly developed value elicitation (rather than stated preference methods that follow best practices), for example implying that scenarios could fail to convey *“full extent of the ecosystem services that they currently derive from wetlands.”*

As is the case with all valuation methods, the validity of stated preference approaches is conditional on the methods that are applied, as outlined by Johnston et al (2017b). In this sense, stated preference methods are no different than revealed preference methods. The imbalanced, unsupported, and overtly negative treatment of stated preference methods in the draft guidance is unwarranted and misleading, and should be deleted. Also note that some of the other text on page 29 (for example, regarding relationships between revealed and stated preference methods) appears to have been copied directly from Circular A-4. Because this draft guidance is designed to supplement information in Circulars A-4 and A-94, I recommend that the guidance simply refer readers to these prior circulars for this information.

References

- Bateman, I., B. Keeler, S. Olmstead, and J. Whitehead (2023), 'Perspectives on valuing water quality improvements using stated preference methods', *Proceedings of the National Academy of Sciences* 120(18), e2217456120
- Bateman, I.J., G.M. Mace, C. Fezzi, G. Atkinson, and K. Turner (2011), 'Economic analysis for ecosystem service assessments', *Environmental and Resource Economics*, 48, 177-218.
- Bishop K.C., N.V. Kuminoff, H.S. Banzhaf, K.J. Boyle, K. von Gravenitz, J.C. Pope, V.K. Smith, and C.D. Timmins (2020), 'Best practices for using hedonic property value models to measure willingness to pay for environmental quality.' *Review of Environmental Economics and Policy* 14 (2), 260-281
- Blomqvist, L. and R.D. Simpson (2017), 'The value of ecosystem services: What is the evidence?' In: *Effective Conservation Science: Data Not Dogma*. Ed. by P. Kareiva, M. Marvier, and B. Silliman. Oxford, UK: Oxford University Press.
- Bockstael, N.E., A.M. Freeman, R.J. Kopp, P.R. Portney, and V.K. Smith (2000), 'On measuring economic values for nature', *Environmental Science and Technology*, 34, 1384-1389.
- Bockstael, N.E., and K.E. McConnell (2010), *Environmental and Resource Valuation with Revealed Preferences: A Theoretical Guide to Empirical Models*, Springer, Dordrecht, Netherlands.
- Boyd, J. and A. Krupnick (2013), 'Using ecological production theory to define and select environmental commodities for nonmarket valuation', *Agricultural and Resource Economics Review*, 42, 1–32.
- Boyd, J. and S. Banzhaf (2007), 'What are ecosystem services? the need for standardized environmental accounting units', *Ecological Economics*, 63(2-3), 616–626.
- Boyd, J., P. Ringold, A. Krupnick, R.J. Johnston, M.A. Weber, and K. Hall (2016), 'Ecosystem services indicators: Improving the linkage between biophysical and economic analyses', *International Review of Environmental and Resource Economics*, 8, 359-443.
- Boyd, J., R.J. Johnston and P. Ringold (2023), 'Biophysical measures to support analysis and communication of existence values.' *International Review of Environmental and Resource Economics*, 17(2-3), 153-230.
- Boyle, K.J., and J.M. Wooldridge (2018), 'Understanding error structures and exploiting panel data in meta-analytic benefit transfers', *Environmental and Resource Economics*, 69, 609-635.
- Brown, T.C., J.C. Bergstrom, and J.B. Loomis (2007), 'Defining, valuing and providing ecosystem goods and services', *Natural Resources Journal*, 47(2), 329-376.
- Carson, R. T., N. E. Flores, and R. C. Mitchell (1999), 'The theory and measurement of passive-use value,' In: *Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries*. Ed. by I.J. Bateman and K.G. Willis. Oxford, UK: Oxford University Press. 97–130.
- Champ, P., Boyle, K., Brown, T. eds. (2017), *A Primer on Nonmarket Valuation*. Netherlands: Springer Science and Business Media.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- Corona J., T. Doley, C. Griffiths, M. Massey, C. Moore, S. Muela, B. Rashleigh, W. Wheeler, S.D. Whitlock, and J. Hewitt (2020), 'An integrated assessment model for valuing water quality changes in the United States', *Land Economics* 96(4), 478-492
- Dale, V.H. and S. Polasky (2007), 'Measures of the effects of agricultural practices on ecosystem services', *Ecological Economics*, 64(2), 286-296.
- Ferrini, Silvia, Marije Schaafsma, and Ian J. Bateman (2015), 'Ecosystem services assessment and benefit transfer.' In: *Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners*, ed. by Robert J. Johnston, John Rolfe, Randall S. Rosenberger, and Roy Brouwer. Dordrecht, The Netherlands: Springer.
- Fisher, B., K. Turner, M. Zylstra, R. Brouwer, R. de Groot, S. Farber, P. Ferraro, R. Green, D. Hadley, J. Harlow, P. Jefferiss, C. Kirkby, P. Morling, S. Mowatt, R. Naidoo, J. Paavola, B. Strassburg, D. Yu, and A. Balmford (2008), 'Ecosystem services and economic theory: Integration for policy relevant research.' *Ecological Applications*, 18(8), 2050–2067.
- Fisher, B., R.K. Turner and P. Morling (2009), 'Defining and classifying ecosystem services for decision making', *Ecological Economics*, 68(3), 643-653.
- Freeman, A.M. (2003), 'The measurement of environmental and resource values: theory and methods', RFF Press: Washington, D.C.
- Freeman A.M., J.A. Herriges, and C.L. Kling (2014), *The Measurement of Environmental and Resource Values: Theory and Methods*, 3rd edition, Resources for the Future, Washington, DC.
- Hanley, N. and E.B. Barbier (2009), *Pricing Nature: Cost Benefit Analysis and Environmental Policy*. Cheltenham, UK: Edward Elgar.
- Holland, D.S., J. Sanchirico, R.J. Johnston and D. Joglekar (2010), *Economic Analysis for Ecosystem Based Management: Applications to Marine and Coastal Environments*, Washington, DC: RFF Press.
- Johnston R.J. and D.M. Bauer (2020), Using meta-analysis for large-scale ecosystem service valuation: Progress, prospects and challenges. *Agricultural and Resource Economics Review* 49(1), 23-63
- Johnston R.J., E.Y. Besedin, and B.M. Holland (2019), 'Modeling distance decay within valuation meta-analysis.' *Environmental and Resource Economics* 72(3), 657-690
- Johnston R.J., E.Y. Besedin, and M.H. Ranson (2006), 'Characterizing the effects of valuation methodology in function-based benefits transfer.' *Ecological Economics* 60:407-419
- Johnston R.J., E.Y., Besedin and R. Stapler (2017a) Enhanced geospatial validity for meta-analysis and environmental benefit transfer: An application to water quality improvements. *Environmental and Resource Economics* 68, 343-375
- Johnston R.J., K.J. Boyle, W. Adamowicz, J. Bennett, R. Brouwer, T.A. Cameron, W.M. Hanemann, N. Hanley, M. Ryan, R. Scarpa, R. Tourangeau, and C.A. Vossler (2017b), 'Contemporary guidance for stated preference studies.' *Journal of the Association of Environmental and Resource Economists* 4, 319-405

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Johnston, R.J. (2022), An Ecosystem Services and Sustainability Approach to Natural Resource and Environmental Economics and Policy, chapter 4 in J.C. Bergstrom and J.C. Whitehead, eds. Teaching Environmental and Natural Resource Economics: Paradigms and Pedagogy. Edward Elgar.

Johnston, R.J., and L.A. Wainger (2015), 'Benefit transfer for ecosystem service valuation: an introduction to theory and methods', In, Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners, Ed. by Robert J. Johnston, John Rolfe, Randall S. Rosenberger, and Roy Brouwer, Dordrecht, The Netherlands, Springer.

Johnston, R.J., and M. Russell (2011), 'An operational structure for clarity in ecosystem service values.' Ecological Economics, 70(12), 2243–2249.

Johnston, R.J., J. Rolfe and E. Zawojcka (2018), 'Benefit transfer of environmental and resource values: progress, prospects and challenges', International Review of Environmental and Resource Economics, 12(2-3), 177-266.

Johnston, R.J., J. Rolfe, R.S. Rosenberger and R. Brouwer, eds. 2015. Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners. Dordrecht, the Netherlands: Springer.

Johnston, R.J., K. Moeltner, S. Peery, T. Ndebele, Z. Yao, S. Crema, W. Wollheim and E. Besedin (2023), Spatial dimensions of water quality value in New England river networks', Proceedings of the National Academy of Sciences, 120(18), e2120255119.

Johnston, R.J., K.J. Boyle, M.L. Loureiro, S. Navrud and J. Rolfe. 2021. 'Guidance to enhance the validity and credibility of environmental benefit transfers.' Environmental and Resource Economics 79(3), 575-624.

Just, R.E., D.L. Hueth and A. Schmitz (2004), The Welfare Economics of Public Policy: A Practical Approach to Project and Policy Evaluation, Cheltenham, UK, Edward Elgar.

Kaul S., K.J. Boyle, N.V. Kuminoff, C.F. Parmeter, and J.C. Pope (2013), 'What can we learn from benefit transfer errors? Evidence from 20 years of research on convergent validity.' Journal of Environmental Economics and Management 66, 90-104

Landers, D.H. and A.M. Nahlik. 2013. Final Ecosystem Goods and Services Classification System (FEGS-CS). EPA/600/R-13/ORD-004914. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

Loomis, J. B. (2000), 'Vertically summing public good demand curves: an empirical comparison of economic versus political jurisdictions', Land Economics, 312-321.

Lupi F., D.J. Phaneuf, and R.H. von Haefen (2020), 'Best practices for implementing recreation demand models.' Review of Environmental Economics and Policy 14(2), 302-323

Lupi, F., J. A. Herriges, H. Kim, R. J. Stevenson (2023), 'Getting off the ladder: Disentangling water quality indices to enhance the valuation of divergent ecosystem services', Proceedings of the National Academy of Sciences, 120(18), e2120261120

Moeltner, K. (2019), 'Bayesian nonlinear meta regression for benefit transfer.' Journal of Environmental Economics and Management 93, 44-62

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- Moeltner, K., R. Puri, R.J. Johnston, E. Besedin, J.A. Balukas and A. Le (2023), 'Locally-weighted meta-regression and benefit transfer', *Journal of Environmental Economics and Management*, 121, 102871.
- Moeltner, K., K.J. Boyle, and R.W. Paterson (2007), 'Meta-analysis and benefit transfer for resource valuation-addressing classical challenges with Bayesian modeling.' *Journal of Environmental Economics and Management* 53, 250-269
- Newbold S., P.J. Walsh, D.M. Massey, and J. Hewitt (2018b), 'Using structural restrictions to achieve theoretical consistency in benefit transfers,' *Environmental and Resource Economics* 69, 529-554
- Newbold S., R.D. Simpson, D.M. Massey, M.T. Heberling, W. Wheeler, J. Corona, and J. Hewitt (2018a). 'Benefit transfer challenges: Perspectives from U.S. practitioners,' *Environmental and Resource Economics* 69, 467-482
- Newcomer-Johnson, T., F. Andrews, J. Corona, Ted DeWitt, M. Harwell, C. Rhodes, P. Ringold, M. Russell, P. Sinha, AND G. Van Houtven. (2020), *National Ecosystem Services Classification System (NESCO Plus)*. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-20/267.
- Olander, L., S. Polasky, J.S. Kagan, R.J. Johnston, L. Wainger, D. Saah, L. Maguire, J. Boyd, and D. Yoskowitz (2017), 'So you want your research to be relevant? Building the bridge between ecosystem services research and practice', *Ecosystem Services*, 26, 170-182.
- Olander, L.P., R.J. Johnston, H. Tallis, J. Kagan, L.A. Maguire, S. Polasky, D. Urban, J. Boyd, L. Wainger, and M. Palmer (2018), 'Benefit relevant indicators: ecosystem services measures that link ecological and social outcomes', *Ecological Indicators*, 85, 1262-1272.
- Plummer, M.L. (2009), 'Assessing benefit transfer for the valuation of ecosystem services', *Frontiers in Ecology and the Environment*, 7, 38-45.
- Polasky, S. and K. Segerson (2009), 'Integrating ecology and economics in the study of ecosystem services: some lessons learned', *Annual Review of Resource Economics*, 1, 409-34.
- Richardson, L., J. Loomis, T. Kroeger, and F. Casey (2015), 'The role of benefit transfer in ecosystem service valuation', *Ecological Economics*, 115, 51-58.
- Santavy, D.L., C.L. Horstmann, L.M. Sharpe, S.H. Yee and P. Ringold (2021), 'What is it about coral reefs? Translation of ecosystem goods and services relevant to people and their well-being.' *Ecosphere*, 12(8), e03639.
- Smith, V.K. (1993), 'Nonmarket valuation of environmental resources: An interpretive appraisal', *Land Economics*. 69(1), 1-26.
- Stapler, R.W., and R.J. Johnston (2009), 'Meta-analysis, benefit transfer, and methodological covariates: Implications for transfer error.' *Environmental and Resource Economics* 42, 227-246
- Tallis, H., and S. Polasky (2009), 'Mapping and valuing ecosystem services as an approach for conservation and natural resource management.' *Annals of the New York Academy of Sciences*, 1162, 265-283.
- United States Environmental Protection Agency (US EPA). (2014). *Guidelines for Preparing Economic Analyses*. Washington DC: Office of Policy, National Center for Environmental Economics.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

United States Environmental Protection Agency (US EPA). (2015). National Ecosystem Services Classification System (NESCS): Framework Design and Policy Application. EPA-800-R-15-002. United States Environmental Protection Agency, Washington, DC.

Van der Ploeg, S. and R. S. de Groot. 2010. The TEEB Valuation Database — A Searchable Database of 1310 Estimates of Monetary Values of Ecosystem Services. Foundation for Sustainable Development, Wageningen, the Netherlands.

Wainger, L., and M. Mazzotta (2011), 'Realizing the potential of ecosystem services: A framework for relating ecological changes to economic benefits', *Environmental Management*, 48(4), 710–733.

Individual Peer Reviewer Comments: Cathy Kling

Questions:

1. **Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).**
 - While there are some good descriptions and definitions of some of the core concepts, there is also room for much more clarity and improvement. The document would benefit from an introduction that defines the core concepts of natural capital (stocks), ecosystem services (flows), benefit cost analysis and other key definitions more specifically. A box or set of boxes with simple definitions (along with a citation to a source) would be useful. This is already done for natural assets), but the box is long and contains a lot of separate ideas, some of which deserve their own line or definition. Additionally, there is a need to clarify the relationship between a policy or regulation which initiates a regulatory analysis and the links from that policy to the **physical change in the environment** (perhaps a reduction in phosphorus pollution) the policy would cause, the resulting change in the **physical ecosystem service** (perhaps an increase in fish abundance and a reduction in harmful algal bloom events) that results, and then approaches to **monetize** those service changes (perhaps recreation demand models, stated preference to value safer contact recreation, etc.) . In the current draft these concepts are not clearly delineated and there is confusion between them. There are a number of papers in the literature that provide alternative flow diagrams that the authors should refer to that depict this flow from a regulation/policy to environmental change, to ecosystem service change to monetization. For example, a missing reference and useful description of a way to think about the link from actions and physical changes to ecosystem services and value in the context of water pollution is (Keeler, Polasky et al. 2012). It may be useful to use a simplified version of the diagram in that paper to help clarify concepts.
 - Other concepts that would be useful to emphasize in a box include: nonmarket goods, market goods, nonuse values, public goods, benefits (=wtp), costs, and transfers, among others. A box for each of the major monetization approaches might be useful in the latter part of the document. Such a box could contain the name of the valuation approach (e.g., hedonic house price capitalization), a brief description of the method, and a few key references about the method.
 - The document descriptions sometimes incorrectly identify things that are monetization approaches with the actual ecosystem services. This happens repeatedly when “property values” are referred to as a service. These monetize values are not the services, the higher price paid for homes with better environmental amenities is a way to monetize the value of the service. The ecosystem service is the enjoyment of living near a clean lake or unpolluted park. The confusion between the environmental service provided by the environment is very important to correct, both with respect to the property value descriptions (which occur repeatedly throughout the document), but also sometimes with respect to recreation expenditures or employment. These are not services and should not be included. The introduction to this document should clearly lay out these distinctions.
 - There are some very nice examples of services that are provided which I applaud the authors for. I found the table on page 7 to contain a number of good examples of ecosystem services, that are indeed services. Keeping these in the document is great, but please be sure that each list contains only real services is important.
2. **Please note any important omissions.**

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- An important omission is benefits transfer and the many books and useful guidance documents on how to perform a defensible benefit transfer. Agencies that will include valuation of ecosystem services will largely accomplish the valuation component through benefits transfer. This document needs a simple explanation and a direction for where analysts should go to learn the details (Champ 2013, Johnston 2015).
- The nonmarket valuation method of Averting Behavior is also missing (Just 2004, Freeman 2014, Phaneuf and Requate 2016). While this is less commonly used, it is important for completeness to include it. Further, averting behavior will generally only be able to estimate a lower bound to the full extent of ecosystem service values, the latter point is often missed in applications so this should be noted.
- One of the topics discussed in the peer review panel zoom call was whether the myriad of examples in the appendices is useful or whether it would be better to choose 2 or 3 good examples of ecosystem service valuation for use in a benefit-cost analysis that has been done and explain each step in the process that was undertaken. I think that is an excellent idea. The many examples in the appendix are confusing, the arrows are unclear and there are some errors in categorization in these examples that would definitely need to be corrected (for example, including “number of jobs created, gross state product, total industry output, etc as endpoints of benefit-cost analyses as opposed to separate components to quantify). I suggest dropping those appendix examples and finding 2-3 well done examples from agencies that are already doing this type of work (EPA, USFS, etc.) and writing a section of case studies (in the appendix or in the document itself) that clearly and simply talks through each of the steps in the valuation process. This would be a great way to talk about how to deal with ecosystem services which cannot be monetized, the need to make defensible judgments in each step of the analysis, etc.

3. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.

- There are a number of problems with the description of the economics components of benefit cost and nonmarket valuation in and following Table 3. Here are a number of the issues:
 - I strongly suggest that the valuation method referred to as “Value of statistical life or value of statistical life years” be revised. First, the terminology is confusing, converting estimates of the value of risk reduction estimated through wage/risk or stated preference studies, to a “statistical life” creates confusion and easy misunderstanding. Economists who work in this area appreciate that the “VSL” is not the value of an *ex post* life, but only a simple aggregate statistic that relates to *ex ante* estimates. Using the term “value of risk reduction” is much more accurate and conveys the *ex ante* nature of the statistics. See (Cameron 2010) and the literature/citations following that call for the “euthanization” of the term.
 - Second, the use of VSL is an example of a benefits transfer, not an original valuation approach. Benefits transfer is often listed as a valuation approach so it probably makes good sense to include it, but it needs to be explained
 - Third, the use of “statistical life years” has not been supported by empirical findings so should not be considered a best practice for valuation endpoints.
 - Following Table 3, it could be very useful to cite the set of “best practices” published in the *Review of Environmental Economics and Policy* (Cameron 2010, Johnston, Boyle et al. 2017, Bateman and Kling 2020, Bishop, Kuminoff et al. 2020, Evans and Taylor

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

2020). Textbooks that might be worth referencing include (Just 2004, Freeman 2014, Phaneuf and Requate 2016).

- Page 28: in the middle of the second paragraph, it states that *ex ante* WTP estimates are different than *ex post* estimates for a variety of reasons, but it does not mention the important difference with respect to uncertainty. By their nature *ex post* estimates can be constructed only after an event has occurred and thus any uncertainty has been resolved. However, *ex ante* estimates are expected values of consumer surplus (or CV/EV) prior to the realization. This distinction has spawned a large literature related to option value and quasi-option value. It may not be necessary to cite that literature here, but it might be worthwhile adding a footnote to that effect. In most cases, the appropriate measure for regulatory impact analysis or benefit-cost analysis will be an *ex ante* measure if possible.
 - The material on pages 28-30 appears to be based on the material in Circular A-4 which is currently revised. Many of the statements regarding the preferability of using revealed over stated preferences are out of date and do not represent current understanding. I realize that the first draft of Circular A-4 from the spring of 2023 contains language to this effect, I and other reviewers of that document strongly urged a revision that goes well beyond the original 2004 Circular A-4 language. The authors of the 2023 draft noted cs
 - This material also discusses benefit transfer but does not provide a clear description of how it differs from the use of primary studies. Clear description of what benefit transfer is and how it differs from an original stated or revealed preference study is needed.
- In general, a very careful read of the document with close attention to whether the definitions are accurate and whether the classification is correct or not. I have provided some examples in the last bullet point and elsewhere, but my examples are not comprehensive.

4. Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

See above.

5. Does the document provide clear and useful guidance for both governmental and nongovernmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

See above.

6. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

- In general, the document provides plenty of examples of what an ecosystem service is (perhaps too many). Rather than think of adding even more, the document should be clearer on what things are actually services, what things are monetization methods, and then choose several to focus on. See suggestion under #2 above.

7. Are there important valuation methods that should be mentioned, including for non-use values?

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- Benefits transfer is a major omission, averting behavior is a minor one for the purposes of this document.
- 8. **Are there other important references or ecosystem services resources that should be included in the references?**
- Page 2: Another examples of an agency with a document describing how to do economic analysis for ecosystem services is (US.EPA 2017).
- 9. Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?

10. Should any elements be removed?

- Figure 1 and discussion: A problematic component of Figure 1 and the following discussion relates to the discussion of how ecosystem services might be altered by education about the good, information, changing preferences, and/or changing norms. Within benefit cost analysis, a core assumption is that people know their own values and have fixed preferences. The provision of information that changes preferences (accurate or not), is complicated to accurately identify welfare measures will vary within each of these situations. (Just 2004) provide a pretty thorough treatment of how to think about welfare changes in these separate cases (see especially chapter 11 on the welfare economics of information). Given the complexity of getting welfare correct in these cases, it would likely be best not to include changes in preferences in the description of Figure 1 and not raise it in the document. E.g., remove discussion of changes in the social systems of “social rules and norms changing.” Valuation and benefit-cost analysis are very complex in these situations and should not be the focus of the vast majority of efforts to measure ecosystem services or their value.

Additional Comments: Many of these comments I have incorporated into my responses to the charge questions and they are duplicative in many cases. But rather than delete them, I include them in case they are of additional value.

- Page 4: “Changes in property value can be tied to ecosystem services” could be interpreted as meaning that the service is the change in property price directly rather than the fact that the price capitalization is a monetary estimate of the economic value of the ecosystem services (which in this example or soil improvements, flood protection etc.). The other bolded values in this discussion (pages 4-6) all identify the services themselves (mental health, changes in production, outdoor recreation...).
- Page 10: In the examples provided about changes in the natural system, the issue of using “property values” in a list of otherwise actual ecosystem services reappears, instead of using “property values” as the apparent ecosystem service, using local amenities (visual/aesthetic values) the service would be a much better term. For examples in the last paragraph on page 10, three examples of lost ecosystem services due to pollution are listed including “physical health, real estate values, and recreation opportunities.” The first and last are the changes in services, the second, changes in real estate values is simply one way to measure the economic value of local amenity losses due to air pollution. More generally, following the logic of the Keeler et al paper in the intro would help to explain these concepts and maintain a clear distinction between the services and the approach to monetize those services.
- Table 2 again includes “property values” and “water supply for real estate value” as something real ecosystem changes rather than the approach for monetization. That said, the majority of examples in the table are very good. I again urge caution in listing “changes in preferences” as a

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

social system change like beach closures, changes in treatment costs or other real changes in value.

- The last two columns of table 2 seem somewhat duplicative and perhaps could be merged or further differentiated. It seems that the goal is to identify examples of changes in physical ecosystem services and their pathways through human experience to economic value. Following a clearer linkage like the one done in the Keeler paper should help clarify.
- The box with questions to consider on page 22 is good.
- More emphasis on the need to do distributional analysis and examples of particularly good examples of such analysis would be very helpful.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

References

1. Bateman, I. J. and C. L. Kling (2020). "Revealed Preference Methods for Nonmarket Valuation: An Introduction to Best Practices." Review of Environmental Economics and Policy **14**(2): 240-259.
2. Bishop, K. C., et al. (2020). "Best Practices for Using Hedonic Property Value Models to Measure Willingness to Pay for Environmental Quality." Review of Environmental Economics and Policy **14**(2): 260-281.
3. Cameron, T. A. (2010). "Euthanizing the Value of a Statistical Life." Review of Environmental Economics and Policy **4**(2): 161-178.
4. Champ, P., Kevin Boyle, and Thomas Brown (2013). A Primer on Nonmarket Valuation, Springer.
5. Evans, M. F. and L. O. Taylor (2020). "Using Revealed Preference Methods to Estimate the Value of Reduced Mortality Risk: Best Practice Recommendations for the Hedonic Wage Model." Review of Environmental Economics and Policy **14**(2): 282-301.
6. Freeman, A. M. (2014). The measurement of environmental and resource values theory and methods. Abingdon, Oxon, RFF Press.
7. Johnston, R. J., et al. (2017). "Contemporary Guidance for Stated Preference Studies." Journal of the Association of Environmental and Resource Economists **4**(2): 319-405.
8. Johnston, R. J., John Rolfe, Randall Rosenberg, and Roy Brouwer (2015). Benefit Transfer of Environmental and Resource Values A Guide for Researchers and Practitioners, Springer publications.
9. Just, R. E., Darryl Hueth, and Andrew Schmitz (2004). The welfare economics of public policy: a practical approach to project and policy evaluation. Cheltenham, UK, E. Elgar.
10. Keeler, B. L., et al. (2012). "Linking water quality and well-being for improved assessment and valuation of ecosystem services." Proceedings of the National Academy of Sciences **109**(45): 18619-18624.
11. Phaneuf, D. J. and T. Requate (2016). A Course in Environmental Economics: Theory, Policy, and Practice. Cambridge, Cambridge University Press.
12. US.EPA (2017). "Guidelines for Preparing Economic Analysis." <https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses>

Individual Peer Reviewer Comments: Stephen Polasky

As requested, I've organized my responses by question as listed in the charge to the expert reviewers.

Questions:

1. Please review the proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis. Peer reviewers may also consult any public comments on the draft proposed guidance. The reviewers are asked to draft their individual reports in response to the questions posed below, consistent with each reviewer's experience and areas of expertise.

I did not consult the public comments. My comments on the proposed Guidance Document are based on my experience and expertise in working on ecosystem services.

2. Peer reviewers are welcome to comment on any aspects of the proposed guidance, including addressing questions raised in the accompanying Federal Register Notice, but we provide some particular questions of interest below.

My overarching comment is that I am very supportive of incorporating ecosystem services into benefit-cost analysis. Ecosystem services are an important category of benefits (and sometimes there are negative services that generate costs), and therefore the values of ecosystem services should be included in benefit-cost analysis. A properly conceived and executed benefit-cost analysis should strive to include all important benefits and costs including changes to ecosystem services.

3. Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).

In general, the recommendations follow the ecosystem services literature and there are no major mistakes that I found in the Guidance Document. There are some places where use of terms is out of date. For example, the Guidance Document makes reference to the Millennium Ecosystem Assessment (2005) but it does not make reference to the International Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which has published a number of assessments over the past eight years, including a global assessment in 2019 (IPBES 2019). IPBES is the international scientific body that summarizes the consensus view of the scientific community on biodiversity and ecosystem services. IPBES has made a number of changes relative to the Millennium Ecosystem Assessment including in describing categories of ecosystem services (see response to Question 6). Not referencing IPBES is akin to a climate change guidance document not referencing the latest IPCC reports.

4. Please note any important omissions.

One key element that is largely missing from the Guidance Document is any discussion of how to quantify ecosystem service provision. The key issue here is to be able to "capture the degree to which

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

proposed regulatory alternatives are expected to change ecosystem services relative to baseline conditions.” (P. 26) To do this, it is useful to think about an “ecological production function” that maps from ecosystem condition, or ecosystem structure and function, to ecosystem services (NRC 2005, Barbier 2007, Daily et al. 2009, Polasky and Segerson 2009, Tallis and Polasky 2009). An ecological production function allows one to predict how changes in ecosystem conditions lead to changes in the provision of ecosystem services. A number of papers have employed this idea to examine how changes in land use affect the provision of a set of ecosystem services (e.g., Nelson et al. 2008, 2009, Polasky et al. 2011, Lawler et al. 2014, among others). The Guidance Document could provide more help in how to think through applications of ecological production functions for regulatory, material, and non-material services (IPBES 2019). The endpoints of this analysis should be goods and services denominated in units that can be assessed using market and non-market valuation techniques. However, the Guidance Document should be clear that we often lack well specified empirically verified ecological production functions. For example, people have noted that exposure to nature contributes to mental health and cognitive function (e.g., Bratman et al. 2019) but specifying a quantitative relationship between nature exposure and mental health benefits is still lacking. More guidance could be provided on what are well established methods for evaluating specific ecosystem services, along with good references, and what are the current frontiers of ecosystem service science. This will of course shift with time and new advances so perhaps this kind of guidance should sit in a document that is regularly updated.

Another important element that is not missing but is under-developed, is the use of benefit-transfer. Because ecosystem service values are location specific, and because there will never be primary studies on all locations of interest, there is a need for the use of accurate benefit-transfer methods. The Guidance Document should go well beyond statements like “Consider best practices for this method” to provide guidance on what best practices entail for ecosystem services. In particular, there has been a long history of abuse of benefit-transfer in ecosystem service assessments starting from some of the earlier and most influential studies. The most widely cited article on ecosystem services is Costanza et al. (1997). This paper has been roundly criticized for a number of reasons (see, for example, Toman 1998, Bockstael et al. 2000). One particular problem with this study was its implicit use of a form of benefit-transfer that relied on using an estimate of value per hectare from a particular location and then assumed that this value held for all hectares of a particular ecosystem type (e.g. wetlands, forests, grasslands). However, the value of ecosystem services depends on ecological context, and on socio-economic context. This type of benefit-transfer is an invalid approach, especially in the context of trying to capture “the degree to which proposed regulatory alternatives are expected to change ecosystem services relative to baseline conditions.” I would like to see the Guidance Document not only provide recommendations about what is good practice that should be adopted, but also provide guidance about bad practices that should be avoided.

A third area that is not missing but is underdeveloped is the discussion of uncertainty. It is true that uncertainty is dealt with in Circular A-4, and what is discussed there does not need to be repeated in this Guidance Document. However, there should be some discussion of the uncertainty that comes from incomplete understanding or lack of data to accurately assess the ecological production function, the links between ecological and economic models, and how uncertainty can cascade from ecological uncertainty through to valuation uncertainty.

An element that appears to be missing entirely from the Guidance Document is any reference to ecosystem regime shifts, thresholds, or tipping points. Crossing tipping points can cause sudden large shifts in the provision of ecosystem services. The possibility of regime shift and its potential impacts on ecosystem services should be explicitly noted along with description of methods capable of accounting for potential regime shifts and how this would affect the valuation of ecosystem services.

5. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.

The definitions of concepts reflect current understanding of ecosystem service science. It was somewhat unclear to me whether the Guidance Document meant to include both biotic and abiotic resources within the definition of ecosystem services or to exclude abiotic resources (see footnote 1). The document should provide clear guidance on this point. I comment in more detail on points about how the presentation of concepts and practical guidance could be improved in response to Question 7.

6. Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

Much time and effort can be spent on providing classifications and categorizations for ecosystem services. In general, I don't think that practitioners should spend much time worrying about categorizations. But as long as you are providing categorizations, it is better to use current internationally agreed upon categories from IPBES (2019). The updated categories eliminate supporting services (these are not final services and should not be monetized) and use the term non-material services rather than cultural services. There are important cultural components in most ecosystem services. For example, food consumption is not just about calories but also about cultural traditions.

7. Does the document provide clear and useful guidance for both governmental and non-governmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

I think the Guidance could be improved by being both more clear and more succinct about stating general principles for ecosystem service assessments as well as providing more help for practitioners who will struggle with carrying out ecosystem service assessments. Many of the important general principles for ecosystem service assessment are included in the Guidance. However, these principles are not always stated clearly and there is a lot of repetition. For example, the Guidance is quite clear on avoiding double-counting of benefits. There are no less than 15 mentions of double-counting (seems rather ironic that double-counting is so repeatedly mentioned). Try to state a principle clearly once and move on. Another example of failure to be clear and concise exists in the explanation of Step 1 in section IV. The principle that benefit-cost analysis should cover all relevant impacts is clear and easily stated. This means that the geographic and temporal scope needs to be wide enough and long enough to cover these impacts. Once this is stated you don't need awkwardly written phrases like "In some cases, it may be appropriate to enlarge the spatial scale of the analysis to include an ecosystem service and to capture alternatives' benefits or costs" (p. 19) or "It is important that the analytical timeline selected for analysis is not arbitrarily short..." (p. 20). These points are covered by the general statement of principle. Rather than providing vague restatements of the general principle, it would be far better to provide several clear examples and provide more detailed guidance on the proper scope (i.e., what impacts need to be included and what impacts are minor enough to be safely excluded).

Because the Guidance Document is building upon Circulars A-4 and A-94, many thorny general issues, such as discussions of discounting and of proper discount rates, can be safely sidestepped. The Guidance Document does not need to dwell on more standard issues in benefit cost analysis including discounting,

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

non-market valuation, scoping, or other aspects that are present in almost any benefit-cost analysis. For the most part, the Guidance Document does a good job of pointing to Circulars A-4 and A-94 where appropriate.

The general principles that should be emphasized in the Guidance Document are those that are novel for ecosystem service assessments. What is most different for ecosystem services assessments compared to standard benefit-cost assessment is the inclusion of ecosystem contributions to benefits and costs. This is what is new and novel about ecosystem services and it is the hardest part of doing a good ecosystem services assessment but there is very little about this in the Guidance Document. Ecosystem service assessments require integrating natural science data, methods, and models with economic data, methods, and models. The weak point of many ecosystem services assessments currently is the failure to adequately link data, methods, and models across disciplines. It is somewhat telling that the Guidance Documents contains zero mentions of multi-, inter-, or trans-disciplinary approaches, that all mentions of integration are in the title of a referenced work, and that the five mentions of ecological economics all are references to the journal *Ecological Economics*. It should be emphasized that a large part of the work in doing good assessments is linking natural sciences and economics appropriately. Most people are not trained to do this. Most offices within government agencies are either dominated by natural scientists with little social science or economics expertise or dominated by economists with little natural science expertise. This institutional arrangement makes it easy to do high quality work within a discipline, but often makes it extremely difficult to do integrative work across disciplines that is necessary for ecosystem service assessments. This difficulty was recently highlighted (e.g., Polasky et al. 2019, Jaeger et al. 2023).

Moving beyond general principles, I feel that the Guidance Document does not provide many practical details to help practitioners with the task of doing an ecosystem service assessment (see, for example, Ruckelshaus et al. 2015). While attempting to provide a detailed textbook approach will likely go quickly out of date, especially in a field evolving as quickly as ecosystem services, providing more guidance on reasonable approaches to quantify ecosystem services (quantification) and how to link this to ecosystem services valuation (monetization) would be helpful (see response to Question 4).

It is good that the Guidance Document explicitly states that baselines are not static and should include “relevant system dynamics.” In this regard, I would specifically reference land use change and climate change as these tend to have large impacts on multiple ecosystem services. I think this can be in addition to saying that relevant changes can emerge from changes in nature, technology, preferences, or policies and the interactions of these changes. I think you could then delete the sentence: “Accounting for how these systems might interact is important for correctly calculating the effect of a rule on the value of ecosystem services.”

There are numerous important details that need to be addressed to do a complete and rigorous ecosystem service assessment. While this Guidance Document cannot be a complete textbook or “how-to-guidebook,” it is important for the Guidance Document to clearly lay out the kinds of details that are needed for doing a complete and rigorous ecosystem service assessment. In this regard, it would be extremely helpful to provide a couple of examples of the current state-of-the-art in doing ecosystem service assessment, pointing out where these assessments do a good job, and what are remaining challenges. It would be especially beneficial to highlight best practice examples from U.S. federal agencies.

8. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

There are many good examples of ecosystem service assessments ranging from very local watershed levels to the global level (Chaplin-Kramer et al. 2019, 2023). Lydia Olander and her colleague has collected many good examples from across federal agencies and the Guidance Document already references some of this group's review documents. It would be nice if the Guidance Document highlighted some of the best current examples from federal agencies. I am personally less familiar with federal agency examples than I am with examples from other countries, so I leave it to others to provide suggestions of good agency examples. The literature on ecosystem services in many other countries is extensive and deep. There is very little recognition of work going on in other countries, which is a real lost opportunity because often these examples are better developed than anything existing in the US. Examples of useful work in other countries includes extensive work in the UK (e.g., Bateman et al. 2013, Dasgupta 2021), Costa Rica (e.g., Pagiola 2008), China (e.g. Ouyang et al. 2016, 2020), among other countries. References should be made to good examples from other countries.

9. Are there important valuation methods that should be mentioned, including for non-use values?

I will largely leave it to other experts better placed than I to give detailed comments on appropriate revealed and stated preference non-market valuation techniques. I do, however, want to comment on providing more guidance on the use of "replacement cost" and "avoided damages." These methods are commonly used in ecosystem service assessments. These methods can be used in some circumstances and are often the easiest and least resource intensive methods to apply, which is one reason they are widely used in practice. However, great care needs to be taken in applying these methods, and they can be easily abused in practice. The Guidance Document should provide guidelines for the appropriate conditions under which it is acceptable to use these methods and conditions when these methods should not be used.

10. Are there other important references or ecosystem services resources that should be included in the references?

There is now a very large literature on ecosystem services with many good examples spanning a broad range of topics. There are a number of important general references on ecosystem services beyond those mentioned already in the assessment that should be included: NRC (2005), EPA (2009), Kareiva et al. (2011), IPBES (2019), Brauman et al. (2020), Dasgupta (2021). There are also many good examples of studies of ecosystem services in various regions, such as Nelson et al. 2009, Polasky et al. 2011, Lawler et al. 2014, among many others, and of services from particular ecosystems or species groups, such as ecosystem services from trees (Cavendar-Bares et al. 2022), urban ecosystem services (Hamel et al. 2021, Keeler et al. 2019), coastal and marine ecosystem services (Barbier et al. 2011), ecosystem services of lakes (Sturner et al. 2020). There are also many fine contributions for particular ecosystem services or types of analysis such the contribution of wetlands to flood mitigation (Watson et al. 2016), pollination services (Klein et al. 2007), and links to global CGE models (Johnson et al. 2023), and many others contributions. The collection of references given in the Guidance Document feels a bit random and haphazard, much as my list is here.

11. Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?

While the Guidance Document includes many good references, there are others that could usefully be mentioned, including: NRC (2005), Polasky and Segerson (2009), Kareiva et al. (2011), Keeler et al. (2012), Olander et al. (2018), IPBES (2019), and Dasgupta (2021).

12. Should any elements be removed?

I did not find much of the material in the Appendices very useful. Much of the material in Appendices I and III was too general and hypothetical to be of much real use. I did not think the columns in the main table in Appendix I made much sense. This seemed like a collection of mismatched categories. In general, I think it would be better to replace the current set of examples and tables in Appendices I and III with a few well thought out examples that illustrate all the steps from initial scoping, impacts of alternatives on ecosystems, ecological production functions to quantity ecosystem services, valuation to get to monetary value, to final reporting.

References

Barbier, E. B. 2007. Valuing ecosystem services as productive inputs. *Economic Policy* 22:177–229.

Barbier, E.B., S.D. Hacker, C. Kennedy, et al. 2011. The value of estuarine and coastal ecosystem services. *Ecological Monographs* 81(2): 169–193.

Bateman, I.J., A.R. Harwood, G.M. Mace, et al. 2013. Bringing ecosystem services into economic decision-making: Land use in the United Kingdom. *Science* 341: 45–50.

Bockstael, N.E., A.M. Freeman, R.J. Kopp, et al. 2000. On measuring economic values of nature. *Environmental Science and Technology* 34(8): 1384–1389.

Bratman, G.N., C.B. Anderson, M.G. Berman, B. Cochran, S. de Vries, J. Flanders, C. Folke, H. Frumkin, J.J. Gross, T. Hartig, P.H. Kahn Jr., M. Kuo, J.J. Lawler, P.S. Levin, T. Lindahl, A. Meyer-Lindenberg, R. Mitchell, Z. Ouyang, J. Roe, L. Scarlett, J.R. Smith, M. van den Bosch, B.W. Wheeler, M.P. White, H. Zheng, and G.C. Daily. 2019. Nature and Mental Health: An Ecosystem Service Perspective.” *Science Advances* 5 (7).

Brauman, K.A., L.A. Garibaldi, S. Polasky, Y. Aumeeruddy-Thomas, P.H S. Brancalion, F. DeClerck, U. Jacob, M.E. Mastrangelo, N.V. Nkongolo, H. Palang, N. Pérez-Méndez, L.J. Shannon, U.B. Shrestha, E. Strombom, M. Verma. 2020. Global trends in nature's contributions to people. *Proceedings of the National Academy of Sciences* 117(51): 32799-32805.

Cavender-Bares, J., E. Nelson, J.E. Meireles, et al. 2022. The hidden value of trees: quantifying the ecosystem services of tree lineages and their major threats across the contiguous US. *PLOS Sustainability and Transformation* 1 (4): e0000010.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- Chaplin-Kramer, R., R.P. Sharp, C. Weil, et al. 2019. Global modeling of nature's contribution to people. *Science* 366: 255-258.
- Chaplin-Kramer, R., R. A. Neugarten, R. P. Sharp, et al. 2023. Mapping the planet's critical natural assets. *Nature Ecology & Evolution* 7: 51–61.
- Costanza, R., R. d'Arge, R. de Groot, et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–60.
- Daily, G., S. Polasky, J. Goldstein, et al. 2009. Ecosystem services in decision-making: Time to deliver. *Frontiers in Ecology and the Environment* 7(1): 21-28.
- Dasgupta, P. 2021. *The Economics of Biodiversity: The Dasgupta Review*. London: H.M.S. Treasury.
- Hamel P., A.D. Guerry, S. Polasky, et al. 2021. Mapping the benefits of nature in cities with the InVEST software. *npj Urban Sustainability* 1, 25.
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). 2019. *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES.
- Jaeger, W.K., E.G. Irwin, E.P. Fenichel, S. Levin, and A. Herziger. 2023. Meeting the challenges to economists of pursuing interdisciplinary research on human–natural systems. *Review of Environmental Economics and Policy* 17(1): 43-63.
- Johnson, J.R., U.L. Baldos, E. Corong, et al. 2023. Investing in nature can improve equity and economic returns. *Proceedings of the National Academy of Sciences* 120(27): e2220401120.
- Kareiva, P., H. Tallis, T.H. Ricketts, G.C. Daily, and S. Polasky (eds.) 2011. *Natural Capital: Theory and Practice of Mapping Ecosystem Services*. Oxford University Press.
- Keeler, B., S. Polasky, K. A. Brauman, et al. 2012. Linking water quality and well-being for improved assessment and valuation of ecosystem services. *Proceedings of the National Academy of Sciences* 109: 18619-18624.
- Keeler, B. L., P. Hamel, P., T. McPhearson, et al. 2019. Social-ecological and technological factors moderate the value of urban nature. *Nature Sustainability* 2: 29–38.
- Klein A.M., B.E. Vaissière, H.C. James, et al. 2007. Importance of pollinators in changing landscapes for world crops. *Philosophical Transactions of the Royal Society B* 274: 303–313.
- Lawler, J.J., D.J. Lewis, E.Nelson, et al. 2014. Projected land-use change impacts on ecosystem services in the U.S. *Proceedings of the National Academy of Sciences* 111(20): 7492-7497.
- Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-Being. Synthesis*. Washington, DC: Island Press.
- National Research Council, Division on Earth and Life Studies, Ocean Studies Board Committee on Assessing and Valuing Services of Aquatic and Related Terrestrial Ecosystems. 2005. *Valuing Ecosystem Services: Towards Better Environmental Decision-making*. Washington, DC, National Academies Press.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

- Nelson, E., S. Polasky, D.J. Lewis, et al. 2008. Efficiency of incentives to jointly increase carbon sequestration and species conservation on a landscape. *Proceedings of the National Academy of Sciences* 105(28): 9471-9476.
- Nelson, E., G. Mendoza, J. Regetz, et al. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment* 7(1): 4–11.
- Olander, L.P., R.J. Johnston, H. Tallis, et al. 2018. Benefit relevant indicators: Ecosystem services measures that link ecological and social outcomes. *Ecological Indicators* 85: 1262-1272.
- Ouyang, Z., H. Zheng, Y. Xiao, et al. 2016. Improvements in ecosystem services from investments in natural capital. *Science* 352: 1455-1459.
- Ouyang, Z., C. Song, H. Zheng, et al. 2020. Using Gross Ecosystem Product (GEP) to value nature in decision-making. *Proceedings of the National Academy of Sciences* 117(25): 14593-14601.
- Pagiola, S. 2008. Payments for environmental services in Costa Rica *Ecological Economics* 65: 712–24.
- Polasky, S., and K. Segerson. 2009. Integrating ecology and economics in the study of ecosystem services: Some lessons learned. *Annual Review of Resource Economics* 1: 409-434.
- Polasky, S., E. Nelson, D. Pennington, and K. Johnson. 2011. The impact of land-use change on ecosystem services, biodiversity and returns to landowners: A case study in the State of Minnesota. *Environmental and Resource Economics* 48(2): 219-242.
- Polasky, S, C. Kling, S. Levin, et al. 2019. The role of economics in analyzing the environment and sustainable development. *Proceedings of the National Academy of Sciences* 116(12): 5233-5238.
- Ruckelshaus, M., E. McKenzie, H.M. Tallis, et al. 2015. Notes from the field: Lessons learned from using ecosystem services to inform real-world decisions. *Ecological Economics* 115: 11-21.
- Sterner, R.W., B. Keeler, S. Polasky, R. Poudel, K. Rhude, and M. Rogers. 2020. Ecosystem services of earth's largest freshwater lakes. *Ecosystem Services* 41: 101046.
- Tallis, H., and S. Polasky. 2009. Mapping and valuing ecosystem services as an approach for conservation and natural resource management. *Annals of the New York Academy of Sciences* 1162: 265–283.
- Toman, M. 1998. Why not calculate the value of the world's ecosystem services and natural capital? *Ecological Economics* 25: 57–60.
- United States Environmental Protection Agency, Science Advisory Board. 2009. *Valuing the Protection of Ecological Systems and Services*. EPA-SAB-09-012. US EPA.
- Watson, K., T. Ricketts, G. Galford, S. Polasky, and J. O'Neil-Dunne. 2016. Economic valuation of flood mitigation services: The value of Otter Creek wetlands and floodplains to Middlebury, VT. *Ecological Economics* 130: 16-24.

Individual Peer Reviewer Comments: Lisa A. Wainger

1. Please review the proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis. Peer reviewers may also consult any public comments on the draft proposed guidance. The reviewers are asked to draft their individual reports in response to the questions posed below, consistent with each reviewer's experience and areas of expertise.

This document is my individual report and is organized by charge questions, as requested.

2. Peer reviewers are welcome to comment on any aspects of the proposed guidance, including addressing questions raised in the accompanying Federal Register Notice, but we provide some particular questions of interest below.

3. Please comment on whether the recommendations in the guidance are supported by the leading theoretical and empirical peer-reviewed academic literature in economics or other relevant disciplines, and if not, please provide alternative recommendations that would be (and citations to support them).

The document is a welcome addition to available guidance on ecosystem service valuation for government agencies. Much of the guidance is consistent with economic theory and research and provides useful insights into analytic methods and relevant citations. However, some information, including concepts provided in tables, is a bit misleading or difficult to interpret. Overall, the document has good content but also has room for improvement in terms of filling in some concepts and organizing recommendations.

The guidance could be better aligned with leading empirical research by streamlining the presentation of guidance, clarifying analytic priorities, and removing examples that could be misinterpreted. Flexibility in ecosystem service valuation methods will be needed to encompass the diverse interests of federal agencies, which I assume drove the approaches used in the guidance document. However, ecosystem service (ES) analysts would likely appreciate if the major recommendations were packaged into a generalizable structure describing common steps for conducting ES valuation. The omissions and lack of clarity in this document could largely be addressed, not by adding new references, but by providing a systematic structure, perhaps illustrated with a single case study example, of the steps to scope, conduct and communicate a benefit-cost analysis. Those steps would include difficulties likely to be encountered and methods commonly used to overcome data gaps and other challenges. Such a structure would make it easier to look up specific questions and avoid some of the repetition or separation of related ideas that now exist in the document. Many reports and papers document the BCA analysis steps and it might be fruitful to draw from an existing report. I am most familiar with our recent work to create a systematic set of steps for ecosystem service valuation that is specific to the USACE policy (Wainger et al. 2020, 2023) that provides this type of advice, but there are many examples.

The steps to organize and streamline an ES analysis might look something like the following which includes some steps missing from the current document:

1. Develop an interdisciplinary team of scientists and interested parties to scope out potential ecosystem service changes of an action.
2. Scope out which categories of ecosystem changes will be harmful/beneficial to interested parties and identify potential harms and benefits by applying knowledge of the likely magnitude of biophysical change and whether that change is likely to create a social welfare change. Creating conceptual models, as mentioned in the guidance, can be a useful part of this step.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

3. Characterize the “without action” future scenario to understand if the baseline is constant, degrading, or improving.
4. Conduct initial “back of the envelope” analyses about which benefits are likely to be the largest (relative to the baseline) before embarking on complex analyses that may return insignificant benefits.
5. Explore availability of existing and empirical “production function models” that relate projected changes in basic ecosystem structures and functions to outcomes that matter to people.
 - These models are often the critical missing link in the causal chain and can prevent valuation unless data and information gaps can be filled with new data/model development, expert elicitation, or other methods.
6. Explore availability of economic studies that would be relevant for benefit transfer or identify resources necessary for conducting primary economic valuation.

The document mentions and provides resources for some of these steps, although Steps 1 and 4 appeared absent. The main benefit of reorganization would be to aggregate related guidance that is currently distributed throughout the document and sometimes repeated. However, some concepts are muddled by the current lists of examples in Table 1

Step 5 is covered in the guidance (e.g., page 22) but the explanation could benefit from a bit more discussion about the common need for models that can project the “with policy” condition, rather than data representing current conditions.

Under Step 2, (p. 21) it would help to mention that conceptual models representing the expectations of ecosystem service produced should be verified with available (ideally empirical) evidence before being used to conduct time-consuming analyses. Conceptual models are quite useful for organizing potential analyses but, in my experience, ecosystem service analysts can waste time on fruitless analyses because they do not confirm before analyzing (e.g., in consultation with subject matter experts) that the necessary conditions exist at project sites to deliver benefits.

Multiple elements of the guidance are quite hard to address, which raises the question of whether there are priorities among the many options suggested. As an example, on page 28, the comment “Transfer effects should also be considered and modeled in an impact analysis, in addition to incremental costs and benefits” may be piling on more analyses than are practical for many ecosystem service analyses. Multiple of these “shoulds” appear throughout the text and it would help non-economists if they were organized into categories of analysis types, explained as something that would be needed only in some circumstances, or removed to focus on the common elements of a BCA that encompasses ecosystem services.

Some specific points of concern:

Page 2. This text could be much clearer about the differences between market prices and social benefits since it seems to imply that they are equivalent. “The ways that ecosystem services relate to markets vary, and include cases in which ecosystem services contribute to goods and services that are bought and sold in markets (e.g., timber and seafood); are bundled with other goods that are bought and sold (e.g., pollinated crops); or are public goods, provided without monetary transactions that reflect their monetary value (e.g., wetlands reducing flood risk...).”

Page 2 & Footnote 3. The text “Some agencies have already developed internal guidance for valuing ecosystem services in their own benefit-cost analyses” is supported, in part with the Reed et al. (2013) citation. For the USACE, this research does not represent guidance and is not necessarily associated with BCA, so that sentence should be edited to read, “Some agencies have developed or explored internal

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

approaches for valuing ecosystem services in their benefit-cost or other analyses.” Also, the Reed et al. reference largely discusses the internal policy that enables use of ecosystem services. It might be helpfully replaced with more recent and specific USACE research on measuring ecosystem services (Wainger et al. 2023, 2020).

I would also consider adding a summary of three reports conducted in collaboration with USDA (Wainger and Ervin 2017) that documents modeling and valuation outcomes for ecosystem services derived from farms and forests.

Page 4. The text after the heading “**Changes in property value** can be tied to ecosystem services” offers imprecise language about how ecosystem features or environmental conditions can be capitalized in market goods. I suggest that the examples be supplemented with language very briefly describing the concept behind hedonic analysis in order to provide more clarity about how the “affected value” represents the value of an ecosystem service. I.e., amenities or qualities can be capitalized in prices as a component (among many) of market price.

References for this question

Wainger, L., and D. Ervin. The Valuation of Ecosystem Services from Farms and Forests: Informing a Systematic Approach to Quantifying Benefits of Conservation Programs (2017), Washington, DC: The Council on Food, Agriculture & Resource Economics and USDA Office of Ecosystem Markets.

<https://static1.squarespace.com/static/6304dd2be941420ba48fb436/t/630d9ca1630db914d4e8fa9f/1661836452496/SynthesisChapter-TheValuationofEcosystemServicesfromFarmsandForests%2Bpg%2B1.pdf>

Wainger, L.A., McMurray, A., Griscom, H.R., Murray, E.O., Cushing, J.A., Theiling, C.H., Komlos, S., 2020. A Proposed Ecosystem Services Analysis Framework for the U.S. Army Corps of Engineers (No. ERDC/EL SR-20-2). US Army Corps of Engineers, Engineer Research and Development Center.

<http://dx.doi.org/10.21079/11681/37741>

Wainger, L.A., Murray, E.O., Theiling, C.H., McMurray, A.M., Cushing, J.A., Komlos, S.B., Cofrancesco, A.F., 2023. Broadening Benefits and Anticipating Tradeoffs with a Proposed Ecosystem Service Analysis Framework for the US Army Corps of Engineers. Environmental Management 71, 901–920. <https://doi.org/10.1007/s00267-022-01777-7>

4. Please note any important omissions.

Given that many government agencies will be looking for simple and expedient ways to value ecosystem services, it could be powerful to provide criteria with which to judge available tools. The text on page 30 provides useful content about how some types of tools, such as area-based values, often provide misleading values. However, this short text could be backed up by more specific guidance about how to judge sufficiency of a tool or method. Some potential criteria are, 1) sensitivity of calculations to the change being valued, including the relevance of spatial and time scales applied; 2) transparency of calculations and the empirical or theoretical basis for mathematical operations (since even seemingly benign choices such as how values are normalized can have substantial analytic consequences); 3) scientific rigor of the approach, that highlights the most critical considerations described in the guidance; and 4) relevance of ecosystem services to the regulatory goals, a decision criterion for some agencies.

Because this document has the potential to be used in diverse circumstances, it would be beneficial if the introduction included a paragraph about how BCA may not be necessary to support all decisions. Also, BCA guidance for regulatory impact analysis may have more rigorous analytic requirements (or norms)

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

than valuation used for other decisions and is usually conducted by economists. BCA offers clear insights about whether a regulation is in the public interest, but many decisions, such as how to allocate project money once funding has been justified, may be better served by cost-effectiveness analysis (with non-monetary benefit indicators) and community engagement, which are activities that can be conducted by non-economists. Approaches outside of monetary valuation tend to broaden the types of potential benefits considered and offer easier pathways to apply local and indigenous knowledge.

Throughout the document, the concepts behind the examples could be better explained and, in some cases refined to avoid misinterpretation. Taking the beach area example on page 30 to demonstrate the point, the underlying concept being described – about marginal values differing over the existing size of a natural asset – is important. However, the example is not translated into a heuristic and if it were, it would not hold for all ecosystem services. The example posits that a change from 0-10 acres of beach is likely to generate a higher value than a change from 100-110 acres. The example implies that value is greatest in the most degraded systems, which may not hold when considering outcomes such as high quality habitat or tourism use, which might not be provided by a small beach. In this case, language to generalize the example could include that the change in value (marginal response) due to action can vary over the ecosystem state or condition (i.e., level of existing degradation), and will vary by ecosystem type (further explanation in Wainger and Mazzotta, 2011). Emphasis may be needed to clarify that the magnitude of the change in value may not correspond to the amount of biophysical change (i.e., amount of beach), relative to a baseline future, since it could depend on minimum requirements for use or enjoyment (by animals and people) and the probability of successful restoration, among other factors. It may also be relevant to mention that project costs can exhibit (non-linear) economies of scale that may be important to consider during project design to achieve net benefits.

Finally, it could help to organize the guidance by the intended user. As it stands now, the guidance appears largely oriented towards non-economists and often relies on general rather than technical terms. Yet, sometimes information is presented that is useful to economists and is probably baffling to non-economists. For the non-economists, consider establishing some minimum desirable qualities of any valuation (e.g., footnote 75) and also identify methods that non-economists could feasibly develop, such as benefit transfer and benefit indicator techniques. Many key points are in footnotes that could be brought into the text as a checklist or table. For example, footnote 42, is an example of the type of clear guidance (on selecting time horizon) that analysts would appreciate. The remainder of the methods presentation could be oriented towards giving the reader sufficient information useful for engaging with economists, rather than trying to bring up many specific aspects of valuation that could potentially be used but that, practically speaking, will only be accessible to economists.

Alternatively, if economists are included in the intended audience, it might be clearer to create a distinct section for economists that uses precise technical language and that describes how guidance in Circulars A-4 and A-94 should be interpreted or modified for ecosystem services. For example, text on page 35 is potentially useful to economists but less accessible to non-economists.

Wainger, L., Mazzotta, M., 2011. Realizing the Potential of Ecosystem Services: A Framework for Relating Ecological Changes to Economic Benefits. *Environmental Management* 48, 710–733. <https://doi.org/10.1007/s00267-011-9726-0>

5. Are concepts defined in a manner that reflects the science and is actionable? Please comment on important ways the concept definitions might be improved.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

More guidance could be given on which benefits can be independently measured and are appropriate to sum. Also, not all services can be compatibly provided by a given site, which can limit which services should be summed. Similarly, measures of utility or willingness to pay cannot be combined with economic impacts as implied by some text. More generally, the use of costs avoided to represent benefits (e.g., p 11 and in many tables) warrants some explanation and caveats since costs can often be a misleading indicator of benefits (see Dickie 2003).

Footnote 24 provides an incomplete definition of nonuse values. A clear definition of nonuse values and measurement options would be useful here, but the level of detail in the footnote about deferred consumption might be deleted since economists have other, more complete, guidance for these methodological details.

See also Question 7.

Dickie, M., 2003. Defensive Behavior and Damage Cost Methods (Chapter 11), in: Champ, P.A., Boyle, K.J., Brown, T.C. (Eds.), *A Primer on Nonmarket Valuation: The Economics of Non-Market Goods and Resources*. Springer, New York, pp. 395–444.

6. Are categorizations consistent with the science and useful for practitioners? Please comment on important ways the categorizations might be improved.

Since categorization can mean many things, I offer two interpretations.

First, I do not see much information about ecosystem service categorization, which seems odd. The only recommendation appears to be in footnote 76 for the National Ecosystem Services Classification System (NESCS) Plus (2022). If an explicit preferred system is not appropriate, it would be useful to mention that many classification systems are available, including the Millenium Ecosystem Assessment (MA framework), which is in common use. However, I would also explain the potential drawbacks of the MA or other systems to aid practitioners.

Second, if categorization means creating categories of terms and concepts, the categorization of nonuse values (footnote 24) representing a case where “an individual forgoes current benefits by not consuming a good or service in the current period” could be misleading. To me this implies option value which I understand to be a use value, but concepts are often in flux or may lack consensus. I recommend that this discussion should be shortened as economists should be able to interpret foregone consumption without this text.

I think the document could be more careful about differentiating measures of utility (e.g. willingness to pay) from costs incurred/avoided. Both types are listed in examples but might not offer equally valuable information, depending on context.

The language could be clearer to distinguish the magnitude of a biophysical change from the importance or value of a change, particularly since the term ecosystem services is often used to represent a basic biophysical change (e.g., nutrient cycling) rather than a change that is closely associated with benefits.

7. Does the document provide clear and useful guidance for both governmental and non-governmental practitioners preparing benefit-cost analyses consistent with OMB Circulars A-4 and A-94? Please comment on important ways the guidance might be improved.

See also Question 3.

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

The document does provide useful guidance and would be improved by isolating the guidance that is specific or most relevant to quantifying and valuing ecosystem services. Some explanations are not presented in enough detail to be actionable and, in many cases, aren't necessary in this document. For example, page 33 provides this incomplete guidance, "Benefits and costs that have been monetized should each be summed (after discounting to present value), and then costs should be subtracted from benefits to compute monetized net benefits." Such methods are well covered in other guidance and could be removed here to make the document easier to read. Similarly, this statement in footnote 24, "Individuals are sometimes willing to forgo other benefits, such as lower product prices, in order to secure public ecosystem services. However, market failures can prevent individuals from doing so. Regulation can help correct some of these market failures." is a true and important point for developing rules and policy. However, this is well known to economists and not actionable for most ES analysts. There are similar instances of *true but not actionable* statements throughout the report that could be removed to enhance readability.

Given the potential for climate change and system shocks to change future benefits, more discussion of methods to reveal and characterize uncertainty in a decision-relevant manner would be useful. For example, on page 20, the discussion of alternative timelines might be characterized more broadly in terms of creating alternative future scenarios to represent uncertainty. Those scenarios could include alternative time horizons, alternative baseline scenarios, and alternative assumptions about ecosystem outcomes to characterize the conditions under which net benefits would be gained/lost. Such analyses are relatively rare in BCA but may be particularly important for understanding the relative value of investments in ecosystem restoration and built infrastructure. The use of certainty-equivalents (p. 33) is an elegant method for incorporating uncertainty when outcomes have defined probabilities. However, the rapid change in climate, ocean and terrestrial conditions may not be fully captured in historic data. Therefore, a complementary analysis includes what-if scenarios of plausible conditions, with unknown probabilities of occurrence, to more fully evaluate extreme or compounding risks.

Page 7. It may be worth mentioning that legal use of SC-GHG (or SCC) is being challenged in court and that users may want to track findings before using. See <https://eelp.law.harvard.edu/2022/10/social-cost-of-greenhouse-gas-estimates/>

Page 11. The heading "**Built infrastructure can also replace** certain uses of ecosystem services." Could be better worded to avoid introducing a potentially concerning concept that built infrastructure might be valued in terms of the ecosystem services replaced. It would be clearer to say that Built infrastructure can preclude some ecosystem service benefits. For conceptual clarity, I would avoid any text suggesting that built infrastructure creates ecosystem services (as opposed to other valued services) since that claim implies that built infrastructure is, broadly speaking, a substitute for ecosystems.

8. Are there other good examples of ecosystem services in benefit-cost analyses that should be referenced or highlighted?

The document has many good examples.

9. Are there important valuation methods that should be mentioned, including for non-use values?

Use of non-traditional (e.g., social media) data are not discussed. Some useful references:

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Merrill, N.H., Atkinson, S.F., Mulvaney, K.K., Mazzotta, M.J., Bousquin, J., 2020. Using data derived from cellular phone locations to estimate visitation to natural areas: An application to water recreation in New England, USA. PLOS ONE 15, e0231863. <https://doi.org/10.1371/journal.pone.0231863>

Holmes, T.P., 2020. Opportunities for systematically valuing ecosystem service benefits produced by federal conservation programs. *Agricultural and Resource Economics Review* 49, 178–191.

Meta-regression analyses are particularly useful. You mention studies in footnotes 59 and 60 but consider adding these references:

Mazzotta, M.J., Besedin, E., Speers, A.E., 2014. A meta-analysis of hedonic studies to assess the property value effects of low impact development. *Resources* 3, 31–61.

Richardson, L., Loomis, J., 2009. The total economic value of threatened, endangered and rare species: an updated meta-analysis. *Ecological Economics* 68, 1535–1548.

10. Are there other important references or ecosystem services resources that should be included in the references?

See references provided in other questions.

For the issue of defining the “servicshed” (perhaps footnote 40), consider

Johnston, R.J., Besedin, E.Y., Holland, B.M., 2018. Modeling Distance Decay Within Valuation Meta-Analysis. *Environ Resource Econ*. <https://doi.org/10.1007/s10640-018-0218-z>

Johnston, R.J., Moeltner, K., Peery, S., Ndebele, T., Yao, Z., Crema, S., Wollheim, W.M., Besedin, E., 2023. Spatial dimensions of water quality value in New England river networks. *Proceedings of the National Academy of Sciences* 120, e2120255119. <https://doi.org/10.1073/pnas.2120255119>

Jarrad, M., Netusil, N.R., Moeltner, K., Morzillo, A.T., Yeakley, J.A., 2018. Urban Stream Restoration Projects: Do Project Phase, Distance, and Type Affect Nearby Property Sale Prices? *Land Econ*. 94, 368–385. <https://doi.org/10.3368/le.94.3.368>

These reports have useful and broad content:

National Research Council (NRC), 2005. *Valuing ecosystem services: Toward better environmental decision making*. National Academies Press, Washington, DC.

US EPA Science Advisory Board (SAB), 2009. *Valuing the Protection of Ecological Systems and Services*. US EPA, Office of the Administrator. <https://nepis.epa.gov>.

11. Are there other good examples of conceptual models helpful for valuing ecosystem services within the context of benefit-cost analysis that should be included in the appendix?

1. (if not cited elsewhere) Wainger, L.A., Murray, E.O., Theiling, C.H., McMurray, A.M., Cushing, J.A., Komlos, S.B., Cofrancesco, A.F., 2023. Broadening Benefits and Anticipating Tradeoffs with a Proposed Ecosystem Service Analysis Framework for the US Army Corps of Engineers. *Environmental Management* 71, 901–920. <https://doi.org/10.1007/s00267-022-01777-7>

2. This report that summarizes three ecosystem service valuation reports developed for and in collaboration with the USDA Office of Ecosystem Markets.

Wainger, L., and D. Ervin. *The Valuation of Ecosystem Services from Farms and Forests: Informing a Systematic Approach to Quantifying Benefits of Conservation Programs* (2017), Washington, DC: The

External Peer Review on OMB's Proposed Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis

Council on Food, Agriculture & Resource Economics and USDA Office of Ecosystem Markets.
<https://static1.squarespace.com/static/6304dd2be941420ba48fb436/t/630d9ca1630db914d4e8fa9f/1661836452496/SynthesisChapter-TheValuationofEcosystemServicesfromFarmsandForests%2Bpg%2B1.pdf>.

3. (alternative to #2) This report contains a detailed conceptual model and demonstrates how to use it to estimate value of ecosystem services by coupling ecological models and use meta-regression benefit transfer.

Wainger, L., Loomis, J., Johnston, R.J., Hansen, L., Carlisle, D., Lawrence, D., Gollehon, N., Duriancik, L., Schwarz, G., Ribaldo, M., Gala, C., 2017. Chapter 2: Ecosystem Service Benefits Generated by Improved Water Quality from Conservation Practices. The Council on Food, Agriculture & Resource Economics and USDA OEM, Washington, DC.

4. This paper is an excellent example of how to elicit expert judgment to fill in data gaps in a conceptual model to enable valuation.

Johnston, R.J., Magnusson, G., Mazzotta, M.J., Opaluch, J.J., 2002. Combining Economic and Ecological Indicators to Prioritize Salt Marsh Restoration Actions. American Journal of Agricultural Economics 84, 1362–1370.

12. Should any elements be removed?

See question 3 about removing some of the more detailed “shoulds” that are not specific to ecosystem service analysis and are covered in Circulars A-4 and A-94 or economic textbooks.

As discussed in question 7, the document would be more readable if the incomplete explanations of technical economic concepts and methods that are not unique to ecosystem service valuation were omitted.

Some suggestions about the appendices:

Appendix I.

Almost all services in the table (starting on p. ii) have -/+ in the cells and some of those that show - probably should have -/+ (e.g., roads). Therefore, I suggest removing -/+ from all cells.

Appendix III could be replaced by a paper or report that provides a more complete explanation of the concepts. This description is missing key information about what some terms mean and is generally difficult to follow. If this appendix is retained, I suggest, at a minimum, summarizing the key take home messages about the “pitfalls” and putting the response to comments directly after each comment.

Appendix IV could be removed since, similar to Appendix III, it is incomplete to the point of being unhelpful. I'm not sure what key information is meant to be imparted by this example but I find the methods difficult to follow and potentially inconsistent with the guidance of not using per acre benefit metrics. Altered land cover can be a useful initial indicator of changing ecosystem services, but the case study requires more context to clarify what types of outcomes are being measured and how. Also, it is not clear whether site-specific qualities are being used to generate changes in ecosystem services, as suggested in the guidance. The references cited in this appendix look quite useful but aren't well integrated into the information being presented.