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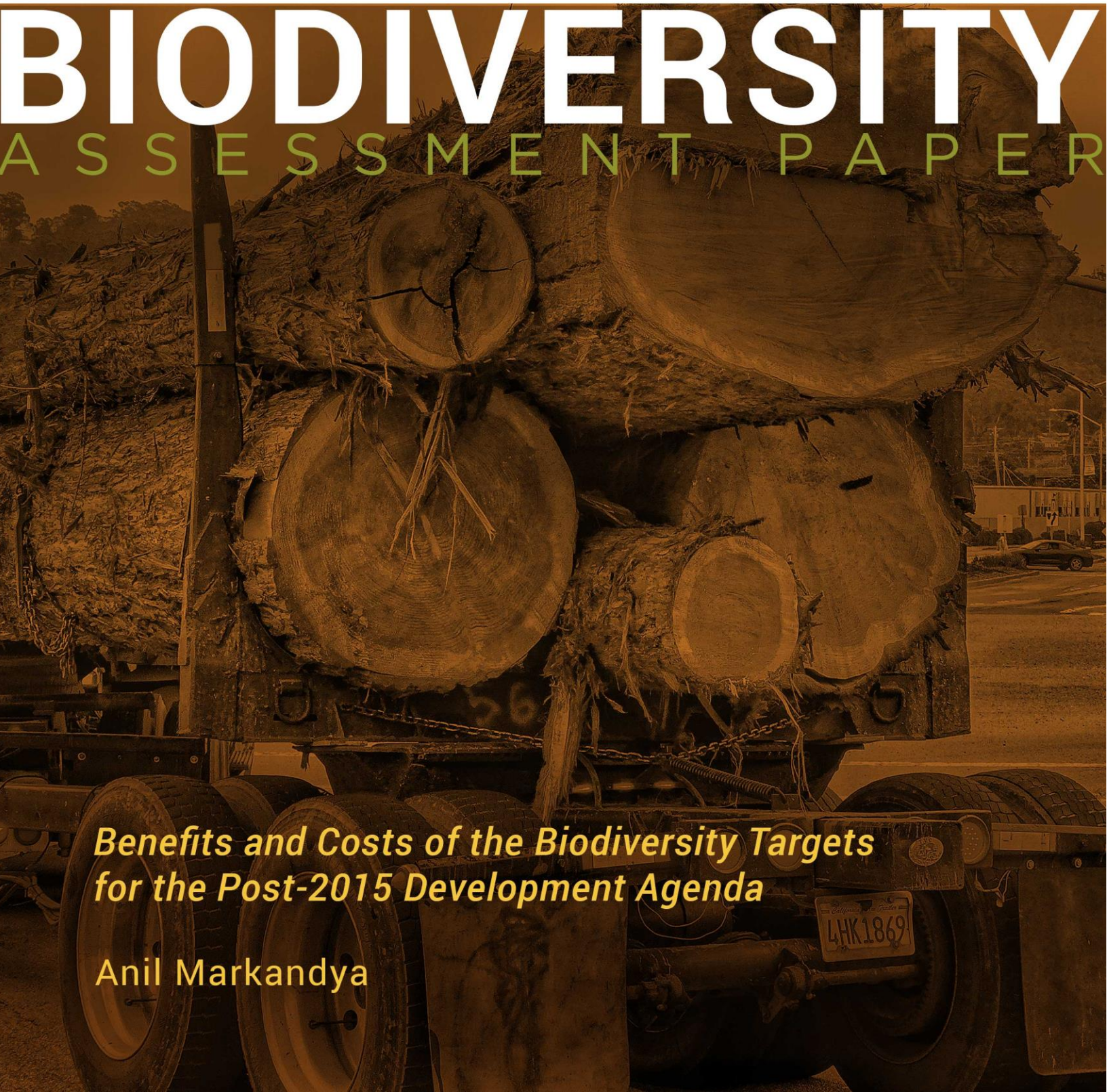

Benefits and Costs of the Biodiversity Targets for the Post-2015 Development Agenda

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POST-2015 CONSENSUS

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Highlights

Within the focus area of Biodiversity and Deforestation the target that has the best benefit-to-cost ratio (BCR) is:

- *"By 2030, stem the loss of coral reefs by 50%",* which has a BCR of 95 and 112

Another valuable targets within this focus area is:

- *"Reduce global forest loss by at least 50%",* which has a BCR between 30 and 137

The following target has an acceptable benefit-cost ratio, although some possible costs of reforestation carried out using exotic species may result in losses of biodiversity.

- *"By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification."*, which has a BCR of between 2 and 14.

The following target is relatively ineffective or there is large uncertainty regarding the benefit-cost ratio**:**

- ***"****By 2020, at least 17 per cent of terrestrial and inland water areas 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 lands"****, which has a BCR between 0.3-2.0*

This is a first attempt at estimating benefit-cost ratios for the biodiversity and deforestation targets. Future work needs to investigate both the benefits and costs more closely but especially the former. It should also look at who pays the costs and who benefits from these investments. Finally the study has considered targets individually and it is possible for one target to have benefits (or costs) on another. These linkages or spill overs need to be examined.

Background

The Millennium Development Goals (MDGs) set up in 2000 tracked a number of indicators for sustainable development to 2015. Some of the goals, such as halving the poverty rate, have been by 2015 met and considerable progress has been made on others. Overall they are seen as a successful way of focussing attention and mobilizing resources to address the major gaps in human development, including those relating to the environment. The post 2015 agenda seeks to replace the MDGs with new goals that "move beyond meeting basic human needs and promote dynamic, inclusive and sustainable development" (CIGI, 2012).

There has been an active debate on what precisely these goals should be and what indicators should be used to track them. At the end of June 2014 the Open Working Group of the UN released a revised Zero Draft of the proposed goals and targets for the Sustainable Development Goals. Biodiversity and deforestation is primarily covered in proposed Goals 14 and 15. Details of these are given in Annex A. Goal 14, which includes 10 targets, focuses on marine resources and seeks to reduce marine pollution, protect and conserve marine areas of special value, reduce subsidies for certain types of fisheries and better regulate and control illegal fishing practices. Goal 15, which includes 12 targets, deals with terrestrial natural resources. It sets targets for reducing deforestation, land degradation, loss of biodiversity and poaching and trafficking of protected flora and fauna. It also sets targets for ecosystem restoration and seeks to promote the equitable sharing of genetic resources as well as increasing financial resources for conservation.

The targets as given in the Zero Draft draw significantly on the Aichi Targets that were adopted as part of the Convention of Biological Diversity's (CBD's) Strategic Plan for Biodiversity 2011–2020, in Nagoya, Japan, in 2010. These targets are given in Table 1. The Aichi Targets and the proposed SDG goals, however, while having a lot in common also have a number of differences. The Aichi Targets include more quantitative values than the proposed SDGs. In terms of coverage the SDGs include the following which are not in the Aichi targets: (a) increasing the economic benefits of marine resources to small island developing states and less developed countries (target 14.7); (b) providing access of small-scale artisanal fishers to marine resources (target 14.b); full implementation of international law and for the conservation and sustainable use of oceans (target 14.c); urgent action to end poaching ad trafficking of protected species of flora and fauna (target 15.7). On the other hand the Aichi targets include specific reference to the following, which are not mentioned in the SDGs: (a) increasing awareness of the values of biodiversity (Target 1 in Aichi); minimise anthropogenic pressures on coral reefs (target 10 in Aichi).

The aim of this exercise is to estimate the costs and benefits of selected biodiversity-related targets that are close to those that could be adopted in the Post 2015 framework for global sustainable development. The assessment is carried out in monetary terms so as to obtain indicators of value for money that can be compared with other uses of public funds. It is only possible to do this, however, when the targets are quantitative, have a given time frame, and when the costs and benefits can indeed be measured in money terms. All these factors imply that the estimation cannot be done for the SDGs as currently constituted.

There is not enough information on quantitative targets and there is not enough data collected on the costs of meeting the targets for a rapid assessment such as this to be carried out. For this reason the paper proceeds to look in detail at the Aichi targets and to estimate the net benefits of those that are able to be evaluated in monetary terms[1].

The paper is structured as follows. Section B discusses the different Aichi targets in some detail and makes a qualitative evaluation of the net benefits. In doing this it draws on the cost estimates of meeting the targets that were put together by UNEP. Section C lays out the basis for the benefit and cost assessments. Sections D-G make a quantitative assessment of the benefits and costs of four targets: Section D looks at target 5 (reducing the rate of loss of natural habitats in forests and wetlands); Section E does the same for Target 10 (coral reefs); Section F for target 11 (Conservation land); and Section G for target 15 (conserving carbon stocks). Section H brings together the results of the analysis and provides some comments on them, in relation to how reliable they are and what further work is needed to get better figures.

[1] Looking at individual targets in terms of their costs and benefits has been criticised as having the shortcoming of not picking up on the synergies and inter-linkages between the goals. There is merit in this criticism and indeed the CBD report notes that "Some of the Targets are inter-related and will benefit from joint programmes of activity that contribute to more than one Target. Thus delivering some Targets will influence the resources required to deliver others and (though delivering Targets by 2020 requires simultaneous action across the Targets) sequencing delivery can be expected to enhance cost effectiveness." (CBD, 2012). The problem is to convert this general statement into something more specific. If it can be shown that significant spillover benefits are being ignored by looking at the targets individually then the analysis should attempt to take account of those. In what follows we would argue that this is not generally the case, or at least no one has demonstrated that important benefits have been ignored. In future work looking at sets of targets as a group may be possible but it will require a higher level of modelling and quantification and the allocation of more resources than has been possible in this exercise.

Table 1: Aichi Targets: Qualitative Assessment of Benefits and Costs
(targets with a thick border are subject to quantitative cost-benefit analysis in this paper)

Target	Possibility of Estimating Net Benefits
1. By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	This is an important objective but it is not amenable to a benefit cost assessment. A measure of degree of awareness and cost effectiveness indicators may be constructed.
2. By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	Also a worthwhile objective. Estimating biodiversity values is a key part of it and can provide the data which will allow future benefit –cost assessments for different interventions to be made. The target itself, however, cannot be credibly evaluated in benefit cost terms.
3. By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.	In principle this is an area where benefit cost methods can be used. Data on the subsidies and their negative effects need to be collected and estimates made of the benefits of removing them. The High Level Panel looking into the targets has, rightly, allowed a budget of between $7.5 and $15 million for these and a similar amount for studies on positive schemes. It will take 2-3 years to do these. The result will not be a single benefit cost figure but different numbers for different schemes.
4. By 2020, at the latest, governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	The target is multi-dimensional. The only component that I think can be evaluated in terms of monetary benefits and costs is the public procurement changes which would alter the use of natural resources. Even for these it would be a major task to get a benefit cost evaluation at the national let alone the global level.
5. By 2020, the rate of loss of all natural habitats, including forests and wetlands, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	We have some estimates of rates of loss of several habitats and we have some estimates of the value of services they provide. Hence we should be able to value a reduction in these rates of loss and compare it to the estimated costs. Separate estimates for wetlands and forests can be made.
6. By 2020, all fish and invertebrate stocks are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe limits.	The benefits of the program can be measured against the costs of inaction where total losses of some species are possible. Such losses can be valued but it is a major task to do so as the background research on the subject is still relatively weak.
7. By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	Degradation of agriculture (at the national level) and forestry (national and global levels) under business as usual have been estimated in some studies. Less is known globally about aquaculture. The problem is to know what share of degradation would be stopped by the program. There is also overlap and conflict with target 5.
8. By 2020, pollution, including from excess	Estimates of damages done by pollutants and

nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	nutrients are available as are some figures for the benefits of marine debris clean –up. But they are not available globally and to make global estimates would be a major task.
9. By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	Invasive species cause a lot of damages, which have been estimated for some regions. Problem is similar to above of not having figures for all regions. In addition it is not clear whether the program would eradicate key species. It is unlikely that it will.
10. By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	We have estimates of rates of loss of coral and we have estimates of the value of coral in different locations. We have to put an interpretation on what they mean by minimized (reduced to zero?). Based on that we could make some estimates of benefit cost ratios.

Target	**Possibility of Estimating Net Benefits**
11. By 2020, at least 17 per cent of terrestrial and inland water areas 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 lands	Some estimates have been made of the benefits of an increase in terrestrial areas of importance for biodiversity. These can be used to make a preliminary cost benefit assessment of the target. Coverage of conservation of coastal and marine areas is more problematic as estimates of benefits of increasing coverage of conservation have not been made and would require considerable work. It can be done, however, given time.
12. By 2020 the extinction of known threatened species has been presented and their conservation status, particularly of those most in decline has been improved and sustained.	While prevention of extinction has been valued for selected species the data do not cover all such species. There is, however, no value for the reduced risk of extinction and no estimates of the amount by which risk is reduced, so benefit cost estimation is not possible.
13. By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio–economically as well as culturally valuable species is maintained and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	This is an important target and, while there are some estimates of the loss of ecosystems across all biomes, the figures are particularly weak on the costs of loss of genetic diversity. It has also been noted that the target should include genetic diversity of trees and wild animals. Undertaking a benefit cost assessment would need considerable further work.
14. By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well–being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	If the program can stop all these losses, we can make a benefit cost estimation but coverage of the loss of biodiversity studies does not pick up all genetic losses.
15. By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	This is mainly referring to forests although other ecosystems also contribute to carbon stocks. We could estimate the extent to which degradation reduces carbon sequestration capacity and then value the increase in carbon sequestration achieved.

16. By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national level legislation	Access to benefit sharing is first and foremost an issue of equity and not one of generating benefits. That said, more equitable systems are more likely to work in preserving genetic resources but information on the size of that effect is not available.
17. By 2015, each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	It is a desirable objective but not one that can be evaluated using benefit cost methods.
18. By 2020, traditional knowledge, innovations and practices of indigenous & local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.	The actions proposed to implement this target are largely to share knowledge and build capacity. Links to increased conservation are extremely difficult to estimate from the program and a benefit cost assessment is impossible.
19. By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	Such knowledge is very useful and will help both evaluate future programs as well as making better use of existing biodiversity. It is not possible to estimate these gains in monetary terms.
20. By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011–2020 from all sources and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization should increase substantially from the current levels.	This target is important but is not amenable to a benefit cost analysis.

The Aichi Targets

In this section the full set of 20 targets is discussed and a qualitative assessment made about the net benefits they provide. Table 1 lists the targets, summarises the methods by which one can evaluate them and provides an assessment on this basis. As noted above, the 20 targets cover: reductions in the loss of natural habitats, reduced pressures on ecosystems and increased conservation of those that are of particular importance, minimizing loss of genetic diversity, reduction in pollution and control of invasive alien species, increased awareness of biodiversity issues and implementation of policies for integrating biodiversity in national and local development strategies, including those relating to sustainable production and consumption. Finally they include a target for mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020.

The CBD and UNEP have grouped the targets into five strategic goals:

A. Address the underlying causes of biodiversity loss be mainstreaming it across government and society (targets 1-4);

B. Reduce the pressures on biodiversity and promote sustainable use (Targets 5-10)
C. Improve status of biodiversity by safeguarding ecosystems, species and genetic diversity (Targets 11-13)
D. Enhance benefits to all from biodiversity and ecosystem services (Targets 11-16)
E. Enhance implementation through participatory planning, knowledge management and capacity building (Targets 17-20).

As far as benefit cost analysis is concerned these targets can also be divided into three other groups: those where the benefit cost method is not possible or appropriate, those where it could be applied if data were available but such data are not, and those where the method can be applied now, with some qualifications.

The first group where we cannot apply benefit cost methods includes seven targets: 1, 2, 12, 16, 17, 18, 19 and 20. These are mostly the targets relating to enhancing implementation through participatory planning, knowledge management and capacity building. In these cases the benefits are impossible to quantify in money terms, or so uncertain as to make the exercise non-credible.

The second group consists of nine targets: 3, 4, 6, 7, 8, 9, 11, 12 and13. For these work has to be carried out from the bottom up at the regional level and then aggregated to arrive at regional and global estimates[2]. It is not clear whether one should do the exercise regionally or globally – it is almost certain that the benefits to cost ratios will vary across regions. The amount of work involved in collecting the data is considerable; for example for target 3 on the benefits of eliminating subsidies the Secretariat has allocated some $15-30 million for the underlying studies. We also note that for some of these targets only partial assessment will be feasible; for example target 4 on sustainable production and consumption only some actions specified under the target (such as public procurement) can be evaluated using benefit-cost methods.

The third group consists of targets where an attempt can be made now to estimate the benefits relative to the costs. This consists of the following four targets: 5, 10, 11, and 15. These have been highlighted with a thicker border in Table 1. The exercise of evaluating these is necessarily approximate and only a first attempt has been made with very limited resources. In some cases only a part of the target has been valued (e.g. for target 11 we can only make a stab at terrestrial areas; for target 12 we cover only some of the species under threat of extinction and for target 15 we have to make many simplifying assumptions about the rate of sequestration.

Cost and Benefit Assessment

In the rest of the paper the present value of the costs and benefits of four targets are presented. Present values are a standard method of representing in a single number the value of a stream of costs or benefits over a period of time. To do so it is also customary to apply a discount rate, so costs or benefits closer to the present have a higher value than

[2] Indeed this is exactly what the CBD is undertaking under its current work program. It recognizes the importance of estimating such benefits but has no figures at the present time (see Section 5.4, CBD, 2012).

those that come later. The rate of discount used here is 5%, to be consistent with the other studies in this series. To place it in context it is relatively low compared to rates applied for investment projects in developing countries. In more developed countries rates are in this range. The US for example has a suggested base case discount rate for cost-benefit analyses of 7%. A 3% discount rate is also suggested for sensitivity analysis (EPA, 2010). The European Commission recommends the use of a discount rate of 4% for environmental cost benefit analyses and a lower discount rate of 2% for sensitivity analyses (EC, 2001). For the purposes of this exercise the 5% can be taken as benchmark and while a sensitivity analysis for different rates can be applied in further work we do not consider that the benefit to cost ratios obtained here will be changed by such an analysis.

The analysis reports the following summary measures of benefits relative to costs: the Benefit Cost Ratio (BCR) and the Internal Rate of Return (IRR). The BCR simply reports the ratio of present value of benefits relative to that of costs. A ratio of more than one is generally a necessary (but not sufficient) condition for a project or policy to be implemented. The IRR gives the rate of discount at which the present value of costs is equal to that of the benefits. An IRR greater than a "test" rate (e.g. 7% in the US) would indicate a project or policy is acceptable on this criterion.

As far as the costs are concerned the assessment has used data collected by UNEP and summarized in Table 2. It is taken from CBD, 2012. The costs are given separately for each of the 20 targets and are stated to cover the period 2013-2020[3]. They are further separated into investment costs and annual recurrent costs, all in 2012 prices. The cost data is supplemented by considerable information on the elements of cost included and the reasons for the range of figures reported. In the analysis carried out we have used as much of this information as possible[4].

In summary we note, as do the authors of the data compiled, that these cost estimates have gaps and inconsistencies and the range of estimates is wide. Nevertheless they do provide a more or less coherent set of figures calculated on a common basis.

[3] There is some uncertainty, however, about the exact period covered, as one source states 2013-2020 (8 years) but the main CBD document which it purports to summarise states different periods for some targets.

[4] A comment on the paper has noted that some of the targets are very broad and the corresponding costs not always credible. We note the problem of uncertainty about the costs and accept that the targets could be improved but that is beyond the scope of this paper: it is work for the community of biodiversity researchers as a whole.

Table 2: Aichi Strategic Goals and Targets and Associated Investment Costs

Strategic Goal	Target	Investment Needs ($Mn.)	Annual Recurrent Exp. ($Mn.)
A: Address underlying causes of biodiversity loss by mainstreaming it across government and society	1. Awareness Raising	54	440-1,400
	2. Biodiversity Values	450-610	70-130
	3. Incentives	1,300-2,000	8-15
	4. Sustainable Consumption & Production	55-107	8-15
B: Reduce the pressures on biodiversity and promote sustainable use	5. Reducing habitat loss	252,300-288,800	13,300-13,700
	6. Fisheries	129,900-292,200	800-3,200
	7. Sustainable Agriculture	20,800-21,700	10,700-11,000
	8. Pollution	77,600-772,700	24,400-42,700
	9. Invasive Alien Species	34,100-43,900	21,005-50,100
	10. Coral Reefs	600-960	6-10
C: Improve status of biodiversity by safeguarding ecosystems, species and genetic diversity	11. Protected Areas (terrestrial and marine)	66,100-626,400	970-6,700
	12. Species Conservation	-	3,400-4,800
	13. Genetic Diversity	55-,1400	15-17
D: Enhance benefits to all from biodiversity and ecosystem services	14. Ecosystem Restoration	30,000-299,900	-
	15. Forest Restoration	100	6,400
	16. Nagoya Protocol	55-313	-
E. Enhance implementation through participatory planning, knowledge management and capacity building	17. National Biodiversity Strategy and Action Plan	114-1,100	110-560
	18. Traditional Knowledge	210-340	180-297
	19. Science Base	1,800-4,200	1,400-1,600
	20. Mobilise financial resources	10-79	3-20

http://www.cbd.int/financial/hlp/doc/communications/HLP%20on%20Resourcing%20the%20CBD%20Strategic%20Plan%202011-2020%20(summary).pdf. Accessed June 11, 2014

Costs and Benefits of Reducing the Rate of Loss of Forests and Wetlands (Aichi Target 5)

Target 5 states that "By 2020, the rate of loss of all natural habitats, including forests and wetlands, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced."

The rationale for this target is that habitat loss, including degradation and fragmentation, is the most important factor driving biodiversity loss and while economic, demographic and social pressures are likely to mean continued habitat loss, particularly due to land-use change beyond 2020, the rate of change needs to be substantially reduced. While for some ecosystems it may be possible to bring the rate of habitat loss close to zero by 2020, for

others a more realistic goal is to halve the rate of loss. Significantly reducing habitat degradation and fragmentation will also be required in order to ensure that those habitats which remain are capable of supporting biodiversity.

The emphasis of this target should be on preventing the loss of high-biodiversity value habitats, such as primary forests and many wetlands, and of ecosystems where continued loss risks passing "tipping points" that could lead to large scale negative effects on human well-being. Reduction in the loss of natural habitats could be achieved through improvements in production efficiency and land-use planning, the use of degraded land for agricultural production, improved ecosystem connectivity and enhanced mechanisms for natural resource governance combined with recognition of the economic and social value of ecosystem services provided by natural habitats. In order to determine if the rate of habitat loss has been reduced there will be a need to establish a baseline against which to gauge progress towards this goal (CBD, 2012a).

The estimation of the loss of habitats is divided into two parts: one for forests and the other for wetlands.

Forests

Some analysis has already been conducted on the damages caused by forest losses, which are of course the mirror image of the benefits to be gained by preventing that loss. Markandya and Chiabai (2013) estimated the value of the physical losses of boreal, temperate and tropical forests under a business as usual scenario. The physical data were taken from the extensive work of Aklemade et al., 2006, who calculated losses if no further actions were taken for the period 2000-2050. These physical losses are estimated at 9% of 2000 boreal forest stocks, 19% of temperate forest stocks and 12% of tropical forest stocks. The losses were then valued using studies of the commercial and fuel wood values of timber, recreational values for forests, passive values (i.e. the values of those who are willing to pay for forest to be conserved in addition to paying for those services they do use), and carbon storage values of forests. Taken together these give the total value for the whole period. As expected the study comes up with a range: the lower bound is US$334 billion per year while the upper bound is US$1,118 billion or over 3 times as much. In this study we have taken these estimates, assumed the losses are uniform over the time period 2000 to 2050 and then updated the figures to US2012 dollars. The corresponding costs are taken from the CBD (2013) study, which cover the period 2013-2020[5].

It is further assumed that: (a) as per the target, 50% of the losses will be arrested as a result of the program, (b) the benefits in terms of reduced losses will only start appearing in 2021 when the program is complete and (c) the benefits will continue to 2050.

The Benefit to Cost Ratio at a 5% discount rate and the internal rate of return (IRR) for forest protection are shown in Table 3[6].

[5] For this component of the target only a single set of figures is given and there is no range of costs.
[6] Calculations can be obtained from the author. A 10% discount rate is only used as benchmark.

Table 3: Net Benefits from target 5: 50% Reduction in Global Forest Loss

	Benefit-Cost Ratio	IRR%
Lower Bound Benefits	29.7	44%
Upper Bound Benefits	99.4	66%

The Table shows very high benefit to cost ratios and IRRs well in excess of any possible test rates. This suggests, therefore, that if the program of forest protection described in the High Level CBD report can deliver the 50% reduction in forest loss it would be highly justified. Annualised benefits in terms of reduced forest loss amount to around $219 billion from 2021 onwards, while costs in the period 2013-2020 run at only $10-14 billion. The issue of implementation, however, is a major factor here. The main funding requirement for the program is derived from WB estimates of lost revenue from uncollected forest fees and taxes. Problems of encroachment are difficult to address and it is possible that the costs of attaining the targets is underestimated. Indeed it may be impossible to prevent losses in some places for this reason. There are also difficulties relating to data on forest stocks that the CBD notes and that make the figures uncertain. Nevertheless the ratios are so high that even a partial success would make a program such as this justified on cost benefit grounds.

Wetlands

In the case of wetlands the calculation is more difficult. Current areas are even more uncertain than they are for forests and services provided vary significantly by location. The present estimates are based on the following assumptions:

a. The current stock of wetlands is divided into inland and coastal with the latter including mangroves. Areas were taken from the wetland database World Wild Life – WWF and Center for Environmental Systems Research, University of Kassel, Germany. From their figures, which are global, we took lakes, rivers, freshwater marshes/flood plains and swamp forests as inland wetlands; and those defined as coastal and saline wetlands (including mangroves) as coastal[7]. The respective areas in 2010 were 1,061 million ha. for the former and 152 million ha. for the latter[8].

b. Estimates of rate of loss from a number of sources, is put at around 0.7% per annum for both types of wetlands (Finlay and Spiers, 1999).

c. The services provided by different wetlands have been synthesised in a number of studies, of which perhaps De Groot et al. (2012) is the most recent. Those included in the studies reviewed cover: Provisioning (food, water, raw materials etc.), Regulating (climate regulation, water flow, erosion prevention etc.), Habitat (nursery and genetic diversity), and Cultural (recreational use, spiritual experience etc.). In total 139 studies of coastal wetlands and 168 studies of inland wetlands studies were carefully analysed to provide a range of benefits in US$/Ha/yr. The ranges are indeed wide: for

[7] http://www.worldwildlife.org/science/data/item1877.html. Aaccessed June 12th 2014.
[8] This still leaves a number of areas that are ambiguous but that would have some wetland function. Excluding them could underestimate the area of wetland by as much as 30%.

freshwater wetlands the lower bound (in 2007 international dollars) is around $3,000/ha./yr. and the upper bound is $105,000/ha./yr.. Likewise the ranges for coastal wetlands range from $37,000/ha./yr. to $888,000/ha./yr.

d. The benefit figures were updates to 2012 prices so the cost and benefits could be compared. The target program that is valued is expected to reduce loss rates by 50%, starting from 2021.

The resulting net benefits are shown in Table 4. Four cases are considered: combining the lower bound of the cost figures and the lower bound of the benefit figures; the upper bound of the benefit figures with the lower bound of the costs; the lower bound of the benefits with the upper bound of the costs; and finally the upper bound of the benefits with the upper bound of the costs.

The results are clearly more sensitive to the benefits than to the costs. If the lower bound of the benefits is right the target is hard to justify on benefit-cost grounds. If, however, the upper bound is correct the target is amply justified. In practice the true values are probably somewhere between the two and will depend on where the programmes are implemented. Further work is required to elaborate the planned actions before the target can be agreed on.

Table 4: Net Benefits from target 5: 50% Reduction in Global Wetland Loss

Case	Benefit to Cost Ratio	IRR%
Lower Bound of Benefits/ Lower Bound of Costs	0.9	5
Upper Bound of Benefits/ Lower Bound of Costs	72.7	63
Lower Bound of Benefits/ Upper Bound of Costs	0.5	1
Upper Bound of Benefits/ Upper Bound of Costs	37.4	50

Note: LB: Lower bound of benefits. LC: Lower bound of costs
UB: Upper bound of benefits. UC: Upper bound of costs

Costs and Benefits of Reducing Loss of Coral Reefs

The Strategic Plan for Biodiversity notes that, given the ecological inertias related to climate change and ocean acidification, it is important to urgently reduce other anthropogenic pressures on vulnerable ecosystems such as coral reefs so as to give them time to cope with the pressures caused by climate change. This can be accomplished by addressing those pressures which are most amenable to rapid positive changes and would include activities such as reducing pollution and overexploitation and harvesting practices which have negative consequences on ecosystems. Indicators for this target include the extent of biomes ecosystems and habitats (% live coral, and coral bleaching), Marine Trophic Index, the incidence of human-induced ecosystem failure, the health and well-

being of communities who depend directly on local ecosystem goods and services, and the proportion of products derived from sustainable sources (CBD, 2012a).

Areas of coral were estimated to be around 25.5 million hectares (Spalding and Grenfell, 1997), and rates of loss are put at around 1-2 percent a year, depending on which region is considered[9]. A NOAA study estimates that loss rates are such that by 2050 60 percent of the world's coral will be dead[10], implying a loss rate of 2.2%. We take this rate and apply it to the estimated stock as of 2010, estimated to be around 19 million hectares (applying the loss rate of 2.2% from 1997 to 2010).

According to the De Groot et al, 2012 coral reefs provide very significant ecosystem services, in the forms of raw materials and genetic resources (habitats for fish), erosion prevention and disturbance moderation, and recreation. The 94 studies reviewed by the authors have a lower bound of benefits of $36,800/ha./yr while the upper bound is $2.129 million/ha.yr[11].

In making the cost benefit estimate we use the lower bound of the benefits and apply it to a program that starts in 2013, and provides benefits starting in 2021. Two programmes are envisaged: one that reduces losses by 50% and the other by 80%. The former has a capital cost of $684 million and a recurrent cost of $81 million, while the latter has a capital cost of $1,036 million and a recurrent cost of $130 million. Table 5 summarises the results.

Table 5: Net Benefits from Target 10: 50% Reduction in Global Coral Loss

	Benefit to Cost Ratio	IRR%
Net Benefits with Losses reduced by 50%	95.3	52%
Net Benefits with Losses reduced by 80%	98.5	53%

Instead of analysing different ranges of costs and benefits we consider here the two programs with a lower bound of the benefits. Even with this lower bound the benefit to cost ratio is well above one for both programs and the IRR is well in excess of the required rate. Hence in this case the target and associated program are well justified. Indeed it would make sense to go for the more ambitious target of reducing losses by 80%. There is some concern, however, that the outlays of around $80 million a year are not enough to achieve the goal of a 50% reduction in loss rates. The CBD study that made the estimates acknowledges the difficulties. It states:

[9] http://news.nationalgeographic.com/news/2007/08/070807-coral-loss.html. Accessed June 13th 2014.
[10] http://www.coris.noaa.gov/about/hazards/. Accessed June 13th 2014.
[11] It has been suggested that a benefit of ecosystem services from coral of $37,000/ha/yr is too high. If applied to the stock of coral for example, it would imply an annual value of $703 billion, which is much greater for example, than the estimated total annual value of fisheries of about $80 billion (http://edition.cnn.com/2008/WORLD/asiapcf/03/24/eco.aboutfishing/). Such a valuation of total stocks of coral, however, is not valid. The studies conducted have valued small changes and cannot be applied to the total stock. It is important to recall that coral ecosystems derive value from many services, especially erosion prevention and recreation, which are highly site dependent. Moreover losses tend to be concentrated in locations where such values are high. Hence the programs to prevent loss need to focus on such locations.

"No complete estimate of the financial resources required to meet Target 10 for tropical coral reef ecosystems was produced in this study, however what is provided is a global estimate of resource needs for coral reef management as part of ICM [Integrated Coastal Management] or CBRM frameworks and networks. The various project examples provided also give an indication of the costs to establish and support some of the actions required to meet the target. The report examines the costs of ICZM [Integrated Coastal Zone Management] and IWRM [Integrated Water Resource Management] with particular attention paid to wastewater and watershed/catchment management and CBRM mainly through the LMMA approach. On the whole it is believed that the unit cost estimates produced are accurate but may be underestimated in some cases where relevant data was lacking and available data was used instead. The main reason for not attempting to make a total estimate of resource needs was the large number of data gaps and future research needs for this topic." CBD (2012), Page 65.

Thus one may conclude that the cost estimates may be on the low side and more resources may be needed to achieve the goals. The big difference between the benefits and costs, however, indicates that there is ample scope to increase outlays on coral protection and still achieve a benefit to cost ratio that is well over one[12].

Costs and Benefits of Increasing Protected Area Coverage (Aichi Target 11)

Target 11 aims to increase protected areas to 17% of terrestrial land area and 10% of coastal and marine areas by 2020. According to the Strategic Plan for Biodiversity (CBD, 2012a) there are currently some 13% of terrestrial areas, 5% of coastal areas and very little the open oceans under protection. Therefore reaching the proposed target implies a modest increase in terrestrial protected areas globally, but, most importantly, with an increased focus on representativeness and management effectiveness, and with major efforts to expand marine protected areas. Protected areas should also be established and managed in close collaboration with, and through participatory and equitable processes that recognize and respect the rights of indigenous and local communities, and vulnerable populations. Other effective area-based conservation measures may also include restrictions on activities that impact on biodiversity, which would allow for the safeguarding of sites in areas beyond national jurisdiction in a manner consistent with the jurisdictional scope of the Convention as contained in Article 4. Relevant indicators to measure progress towards this target are sites of biodiversity significance covered by protected areas and the connectivity/ fragmentation of ecosystems. Other possible indicators include the overlay of protected areas with ecoregions, and the governance and management effectiveness of protected areas.

The closest estimate of the benefits of the increase in terrestrial area is in the TEEB-related study of Hussain et al. (2011). They analyse a slightly different expansion: of 20% by 2030 but from their annual benefits and costs of the programme we can make an estimate of the corresponding costs and benefits for the target program. We assume, as they do, that currently 10% of all eco-regions of the world are protected, giving a total protected area of 13.2 million Km^2 in 2000 (i.e. the same as the CBD estimate).

[12] One reviewer asked what would happen if the program only reduced 25% of all coral losses. The calculations show that even with this halved rate of success the benefit to cost ratio is 47 (instead of 95), indicating that the result is robust to major reductions in achievement of the target.

The cost of converting land to protected areas is considerable. Hussain et al. carried out a detailed survey of the different components of the cost, which include transfer of property rights in some cases, establishing and maintaining networks of areas, transactions costs and, most importantly, opportunity costs of the alternative use of the land. Cost per hectare turn out to be in the range of $2,473/Ha. to $10,513/Ha.[13] On the other hand the costs in the CBD (2013) study are even higher: in total they estimate costs of around $761 billion over the period 2011-2020 to attain the target increase (compared to a range of $46-196 billion by Hussain et al.). The CBD figure includes, however not only the terrestrial increase of 17% in protected areas but also a target of 10% of all marine areas. Since it has not been possible to get the breakdown between the two it has been necessary to only use the cost data from Hussain et al.

In terms of benefits Hussain et al. estimate the biophysical changes resulting from the protection and value the ecosystem services that such a change provides. The areas that increase in most parts of world include grassland and forest, but in some cases protected areas are created by reducing land from these biomes as well. They provide estimates of the services gained into two groups: those related to the capture of carbon and the rest. The reason is that the former has, in their view, much greater uncertainties and are global benefits, while the rest are, in large part, local benefits. The benefits are then reported as a lower bound (without carbon storage benefits) and an upper bound (with carbon storage benefits)[14].

The results are summarised in Table 6, in which we have taken per hectare benefits and costs from Hussain et al. and applied it to the increases in protected areas proposed by the Target, to be achieved over the period 2011-2020.

Table 6: Net Benefits from Target 10: Increase in Protected Areas

	NPV and Benefit Cost Ratios			
	Costs from Hussain et al			
Benefit-Cost Ratio	LB LC	LB HC	HB LC	HB HC
	1.15	0.27	1.97	0.46

Note: LB: Lower bound of benefits. LC: Lower bound of costs
UB: Upper bound of benefits. UC: Upper bound of costs

The target only comes up with a Benefit Cost Ratio of more than unity when we take the lower bound of the costs. With the upper bound of costs it is below one irrespective of the benefits. It is not possible to calculate the IRR because the stream of net benefits does not have a turning point.

[13] Hussain et al, 2011 figures updated to 2012 prices.
[14] The carbon benefits are estimated on two basis: first from models in which a carbon target has been set and in which one can calculate the cost per ton reduced; and second from models that estimate the damages done per ton emitted via climate change. See Hussain et al, 2011 for details.

Some important qualifications apply here. First the method of estimating benefits does not account for some of the possible gains from protection, in the form of species protection and increase in biodiversity. Second it is doubtful that such an increase in area can be achieved in a period as short as 2011 to 2020, at least without a substantial increase in transactions costs. Third the distribution of the costs of protection is important. If an areas is heavily used by poor people then the costs to them of restricting access has be taken into account. This has not been done in the present analysis.

Costs and Benefit of Conserving Carbon Stocks (Aichi Target 15)

The program for forest restoration assumes that 150 million hectares will be planted over the period 2013 to 2020. The carbon value depends critically on where these plantations will take place and what species will be planted. In the calculations made here we assume that the carbon sequestered is between 2.4 and 16.9 metric tons of CO_2 per hectare per year (Gorte, 2009). The sequestration starts after year 1, reaches a maximum at year 10 and continues for another 30 or more years (Johnson and Coburn, 2010)[15]. Again these are indicative figures and others may apply. The value of carbon sequestered is valued using two methods. First a global model economic (POLES) was used to estimate the marginal cost of reducing carbon emissions so as to achieve a given target reduction. Second, Integrated Assessment Models were used to estimate the damages done per ton of CO2 equivalent emitted. Details of the estimates, which go up over time and are referred to as the Social Costs of carbon (SCC), can be found in Hussain et al. (2011).

The costs of the program are taken from the CBD (2013) report, which estimates a one-off investment cost of $100 million and a recurrent cost of $6.4 billion per year for the years 2013 to 2020. It is assumed that the reforestation of the 150 million hectares takes place evenly over that period.

The net benefits of the program are positive with both sets of carbon values and the whole range of sequestration referred to above. With the lower end of the sequestration range (2.4 tonnes/CO_2/ha./yr) the net benefits (NPV) are $2 billion using the SCC estimate and $119 billion using the Marginal Cost of Abatement Method. The IRR is 11% in the first case and 25% in the second case and the Benefit to Cost Ratios are 2.1 in the first case and 10.5 in the second. With higher rates of sequestration the IRRs and the Benefit to Cost Ratios rise correspondingly, indicating that the program is well justified[16][17].

Conclusions

This paper has made an initial attempt to estimate the benefits and costs of the different Aichi biodiversity targets. A summary of these is provided in Table 7. These are a guide to

[15] Estimates of the rates of sequestration are different in this report from those in Gorte (2009) but it provides some guide to the rate at which sequestration takes place. It also states that sequestration can go on for up to 100 years. I have stopped the calculations in 2050 (about 40 years at a maximum) partly because the very long periods are more speculative and partly because it makes little difference to extend the benefits after about 40 years.

[16] Calculations are available from the author.

[17] It has been pointed out that the reforestation program may be in conflict with the target of maintaining biodiversity. If fast growing exotic trees are planted where formerly slower growing trees that provided habitat were present there will be a cost in this respect. This has not been accounted for.

what may be gained from the SDG targets when the latter are finally confirmed and quantified. We note that so far no such exercise has been carried out, although some are being undertaken currently at the regional level, which is the right way to go, given the huge variations in potential benefits. Nevertheless some overall assessment is also worthwhile given that the targets are at the global level.

A qualitative review of the Aichi targets reveals three groups. The first consists of seven targets those where benefit cost methods cannot be applied (1, 2, 16, 17, 18, 19 and 20). The second group consists of nine targets (3, 4, 6, 7, 8, 9, 11, 12, and13) where such methods could be applied but it needs considerable work to do so and the data for making the estimate is not available at present. The third group of four targets (5, 10, 11, 15) has been evaluated here. It has to be noted that this is only a first cut and more work is needed to confirm the results.

This review of the targets draws attention to the fact that many of them are really difficult to evaluate on cost benefit grounds. This is not a reason to reject them outright (not everything that is important can be so quantified), but it does suggest that we will need other indicators of cost effectiveness to be sure we get good value for money. We do not discuss such indicators here but it is clearly an important area for further work.

Where benefit cost methods could be applied with existing information we have some interesting results. For Target 5 (to halve the rate of loss of forests and wetlands) it is necessary to divide it into the forests and wetlands components. The figures indicate that the forest component is justified at the global level but the wetlands component depends on which of the wide range of possible benefits we take. The findings point to the need to focus efforts on the areas where the benefits are greatest, possibly using some screening rules to select the sites.

Target 10 relates to coral reefs and the figures indicate that the benefits are well in excess of the costs even with the lower bound of estimates being taken for the former. The costs, however, may be underestimated and more work is needed to fully determine these.

Target 11 is analysed only with respect to the terrestrial protected areas as data were not available for the marine areas. The figures here are more problematic as the range of costs is very wide and the benefits that can be quantified are limited. The analysis shows that if we include carbon benefits and take the lower end of the range of costs the target is justified but it is not justified if the costs are at the upper end. Further work is needed to make the costs more precise and to estimate more of the benefits of creating protected area.

Finally for Target 15 (forest restoration) the benefits are in excess of the costs based on current estimates of carbon values.

One important caveat is the need to look at who pays the costs and who benefits from these investments. We have hinted at some cases where such issues are likely to arise but a comprehensive coverage of the distributional issues is warranted.

A second caveat is the need to account for effects of one target on other targets through an integrated assessment. In one of the comments received it was noted that IIED is proposing a "modular" approach in which targets are evaluated as a group. This may represent a way forward but if it is to generate measures of performance that are comparable to those used for other investments considerable work will be needed to develop summary indicators of overall outcomes, and to show how these outcomes change if one target is modified.

A key message therefore, further work should be undertaken to confirm these results.

Table 7 – Costs and Benefits of Biodiversity Goals ($Bn. 2012 Prices)

Target	3% Discount			5% Discount		
	Benefit	Cost	B:C Ratio	Benefit	Cost	B:C Ratio
Reduce global coral loss by 50%	130	1.2	112	105	1.1	95
Reduce global coral loss by 80%	207	1.8	115	167	1.7	98
Reduce global wetland loss by 50% Lower Benefit Estimate	164	127	1.3	111	227	0.5
Reduce global wetland loss by 50% Higher Benefit Estimate	12,527	247	51	8,502	227	37
Reduce global forest loss by 50% Lower Benefit Estimate	3,388	82	41	2,278	77	30
Reduce global forest loss by 50% Higher Benefit Estimate	11,,339	82	137	7,625	77	99
Increase PAs to 17% of land area Low Cost/Low Benefit	69	60	1,2	64	56	1.2
Increase PAs to 17% of land area High Cost/Low Benefit	69	259	0.3	64	239	0.3
Increase PAs to 17% of land area Low Cost/High Benefit	119	60	2	109	56	2
Increase PAs to 17% of land area High Cost/High Benefit	119	259	0.5	109	239	0.5
Forest Restoration Low Carbon Benefit	114	39	3	76	36	2
Forest Restoration High Carbon Benefit	570	39	14	378	36	11

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Annex A: Biodiversity and Deforestation as Covered in the Proposed SDGs

Goal 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development

14.1 by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution

14.2 by 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration, to achieve healthy and productive oceans

14.3 minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

14.4 by 2020, effectively regulate harvesting, and end overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices and implement science-based management plans, to restore fish stocks in the shortest time feasible at least to levels that can produce maximum sustainable yield as determined by their biological characteristics

14.5 by 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on best available scientific information

14.6 by 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, and eliminate subsidies that contribute to IUU fishing, and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the WTO fisheries subsidies negotiation*

14.7 by 2030 increase the economic benefits to SIDS and LDCs from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

14.a increase scientific knowledge, develop research capacities and transfer marine technology taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular SIDS and LDCs

14.b provide access of small-scale artisanal fishers to marine resources and markets

14.c ensure the full implementation of international law, as reflected in UNCLOS for states parties to it, including, where applicable, existing regional and international regimes for the conservation and sustainable use of oceans and their resources by their parties

Goal 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

15.1 by 2020 ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

15.2 by 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and increase afforestation and reforestation by x% globally

15.3 by 2020, combat desertification, and restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land-degradation neutral world

15.4 by 2030 ensure the conservation of mountain ecosystems, including their biodiversity, to enhance their capacity to provide benefits which are essential for sustainable development

15.5 take urgent and significant action to reduce degradation of natural habitat, halt the loss of biodiversity, and by 2020 protect and prevent the extinction of threatened species

15.6 ensure fair and equitable sharing of the benefits arising from the utilization of genetic resources, and promote appropriate access to genetic resources

15.7 take urgent action to end poaching and trafficking of protected species of flora and fauna, and address both demand and supply of illegal wildlife products

15.8 by 2020 introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems, and control or eradicate the priority species

15.9 by 2020, integrate ecosystems and biodiversity values into national and local planning, development processes and poverty reduction strategies, and accounts

15.a mobilize and significantly increase from all sources financial resources to conserve and sustainably use biodiversity and ecosystems

15.b mobilize significantly resources from all sources and at all levels to finance sustainable forest management, and provide adequate incentives to developing countries to advance sustainable forest management, including for conservation and reforestation

15.c enhance global support to efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

This paper was written by Anil Markandya, Scientific Director at BC3 Basque Centre for Climate Change. The project brings together 62 teams of economists with NGOs, international agencies and businesses to identify the goals with the greatest benefit-to-cost ratio for the next set of UN development goals.

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