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An index for evaluating biodiversity protection parity

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Abstract: Since destruction of natural ecosystems can endanger many species simultaneously, the Strategic Plan for Biodiversity 2011- 2020 set a target for the share of protected areas. They should cover 17% of land area. There are, however, some concerns about the use of uniform regional targets as the basis for biodiversity protection strategies. This paper is to propose an index that could express socio-ecological disparities between regions and serve as a basis for setting up equitable differentiated regional targets.

***Keywords**:* biodiversity, biological conservation**,** sustainable development

1 INTRODUCTION

Protection of endangered species has been the major purpose of biological conservation. This task would become even more difficult in the future due to the growth of world population, agricultural expansion, urbanization and wood extraction. Since the massive destruction of natural ecosystems can endanger many species simultaneously, protection of natural ecosystems has received considerable attention in the Strategic Plan for Biodiversity 2011- 2020 and Aichi Biodiversity Targets [CBD, 2011].

The Aichi Biodiversity Targets suggest that the protected areas should form a well connected network representing most natural habitats and covering 17% of land area (including inland waters). In contrast to the 2010 Biodiversity Target [CBD, 2001], the Aichi Biodiversity Targets do not pursue the goal to conserve at least 10% of each of the world's ecological region. Protected areas covered about 10% of land area (including inland waters) and occupied from 5 to 25% of land in major ecological regions at the time when the 2010 Biodiversity Target was adopted [Chape et al. 2003]. One might expect then that it could be feasible to conserve at least 10% of each of the world's ecological region. However, this goal has not been achieved in the half of terrestrial ecological regions [WWF, 2010].

There are some concerns about the use of uniform targets as the basis for biodiversity protection strategies [Barr et al., 2011]. A target for the total share of protected areas can be achieved by conserving those habitats that are cheaper to protect. The habitats located in densely populated regions may thus receive less

protection than the habitats located in sparsely populated regions. This paper is to propose an index that could be used for setting up equitable differentiated regional targets.

2 METHODOLOGY

The proposed index is based on the assumption that human appropriation of the organic matter produced by terrestrial ecosystems would undermine natural food sources of wild species, if it will be growing at the same rate [Foley et al., 2007]. The total amount of organic matter annually produced by terrestrial ecosystems, so called net primary production or NPP, is estimated at 60 PgC/y. Humans appropriate about 20% of the total terrestrial NPP, or 1-2 tC/person/y [Imhoff et al., 2004]. Hence, wild species may face the growing scarcity of natural food sources in the regions where NPP per capita is less than 2.5 tC/person/y (Fig 1).

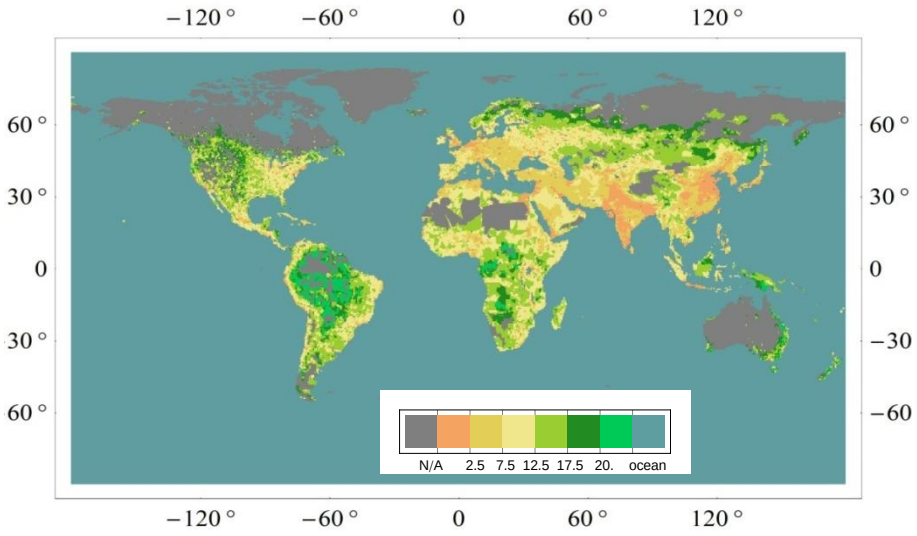

Figure 1. Net Primary Production per capita, tC/person/y, as calculated from the data provided by Alexandrov and Matsunaga [2008] and CIESIN [2010].

The maximal share of NPP that could be reserved for wild species ($WSNPP_{max}$) in a given region depends on the regional values of NPP per capita (NPPC) and human appropriation of NPP per capita (HANPPC):

$$\mathrm{WSNPP_{max}} = (\mathrm{NPPC} - \mathrm{HANPPC})/\mathrm{NPPC} \quad (1)$$

The Aichi Biodiversity Targets suggests in effect that 17% of total NPP produced by terrestrial ecosystems should be reserved for wild species. This goal could be achieved either by setting a uniform regional target for the reserved amount of NPP:

$$\mathrm{NPPR} = 0.17\ \mathrm{NPP} \quad (2)$$

or by setting differentiated regional targets:

$$\mathrm{NPPR} = 0.17\ \mathrm{NPP}\ \frac{\mathrm{WSNPP_{max}}}{1 - \mathrm{HSNPPW}} \quad (3)$$

where HSNPPW is the human share of NPP produced by terrestrial ecosystems (HSNPPW ≈ 0.2).

This statement can be proved as follows.

Let the total number of regions is equal to *n*. For the i-th region

$$WSNPP_{max\,,i} = \frac{(NPPC_i - HANPPC_i)}{NPPC_i} \tag{4}$$

hence

$$WSNPP_{max\,,i} NPPC_i = NPPC_i - HANPPC_i \tag{5}$$

or

$$WSNPP_{max\,,i} NPP_i = NPP_i - HANPP_i \tag{6}$$

where $HANPP_i$ is the human appropriation of NPP in the i-th region.

Then

$$\sum_{i=1}^{n} WSNPP_{max\,,i} NPP_i = \sum_{i=1}^{n} NPP_i - \sum_{i=1}^{n} HANPP_i = NPPW - HANPPW \tag{7}$$

where NPPW is the total NPP produced by terrestrial ecosystems, and HANPPW is the total human appropriation of NPP.

This implies

$$\frac{\sum_{i=1}^{n} WSNPP_{max\,,i} NPP_i}{NPPW} = 1 - \frac{HANPPW}{NPPW} = 1 - HSNPPW \tag{8}$$

and

$$\frac{\sum_{i=1}^{n} WSNPP_{max\,,i} NPP_i}{1 - HSNPPW} = NPPW \tag{9}$$

Thus,

$$\sum_{i=1}^{n} NPPR_i = \frac{0.17 \sum_{i=1}^{n} WSNPP_{max\,,i} NPP_i}{1 - HSNPPW} = 0.17\, NPPW \tag{10}$$

3 RESULTS AND DISCUSSION

The idea that protected areas located in densely populated regions are more valuable than those in sparsely populated regions can be expressed in the form of the biodiversity protection parity index (BPPI):

$$BPPI = \begin{cases} \dfrac{1}{1 - HANPPC/NPPC}, & \dfrac{HANPPC}{NPPC} < 1 - \dfrac{1}{BPPI_{max}} \\ BPPI_{max}, & \dfrac{HANPPC}{NPPC} \geq 1 - \dfrac{1}{BPPI_{max}} \end{cases} \tag{11}$$

where $BPPI_{max}$ is the relative value of the protected areas located in overpopulated region (e.g., where HANPPC>NPPC). BPPI ranges from 1, in the case of unpopulated regions, to $BPPI_{max}$, in the case of over-populated regions, and shows the relative value of protected areas in a given region as compared to those in unpopulated regions.

Since

$$\frac{1}{BPPI} \geq WSNPP_{max} \tag{12}$$

a differentiated regional target can be set using BPPI as

$$NPPR = \frac{0.17\ NPP}{1 - HSNPPW}\ \frac{1}{BPPI} \tag{13}$$

If the average NPP of protected areas is equal to the average NPP of the region, the differentiated regional target can be expressed in the units of area:

$$SR = \frac{0.17\ S}{1 - HSNPPW}\ \frac{1}{BPPI} \tag{14}$$

where SR is the area of protected areas, and S is the area of the region.

Since HSNPPW ≈ 0.2, the regional targets for the percentage of protected areas could be set at 20/BPPI %. This ensures that the protected areas will cover from 17 to 20% of the total land area.

The map of differentiated regional targets calculated for HANPPC = 2 tC/person/y and $BPPI_{max}$ = 20 is shown at the Figure 2. This map shows the regions where the differentiated targets could be reduced if the deficit of land suitable for conservation would be taken into account.

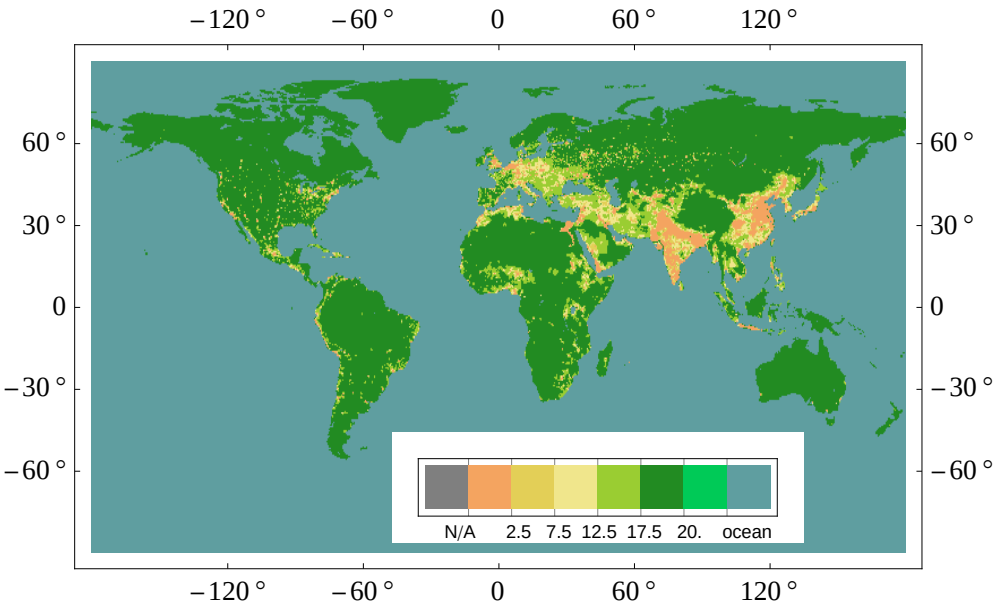

Figure 2. Differentiated regional targets as calculated by using the proposed method (HANPPC = 2 tC/person/y, $BPPI_{max}$ = 20), % of land.

The results of recently published assessment [Barr et al., 2011] show that many countries have an unevenly distributed coverage of protected areas. The authors of that assessment proposed the protection equality metric to measure the "reservation bias toward areas that are not useful for extractive uses".

In the present paper, this problem is treated from different angle of view. It does not seem fair to set the same targets for unpopulated and overpopulated regions. The "reservation bias" cannot be easily corrected, if it reflects the distribution of land suitable for conservation. Therefore, this paper concentrates on socio-ecological disparities between regions and suggests that the disparities should be adequately addressed in differentiated regional targets.

3 CONCLUSIONS

The socio-ecological disparities between regions cast some doubts on the relevance of uniform targets as the basis for biodiversity protection strategies. The index of biodiversity protection parity introduced in this paper expresses in quantitative form the idea that protected areas located in densely populated regions are more valuable than those in sparsely populated regions. This index can be calculated with a reasonable spatial resolution -- for each half-degree cell of the geographic grid – and may serve as the basis for setting differentiated regional targets that leads to the goal formulated in the Strategic Plan for Biodiversity 2011-2020. Since development of equitable targets is critical for achieving the purpose of the Convention on Biological Diversity, the proposed method could be of some significance as a part of this broad research agenda.

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