Ecosystem services can promote conservation over conversion and protect local biodiversity, but these local win-wins can be a regional disaster

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ABSTRACT

Ecosystem services programs are rapidly increasing and are seen as a pathway for biodiversity conservation based on the attractive idea that quantified values of the ecosystem services of intact land may exceed any gains from conversion to intensive logging or other non-conservation uses. However, I show that, even when all local biodiversity is protected whenever ecosystem services values create greater benefits from conservation compared to conversion, this may lead to poor outcomes for regional biodiversity conservation. I examine this dangerous idea by re-visiting early planning case studies in the Bateman's Bay region of NSW. Integration of ecosystem services into systematic conservation planning typically can ensure good regional biodiversity outcomes. However, as we increase the estimated value of ecosystem services in localities, the region reaches a tipping point where the capacity for good regional biodiversity outcomes collapses. This collapse results because the priority ecosystem services sites tend to represent similar biodiversity, contrasting with the biodiversity *complementarity* required for efficient conservation planning. Recent proposals for spatial planning that continue to focus only on local win-win outcomes highlight the disregard for planning lessons forged 20 years ago in NSW, and promote a dangerous planning framework where we may never know how much biodiversity we have lost.

Key words: biodiversity, ecosystem services, systematic conservation planning, trade-offs, conservation, convention on biological diversity, aichi targets, IPBES

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Introduction

This paper was presented as a contribution to a Forum at the Australian Museum on "Dangerous Ideas in Zoology". The Forum welcomed various interpretations of "dangerous ideas", considering not only ideas that are dangerous to zoology and conservation, but also ideas that are counter-intuitive and daring in challenging the status quo.

My topic is conservation planning for biodiversity and ecosystem services. We are in a biodiversity crisis, documented by a continuing trend in the decline of biodiversity (Butchart *et al*. 2010). Conservation planning therefore is an area where dangerous ideas – positive and negative – deserve careful scrutiny. Some clarification of terms will be useful at the outset. I will use "biodiversity" in the sense of living variation (e.g., Convention on Biological Diversity 2010). I will side-step the perhaps dangerous tendency to use the term too-generally (e.g. including practically any aspect of ecology), or too-vaguely (e.g. as in the "fabric of life"; for discussion see Faith 2008). An "ecosystem" is "the set of organisms living in an area, their physical environment, and the interactions between them" (Daily 1997), and I use "ecosystem services" more or less following the definition in the Millennium Ecosystem Assessment (2005): ecosystem services are the benefits (or conditions and processes leading to benefits) that people obtain from natural ecosystems. Examples include clean water, carbon sequestration and recreation value. The global importance of both biodiversity and ecosystem services is reflected in the newly created Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES).

Conservation planning increasingly has recognized the need to integrate biodiversity and ecosystem services. A central argument (reviewed below) is that the total benefits from conserving the ecosystem services of a locality or ecosystem, if they can be quantified (in monetary or non-monetary units), often will exceed the benefits to be gained from conversion of that locality (e.g. to commercial logging). An implication is that maintaining the unconverted land also preserves its biodiversity.

In this context, I will discuss a dangerous idea that captures both interpretations from the Forum. I will argue that the vision of ecosystem services as a pathway for biodiversity conservation, in fact, should be regarded as a dangerous idea for biodiversity conservation. At the same time, my own argument may be regarded as a dangerous idea, because it challenges the status quo and is counter-intuitive. After all, if ecosystem services benefits exceed those of conversion, and we gain biodiversity conservation benefits as well, surely we have a win-win outcome. What could go wrong? To see the problem, I will begin with some background and then present a revealing case study from New South Wales, Australia.

Background

Ecosystem services conservation has been promoted for some time as a way to address the biodiversity crisis (for review, see Armsworth *et al.* 2007, Rands *et al.* 2010). Some argue that the failure to integrate ecosystem services values in the past has been a root cause of the biodiversity crisis. The reports from the influential study, "The Economics of Ecosystems and Biodiversity" (TEEB; 2010, 2011, 2012ab) argue that "under-valuation of ecosystem services and failure to capture the values is one of the main causes underlying today's biodiversity crisis", and that "we're losing nature because we don't price it in."

Balvanera *et al.* (2001) suggest that "we must remember that biodiversity is in serious jeopardy for a reason: namely, that the opportunity costs of conservation are perceived to be too high." Balvanera *et al.* see ecosystem services conservation as a way to reduce those opportunity costs of conservation and so increase incentives for conservation: "The best hope for biodiversity is to create and align diverse incentives for conservation wherever possible and to integrate these into the larger policy-making arena." Thus, any place where opportunity costs of conservation are reduced is seen as a boost to biodiversity conservation.

The Economics of Ecosystems and Biodiversity (TEEB; 2010, 2011, 2012ab) refers to seven case studies in different countries finding high total ecosystem services benefits of conservation relative to benefits from conversion. These studies echo an earlier study of Balmford *et al.* (2002) which concluded that economic valuation of ecosystem services will show that benefits of intact land far exceed benefits of conversion (e.g., to forestry production).

Goldman *et al.* (2008) reviewed studies promoting the core idea that taking values of ecosystem services into account in planning and decision-making can counter the economic case for conversion and so promote conservation of biodiversity. They concluded: "Ecosystem service approaches to conservation are being championed as a new strategy for conservation, under the hypothesis that they will broaden and deepen support for biodiversity protection". In accord with this perspective, the new Strategic Plan of the Convention on Biological Diversity (CBD) includes ecosystem services in its Mission statement (Convention on Biological Diversity 2010).

This new optimism in making a case for conservation is reflected in Polasky *et al.*'s (2012) conclusion that "from a conservation standpoint, the most important thing is to protect and conserve land and that the benefits of conservation will outweigh the costs." This optimism extends to the suggestion by TEEB that even incomplete valuation not covering the full range of ecosystem services can provide useful information for decision makers, when compared with the benefits from conversion (see also Balmford *et al.* 2002; Cimon-Morin *et al.* 2013). Noss *et al.* (2009) argue that even partial quantification of ecosystem service benefits is often enough to make the case for conservation, promoting conservation over conversion. A case study by Tallis and Polasky (2009) supports this idea:

"Paying for just one ecosystem service, carbon sequestration, using a price of $43 per ton of carbon… made the conservation scenario the most valuable outcome rather than the least valuable outcome in terms of market value of goods and services produced." Balmford et al. (2002) echoes this idea: "Our examples show that even when only a few ecosystem services are considered, their loss upon conversion typically outweighs any gains in marketed benefits." Tallis and Kareiva (2006) similarly conclude that "Economic valuation need not cover all values of ecosystems; progress is made simply by capturing values that are presently egregiously overlooked." Ring et al. (2010) argue that, while ecosystem services need to be properly valued in economic terms, "a rough approximation is still preferable to not valuing them at all".

These studies promote the popular idea that any available information that implies that estimated conservation benefits exceed conversion benefits effectively makes the case for conservation of that place. This core ecosystem services argument focuses within planning units or ecosystems, and the "win-win" corresponds to local gains related to both ecosystem services and biodiversity (note that "win-win" is sometimes used at multiple spatial scales; see e.g. Howe *et al.* 2013). Here, I will use the term "regional" to refer to planning concerned with allocation of land uses among multiple areas or ecosystems. In the next section, I consider how the win-win perspective is extended as part of regional land use planning.

Ecosystem services and biodiversity in regional planning

One simple regional-scale approach uses mapping of available information on services and biodiversity. A recent "roadmap" (UNEP-WCMC and IEEP 2013) for national biodiversity action plans suggests mapping to identify places where multiple benefits of ecosystem services and biodiversity co-exist. These are to define conservation priorities: "Investing in natural capital in areas where such clear synergies exist can benefit both nature and people, ensuring the efficient allocation of limited environmental and financial resources." In this formulation, both the ecosystem services and biodiversity contribute to the apparent advantages over conversion. Thus, the priority areas will be places valuable for both ecosystem services and biodiversity.

At that national scale, a recent high-profile study for the United Kingdom (U.K.) (Bateman *et al.* 2013) begins with this core idea that valued ecosystem services exceed conversion gains: "the overall values of unconverted natural habitats can exceed the private benefits after conversion." The U.K. study concludes that "highly significant value increases can be obtained from targeted planning by incorporating all potential services and their values and that this approach also conserves wild-species diversity" (in fact, that they only use "all of those ecosystem services for which robust economic values can be estimated"). The regional planning method in this study selected, for each locality, the land use that maximized ecosystem services gains, under the constraint that the land use implied essentially no loss of local biodiversity (I discuss their odd measure of "biodiversity" below).

Other regional-scale planning studies have considered whether ecosystem services occur in the places where there are high biodiversity conservation needs (Bennett *et al.* 2009). For example, Anderson *et al.* (2009) conclude that "The extent to which the locations that are most valuable for ecosystem services coincide with those that support the most biodiversity is of critical importance when designing conservation and land management strategies" (see also Naidoo and Ricketts 2006; Nelson *et al.* 2009).

All these regional approaches focus in various ways on the biodiversity (however measured) within each of the localities. If this was all that mattered, then successful biodiversity conservation would simply depend on demonstrating the relative benefits of the conservation option for a given locality. Even a partial valuation of perceived ecosystem services might mean that conservation beats conversion. The biodiversity within the locality may not have to be measured (see e.g., Tallis and Polasky 2009), except in those cases where highest priority for conservation is to be given to those places with high local biodiversity (as in Anderson *et al.* 2009). The other apparent good news, suggested by the study of Bateman *et al.* (2013), is that many different land uses effectively might be regarded as equivalent to "conservation", as long as the biodiversity under such uses is judged to remain relatively intact.

Of course, as good as this kind of framework sounds, such strategies do not guarantee that the set of conserved areas protects overall regional biodiversity (imagine a scenario where every place where ecosystem services benefits exceed conversion benefits is identical in its elements of biodiversity - the set of conserved places will not represent regional biodiversity). This representativeness issue is, of course, an old story. I highlighted this issue through my inputs to the Millennium Ecosystem Assessment (2005): "Ecosystem services may well value exactly what makes that place similar to many others, even though this amounts to "redundancy" at the regional scale" (McNeely *et al.* 2005; see also Faith 2006).

The opposite of redundancy is representativeness, and this biodiversity goal is a foundation of systematic conservation planning ("SCP"; e.g., Margules and Pressey 2000). SCP can integrate ecosystem services, local biodiversity and regional biodiversity representation. For example, a Papua New Guinea (PNG) planning study (Faith *et al.* 2001a, b), recognized Wildlife Management Areas supporting ecosystem services for traditional owners, including hunting and subsistence agriculture. The study's SCP analyses incorporating ecosystem services credited these localities with biodiversity conservation. SCP derived a priority set consisting of Wildlife Management Areas and additional areas, which maximized regional biodiversity representation while minimizing opportunity costs of conservation. Following typical SCP analyses, the contribution of an area was based on its biodiversity contribution to the final set ("complementarity" value), not its own total biodiversity.

The framework for that PNG study can be traced back to early planning studies in the Bateman's Bay region on the south coast of New South Wales (NSW), Australia (Faith *et al.* 1994, 1996; see also Cocks *et al.* 1995). While Bateman *et al.* (2013) claimed to demonstrate "the benefits of spatially explicit decision-making", important lessons appear to have been missed from those studies 20 years before. Bateman *et al.* made a surprising assumption that "difficult-to-monetize impacts, such as those on wild species, should be incorporated through the imposition of sustainability constraints." In contrast, the Bateman's Bay studies established regional scale multi-criteria analyses as a pathway to exploring trade-offs and synergies among different needs of society, including biodiversity. I will argue below that it is Bateman's Bay, not Bateman *et al.*, that provides the framework that we need for integrating ecosystem services and local/regional biodiversity conservation.

Below, I review the framework developed and explored in the Bateman's Bay studies. This also provides a convenient launching point for my extension of those studies. This new analysis provides some fresh lessons related to my "dangerous idea".

Two early Bateman's Bay NSW planning studies

A number of land use planning techniques have been developed and trialed in the Bateman's Bay area, including the SIRO-PLAN (Cocks *et al.*, 1983) method for land use planning, and the related spatial decision-support package LUPIS (Ive and Cocks, 1988). In applications of these methods, plans are evaluated in terms of the extent that guidelines, expressing the values of different stakeholders or interest groups, are satisfied. SIRO-PLAN and LUPIS allow the exploration of land-use plans in which an area is assigned the land-use for which it has highest suitability. These relative suitabilities depend in part on nominated weights assigned to the user-defined guidelines, and so the method amounts to a form of multi-criteria analysis.

Cocks and Ive (1996; see also Cocks *et al.* 1995) described the results of an extensive demonstration of the SIRO-PLAN and LUPIS methods in a case study that began in 1990 in the Bateman's Bay region. This region includes an extensive area of native eucalyptus forest, which in the early 90s was at the centre of conflict over land use. Faith *et al.* (1996) summarized the land-use issues in these native eucalyptus forests: "conservationists were concerned that those parts of the forest with particular value for biological conservation, recreation and aesthetic appreciation were protected from logging operations", and "the timber industry sought on-going access to the forest resources of the area for sawlogs and pulpwood."

The suggested protected areas emerging from the Cocks and Ive (1996) study were recognized as satisfying guidelines relating not only to biodiversity, but also to what we would now call ecosystem services: fresh water, recreation, wilderness value, and so on. Critically, conservation of an area could gain priority based on multiple guidelines:

"Any suggested allocation of forest lands between competing uses can be evaluated as to how well it satisfies a range of land allocation guidelines representing the preferences of different stakeholders in relation to the issues that made planning necessary" (Cocks and Ive

1996; see also Cocks *et al.* 1995). Thus, a conservation (or related land use) option for a place gains credit for not only its biodiversity contribution, but also fresh water, recreation, and other benefits. This combined benefit could be enough to create preference for that use over some other conversion use providing other benefits.

This early 90s Bateman's Bay regional case study was perhaps the first planning exercise to demonstrate the use of ecosystem services to boost the conservation case for localities in a region. This study largely has been ignored in the literature, but even today can provide planning guidance. In embracing a flexible form of multi-criteria analysis that includes both ecosystem services and biodiversity goals, this old study is perhaps a better implementation of the approach attempted by Bateman *et al.* (2013), where the land use that best combines ecosystem services and biodiversity benefits is to be preferred over a conversion use having lesser benefits.

The second Bateman's Bay regional planning study

The early Bateman's Bay and recent Bateman *et al.* studies do have something in common: both focused on the status of the biodiversity within localities and did not use complementarity in order to maximize the biodiversity represented in the final set of protected areas. Another early 90s Bateman's Bay case study (Faith *et al.* 1994; 1996) was designed to illustrate the potential gains in integrating biodiversity complementarity into the planning framework explored by Cocks and Ive (1996). Such a complementarity-based approach resembles the early minimum set approaches for reserved selection (Margules and Pressey 2000), but importantly differs in also using opportunity costs of conservation that vary among areas. This extension of multi-criteria analysis methods to incorporate the principle of complementarity for regional land-use planning builds on the development of methods in the DIVERSITY software package by Faith and Walker (1993, 1996; see also the "Regional Sustainability Analysis" of Faith 1995). In this iterative approach, a locality is assigned to conservation if its biodiversity complementarity value exceeds its weighted opportunity cost. Varying the weights over multiple analyses produces an efficiency frontier curve (for examples, see Faith 1995; Faith *et al.* 1996). This DIVERSITY procedure (as applied in the PNG study referred to above) serves as an exemplar for Systematic Conservation Planning (Margules and Pressey 2000).

This second Bateman's Bay regional case study (Faith *et al.* 1994, 1996) applied the DIVERSITY procedure to the 2914 grid cells of the Bateman's Bay region falling within the forest province (Cocks *et al.* 1995). These defined the basic "areas" for land-use allocations. A 6-dimensional ordination space formed regional biodiversity surrogate information, covering the 2914 forest localities. The ordination captures patterns of biodiversity differences among the areas and is the basis for estimating representativeness of subsets of areas and biodiversity complementarity values (for methods details see Faith and Walker 1996; Faith *et al.* 1996).

This case study extended the earlier study of Cocks *et al.* (1996) which used the LUPIS decision support package to explore allocations in the Bateman's Bay region. The DIVERSITY procedure (Faith and Walker 1993, 1996) was integrated with the LUPIS (Ive and Cocks. 1988), so that the "opportunity costs" of conservation reflected different weightings on the guidelines or criteria underlying competing land uses. The value of any area for Forestry was taken as being the highest suitability score of the four forestry-oriented land uses from the previous study. These forestry suitabilities derived by LUPIS for input to DIVERSITY reflect consideration of 47 guidelines (reflecting factors such as distance to saw mill, regeneration potential and site productivity). The final suitability values depended on the relative weights on these guidelines, produced in the previous study (Cocks *et al.* 1996). These values amount to forestry production opportunity costs of conservation in the DIVERSITY procedure.

The new study varied weights on the forestry production opportunity costs (relative to biodiversity complementarity values) to derive an efficiency frontier curve (see Faith *et al.* 1996). This trade-offs planning strategy also was compared to planning that simply optimized biodiversity protection for a given number of protected areas. The effective trade-offs planning balanced biodiversity protection and non-conservation forestry production, and would allow, at the same cost, a greater take-up of non-conservation forestry production for about the same biodiversity achievement level. This was a first study to demonstrate the advantages of including variable opportunity costs of conservation in regional planning for biodiversity conservation.

This study balanced biodiversity conservation and a non-conservation ecosystem service (forestry production); for simplicity, the study did not consider other ecosystem services that would support conservation. In the next section, I describe new analyses that fill in this gap in the Bateman's Bay studies, by combining the implementation of complementarity with the ecosystem services conservation values.

Bateman's Bay revisited, again

The few existing studies that have integrated ecosystem services conservation goals into SCP suggest that conservation of ecosystem services localities can promote regional biodiversity outcomes. For example, Barton *et al.* (2009) examined ecosystem services in localities that were assumed also to contribute complementarity values for regional biodiversity protection. They found that, for about the same cost (in lost forestry or agriculture conversion) incurred when using only biodiversity goals, they could achieve ecosystem services and about the same biodiversity protection level when both were optimized (see also Faith 1995; Venter 2009; Nelson *et al.* 2009; Egoh *et al.* 2007, 2010; Chan *et al.* 2006, 2011; Goldman *et al.* 2010; Cimon-Morin *et al.* 2013).

I now describe new analyses for the Bateman's Bay region, incorporating opportunity costs and ecosystem services and biodiversity conservation benefits, revealing some surprising limitations in using ecosystem services to support biodiversity conservation.

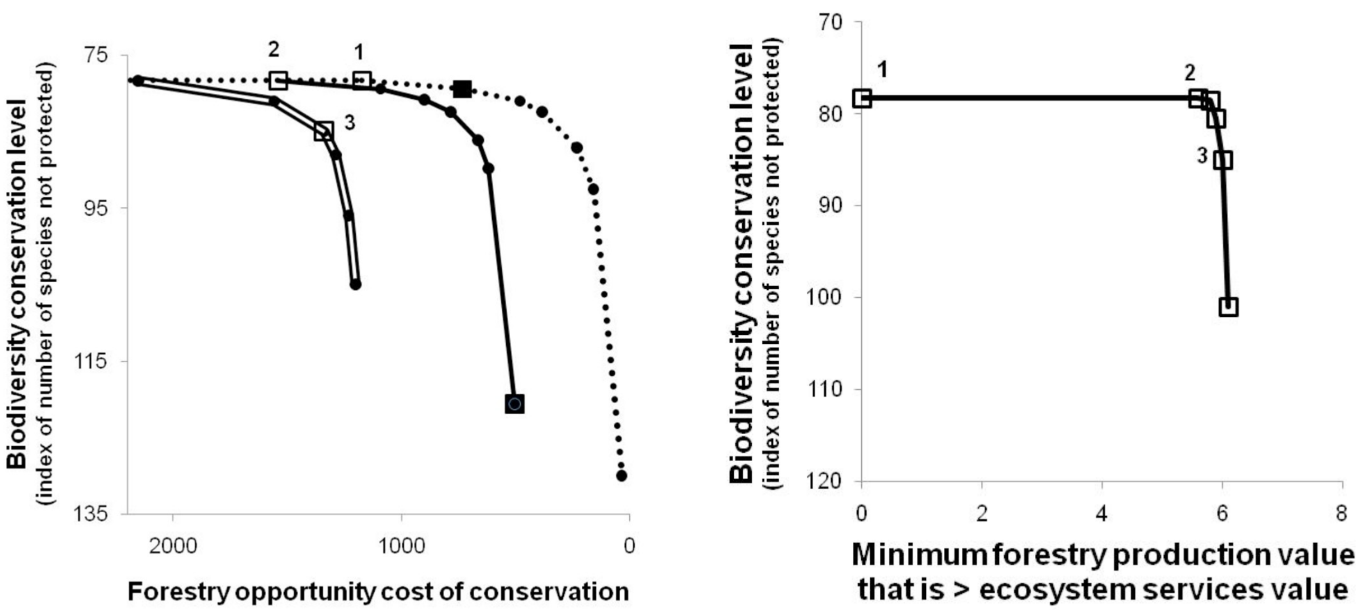
For these new analyses, I used the existing data sets, SCP methods, and DIVERSITY software described in the earlier study (Faith *et al.* 1994, 1996). Again, a 6-dimensional ordination space formed regional biodiversity surrogate information, covering 2914 forest localities. I calculated SCP efficiency-frontier curves, with and without inclusion of ecosystem services, using the available information on ecosystem services, regional biodiversity, and opportunity costs (forestry production values). As a first analysis, I extended that original SCP analysis from Faith *et al* (1996) to produce a range of solutions for varying weights, resulting in the dotted frontier curve (Fig 1a). Each point along the frontier curve results from a different relative weighting on biodiversity as compared to opportunity cost.

Further analyses repeat this process of varying weights on opportunity costs to derive an efficiency frontier curve, but now also include other ecosystem services contributing to conservation benefits. Thus, I retain the outcomes where ecosystem services benefits can exceed the benefits from conversion to forestry production (from Cocks *et al.* 1995), but also have complementarity (as in Faith *et al.* 1994; 1996). Adjusted opportunity costs take these ecosystem services values into account. The adjusted opportunity costs of conservation now consider forestry conversion benefits minus the ecosystem services benefits of the non-converted land.

In order to estimate these ecosystem services benefits of conserved land, I used the ecosystem services maps from the original Bateman's Bay study (Cocks *et al.* 1995). These maps indicated that essentially all forested areas in the region have one or more recognized ecosystem services, including water, recreation, and wilderness values. I examined scenarios where the total ecosystem services values exceeded low forestry production benefits, supporting conservation of ecosystem services and local biodiversity for those localities.

In the absence of economic valuations for these services, the various scenarios assumed that the economic valuation of such services in a given site would produce values that exceeded some nominated threshold value, T, of forestry production benefits. Different scenarios therefore corresponded to different assumed magnitudes of locality's ecosystem services benefits (by varying T). If T is large, then the economic value of the ecosystem services is high, and more areas are supported for conservation; if T is small, then the economic value of the ecosystem services is low (only areas with small forestry benefits can be preferred for conservation based on ecosystem services).

Any locality where ecosystem services benefits exceed T will be allocated to conservation in these solutions (providing both ecosystem services and biodiversity, as compared to an alternative, smaller, forestry production benefit). Thus, for a given SCP analysis, all localities with forestry production values less than T had negative opportunity costs of conservation and in effect were allocated at the outset of the analysis to conservation (of ecosystem services and local biodiversity). For each analysis, I applied DIVERSITY software (Faith and Walker 1993, 1996; Faith *et al.* 2004), with varying weights on opportunity costs and then allocated the remainder of areas/cells to either forestry or biodiversity conservation. This produced a final efficiency frontier curve for a given value of T. Solutions along each frontier curve balanced forestry



A) Frontier curves for the Bateman's Bay Region, NSW, Australia

B) Regional sustainability tipping point

Fig. 1. Efficiency-frontier curves reflecting biodiversity conservation level (ordinate) and opportunity costs of conservation (abscissa). Allocations offering both high biodiversity conservation and high forestry production would be in the upper right corner. A) Dotted curves ignore ecosystem services values; solid curves integrate ecosystem services values, with double solid curve for the scenarios where magnitude of ecosystem services values is greater. Solid squares = 100 conserved areas. Hollow squares (1-3) = 240 conserved areas. B) For a target of 240 conserved areas, biodiversity conservation levels remain high as ecosystem services magnitude increases (abscissa), until a tipping point is reached. Solutions 1-3 shown from A).

opportunities, ecosystem services benefits, and biodiversity conservation. Note that DIVERSITY output indicates level of biodiversity conservation as an index of number of species not-conserved (Fig. 1; Faith and Walker 1996).

In Fig. 1a, when T is 0.0 we have the previous dotted frontier curve. It follows that, for the original dotted curve, no cells gain this immediate allocation to conservation. When T is 5.6, we obtain the solid-line curve, and when T is 6.0, we obtain the double-line curve. When T is larger more cells are immediately allocated to conservation.

I highlight the variation in the solutions for a fixed total number of protected areas, by noting solutions for 100 conserved areas (solid squares) and 240 conserved areas (hollow squares, numbered 1-3). I next focus further on solutions with 240 areas, to explore the consequences of increased magnitude of ecosystem services benefits (Fig. 1B). I varied the threshold value, T, to range over the set of values: {0.0, 5.6, 5.8, 5.9, 6.0, 6.1}. The DIVERSITY software in each case was used to identify solutions having 240 conserved localities, providing the 6 solutions in Fig. 1B.

The analyses reveal steep reductions in regional biodiversity conservation when SCP includes higher valuations of ecosystem services benefits (Fig. 1B). Some achievement levels for regional forestry production and for total area conserved now yield solutions on the steep-reductions part of the new efficiency-frontier curves (Fig. 1B). Critically, increases in the magnitude of estimated ecosystem services benefits can move initial high-biodiversity SCP solutions towards a tipping point in which best-possible regional biodiversity conservation levels collapse (Fig. 1B). Moving along this curve from left to right, the assumed benefits of ecosystem services (horizontal axis) increase (at each forest site). For initial increases, the total regional biodiversity represented (vertical axis) remains high; conserved ecosystem services areas may not represent regional biodiversity well on their own, but selection of additional areas compensates for this. However, at some point the supposed high benefits of ecosystem services mean that so many areas are selected on this basis that there is little scope to select any other areas to increase overall biodiversity representativeness of conserved areas for the region. The dangerous reliance on local win-win areas for conservation results in a collapse in representation of regional biodiversity.

Discussion

I briefly reviewed the popular prescription for the use of ecosystem services in a powerful strategy to address the biodiversity crisis: if estimated ecosystem services benefits for an area exceed its conversion benefits, then conserve the area and also gain local conservation of biodiversity. My "dangerous idea" is that, far from being a positive outcome, this local win-win can be a negative outcome for regional biodiversity conservation. The re-visited Bateman's Bay case study dramatically illustrates these dangers. It also casts doubt on the confidant statements (reviewed above) that any estimated ecosystem services benefits will be helpful for decision-making. If the estimates are inflated, then the regional may unnecessarily be driven close to the tipping point exemplified in Fig 1b.

It is worth noting that some aspects of this problem should not be surprising. It makes sense that conserving a set of areas for ecosystem services is not a recipe for producing a set that is representative of regional biodiversity. I noted above the Millennium Ecosystem Assessment (2005) warning that ecosystem services may value exactly what makes that place similar to many others, even though this amounts to biodiversity redundancy at the regional scale (see also Faith 2005). I also highlighted the PNG country study (Faith *et al.* 2001a, b) where the large number of existing protected areas selected for their ecosystem services were found to be poor in representation of the country's total biodiversity.

Thus, it should not be surprising that biodiversity would not fare well on any occasions when biodiversity is not measured and integrated into regional planning. This problem is apparent also when biodiversity is measured, but the measure of "biodiversity" merely reflects local ecosystem properties related to ecosystem services. For example, Bateman *et al.* (2013) use a measure that reflected local abundance of different species. While they boldly claim to have a novel regional planning method that "also conserves wild-species diversity", in fact, their "biodiversity" measure, in focusing on relative abundance of local species, could look good even when 99% of the U.K.'s species were lost. The Bateman *et al* study is not atypical; it reflects the popular within-ecosystems focus in current research on synergies and trade-offs between biodiversity and ecosystem services (e.g. Balvanera *et al.* 2014).

More surprising is my finding that integration of both ecosystem services and biodiversity into SCP, with its explicit goal of maximizing representativeness, and use of complementarity, does not automatically avoid these problems (Fig.1). SCP tries to maximize regional biodiversity conservation, but is hindered by having many cases where the areas selected for conservation are determined by ecosystem services and have low complementarity. For example, consider the comparison of outcomes for 240 conserved areas (Fig. 1b). Over different scenarios, the biodiversity conservation levels remain high as the magnitude of the benefits from ecosystem services increases (abscissa), until a tipping point is reached. For a while, the areas conserved based on ecosystem services can be complemented by additional SCP-selected areas, so that the total representation of biodiversity is good. But, at some point, the number of largely redundant ecosystem services areas cannot be adequately complemented by a small number of additional conserved areas.

Consideration of a fixed number of conserved areas is timely and appropriate. A region/nation that has a conventional conservation target equivalent to some total number (or area coverage) of protected area may be fooled into thinking that they are doing a good job for biodiversity conservation by reaching its area target. I referred above to the UNEP recommendations to identify places where multiple benefits of ecosystem services and biodiversity co-exist, and to the take-up of ecosystem services by the Convention on Biological Diversity (CBD). The new Strategic Plan of the CBD has 20 key targets, including Target 11: "By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider land."

Ecosystem services conservation may achieve primary attention in addressing this target, with the assumption that biodiversity gains follow. A recent review (Schroter *et al.* 2014) concluded that the CBD's targets comprise "the principle that biodiversity can be, directly or indirectly, safeguarded by managing, restoring or enhancing ES [ecosystem services] provision." To extend my example, a country seeking 240 conservation areas to satisfy Target 11 could be satisfied with 240 areas of key ecosystem services that also each protect their local biodiversity – but in fact, the country may have a very low representation of its total biodiversity conserved (Fig. 1).

When ecosystem services and biodiversity are integrated into SCP, it may be possible to anticipate these problems and make adjustments. When candidate SCP solutions are identified on the steep part of an efficiency-frontier curve, a small increase in total area conserved or increase in opportunity costs (moving to point b, Fig 2), or small decrease in magnitude of ecosystem services benefits values (moving towards point c, Fig 2), yield improved biodiversity conservation outcomes.

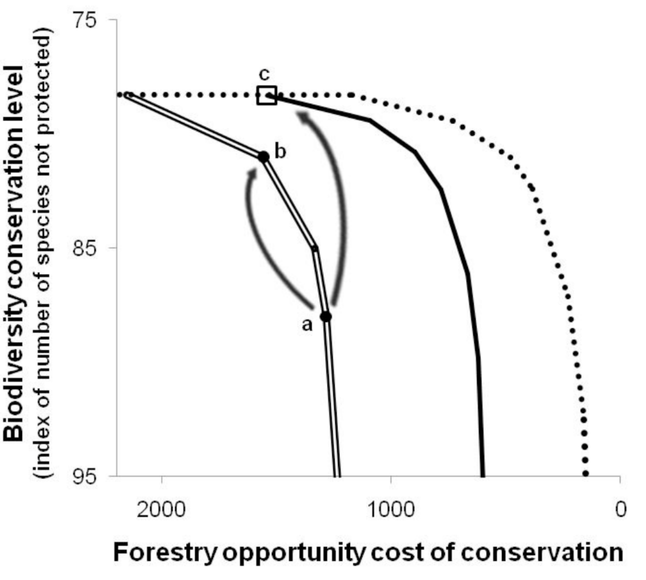


Fig. 2. Extending Fig. 1B, the solution at point a has low biodiversity conservation. A small increase in total area conserved or an increase in opportunity costs of conservation (moving to point b), or a small decrease in magnitude of ecosystem services values (moving towards point c), yield much-improved biodiversity conservation outcomes.

This need to anticipate tipping points, and make adjustments, extends to other CBD targets. For example, Target 5 is intended to reduce direct pressures on biodiversity: "By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced". Among the relevant policy contexts is carbon sequestration in forests through "Reduced Emissions from Deforestation and Degradation" (REDD) programs. So-called "REDD+" programs select carbon sequestration areas in order to integrate this ecosystem service with conservation of biodiversity. This basic strategy has been integrated into systematic conservation planning for some time (Faith *et al.*, 2001a; Venter *et al.* 2009), but further work is needed if we are to avoid what amounts to "REDD–", where over-focus on local carbon/biodiversity win-wins could mean that the regional capacity to conserve biodiversity in fact collapses.

Countries presently have the flexibility to modify these CBD targets. Without such efforts to analyze trade-offs and adjust individual targets, conservation planning or other decision-making that is strongly influenced by ecosystem services valuations could be accompanied by a tipping point delivering poor outcomes for regional biodiversity conservation.

I finish by noting that this tipping point, as illustrated in Fig.1, is one example of a more general "sustainability tipping point" problem (see Faith 2011). In all such cases, the tipping point means that the region has lost its capacity to achieve solutions along a good frontier curve. In order to find balanced plans, SCP depends the flexibility found in the universe of possible land allocations; it is this flexibility that is lost (for discussion, see Faith 2011). Understanding these problems requires consideration of multiple scenarios in trade-offs (sustainability) space. It also requires new socio-economic – biodiversity models that can help to anticipate a sustainability tipping point and guide decisions that may help the region stay a safe distance away from that tipping point.

My conclusion is that the guidelines and foundations for this approach are best found in the old Bateman's Bay studies, not the new Bateman *et al.* (2013) study. These early Bateman's Bay studies (Cocks *et al.* 1995; Cocks and Ive 1996; Faith *et al.* 1994, 1996) illustrate multi-criteria analyses, incorporating a range of land uses, offering a range of degrees of satisfaction of guidelines for multiple stakeholders. Ecosystem services benefits represent just one aspect of this link between different land uses and possible benefits or dis-benefits for multiple stake-holders. Importantly for biodiversity conservation, this flexible approach includes biodiversity complementarity as a basis for investigating regional trade-offs and synergies, ensuring that ecosystem services and biodiversity provide more than just a win-win story within localities.

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