Land productivity dynamics in and around protected areas globally from 1999 to 2013

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Abstract

Tracking changes in total biomass production or land productivity is an essential part of monitoring land transformations and long-term alterations of the health and productive capacity of land that are typically associated with land degradation. Persistent declines in land productivity impact many terrestrial ecosystem services that form the basis for sustainable livelihoods of human communities. Protected areas (PAs) are a key strategy in global efforts to conserve biodiversity and ecosystem services that are critical for human well-being, and cover about 15% of the land worldwide. Here we globally assess the trends in land productivity in PAs of at least 10 km^2 and in their unprotected surroundings (10 km buffers) from 1999 to 2013. We quantify the percentage of the protected and unprotected land that shows stable, increasing or decreasing trends in land productivity, quantified as long-term (15 year) changes in above-ground biomass derived from satellite-based observations with a spatial resolution of 1 km. We find that 44% of the land in PAs globally has retained the productivity at stable levels from 1999 to 2013, compared to 42% of stable productivity in the unprotected land around PAs. Persistent increases in productivity are more common in the unprotected lands around PAs (32%) than within PAs (18%) globally, which may be related to more active management and vegetation cover changes in some of these unprotected lands. About 14% of the protected land and 12% of the unprotected land around PAs has experienced declines in land productivity from 1999 to 2013 globally. Oceania has the highest percentage of land with stable productivity in PAs (57%) followed by Asia (52%). Europe is the continent with the lowest percentage of land with stable productivity levels in PAs (38%) and with the largest share of protected land with increasing land productivity (32%), which may be related to the high population density and share of agricultural land within PAs as well as to rural land abandonment processes in many regions of Europe. In conclusion, we provide a relevant indicator and assessment of land productivity dynamics that contributes to characterise the state, pressures and changes in and around protected areas globally. Further research may focus on more detailed analyses to disentangle the relative contribution of specific drivers (from climate change to land use change) and their interaction with land productivity dynamics and potential land degradation in different regions of the world.

1. Introduction

The increasing demand of biomass for food, fodder, fibre and energy is driving changes in ecosystems globally (Vitousek et al., 1986; Erb et al., 2009; Ellis et al., 2010; Cherlet et al., 2018). The state of vegetation cover is one reliable and accepted measure associated with land productivity, since it is related to the set of ecological conditions and to the impacts of natural and anthropogenic environmental change (Cherlet et al., 2018). Therefore, changes in total biomass production or land productivity are required to characterize land transformations that are typically associated with land degradation (Yengoh et al., 2016). Persistent changes in land productivity, as captured through plant biomass production, point to long-term alteration of the health and productive capacity of land (Cherlet et al., 2018). Trends in land productivity have been adopted as one of three land-based progress indicators of the United Nations Convention to Combat Desertification (UNCCD, 2013), which are used for mandatory reporting. Land productivity trends have also been proposed as one sub-indicator for monitoring and assessing progress towards achieving the UN Sustainable Development Goal (SDG) 15, target 3 (UNCCD, 2015). Almost all terrestrial ecosystem services that sustain human livelihoods will be directly or indirectly impacted by a persistent reduction in land productivity. Declining productivity, however, is certainly not the only indicator of possible land degradation. Increased productivity can sometimes happen at the cost of other land resources, such as water or soil; in this case, it can lead to degradation that would be observable only in later stages (Cherlet et al., 2018).

Protected areas (PAs) are a key strategy in global efforts to conserve biodiversity and ecosystem services that are critical for human well-being (Watson et al., 2014; UNEP-WCMC et al., 2018). PAs are established and managed to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley, 2008). They play a fundamental role in the *in situ* conservation of genetic, species and ecosystem diversity, and the delivery of economic, social and cultural benefits from nature to people (Mulongoy and Gidda, 2008; UNEP-WCMC et al., 2018; Vačkář et al., 2016). The critical importance of PAs is recognized in several international agreements and targets for biodiversity conservation and sustainable development. In Aichi Target 11 of the Strategic Plan for Biodiversity 2011-2020 of the Convention on Biological Diversity (CBD), the international community agreed to conserve by 2020 at least 17% of terrestrial and inland water areas through effectively and equitably managed, ecologically representative and well-connected systems of PAs (CBD, 2010). Terrestrial PAs also contribute to the conservation target 15.1 of SDG 15 as they seek to "protect, restore and promote sustainable use of terrestrial ecosystems" (UNGA, 2015).

As of July 2018, PAs cover almost 15% of the Earth's land area, compared to around 10% in 1992 when the CBD was signed (UNEP-WCMC et al., 2018). Thus, terrestrial PAs are globally important and are expanding their extent. Depending on their primary management objectives, PAs are commonly classified into different management categories, ranging from strict nature reserves to sustainable use areas (Dudley, 2008).

1   Here, we assess the trends in land productivity in PAs and in their unprotected surroundings (10
2   km buffers) globally from 1999 to 2013. We quantify the percentage of the global protected and
3   unprotected land that shows stable, increasing or decreasing trends in land productivity, and
4   examine the difference in land productivity dynamics across continents and for different PA
5   management categories. By doing so, we provide a relevant indicator that contributes to
6   characterise the state, pressures and changes in and around protected areas globally. We note
7   that to identify critical land degradation zones, land productivity dynamics (hereafter LPD) must
8   be further analysed within the context of anthropogenic land use and other environmental
9   changes. Land productivity as here analysed and presented refers to observed changes of above-
10   ground biomass and is conceptually different from, and not necessarily related to, agricultural
11   production or income per unit area.

12   **2. Materials and Methods**

13   *2.1. Protected areas and 10 km buffer zones*

14   We downloaded the public version of the World Database on Protected Areas (WDPA) for May
15   2019 from Protected Planet (UNEP-WCMC and IUCN, 2019). The WDPA is managed by the World
16   Conservation Monitoring Centre (WCMC) of the United Nations Environment Programme
17   (UNEP) in collaboration with the International Union for Conservation of Nature (IUCN), and is
18   collated from national and regional datasets (UNEP-WCMC, 2017). This dataset consists of
19   235,522 protected areas (PAs), of which those of 10 km^2 or larger are documented in detail in
20   the Digital Observatory for Protected Areas (DOPA) developed by the Joint Research Centre of
21   the European Commission (Dubois et al., 2016), and are those considered in this study. The
22   selection of this 10 km^2 threshold is based on computational limitations in processing the large
23   datasets involved in this study. The DOPA, accessible at http://dopa.jrc.ec.europa.eu, provides
24   a broad range of consistent and comparable indicators on PAs at country, ecoregion and
25   protected area level (Dubois et al., 2016). These indicators are particularly relevant for Aichi
26   Biodiversity Target 11 (Protected Areas) of the CBD, and the UN Sustainable Development Goals
27   14 (Life below Water) and 15 (Life on Land).

28   In this study, we excluded, in addition to PAs with an area below 10 km^2, the following PAs. First,
29   all PAs with undefined boundaries, so-called point PAs that are reported by national authorities
30   with only a single geographic reference for the centre of the PA. Second, we excluded all marine
31   PAs, i.e. we only considered PAs classified in the WDPA as terrestrial and coastal (the latter
32   comprised both terrestrial and marine portions). We only considered their land portion for all
33   analyses. The land portion was determined using the land mask obtained from the combination
34   of the Global Administrative Unit Layers (GAUL) for year 2015, developed by the Food and
35   Agricultural Organization (FAO) of the United Nations[1], and the layer on Exclusive Economic
36   Zones (Flanders Marine Institute, 2016), according to the combination method described in
37   Bastin et al. (2017). Third, we excluded PAs with a "proposed" or "not reported" status in the

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[1] http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

1 WDPA, in line with common practice for global PA analyses (e.g., UNEP-WCMC and IUCN, 2016;
2 Saura et al., 2018). Fourth, we excluded UNESCO Man and the Biosphere Reserves, as their
3 buffer areas and transition zones may not meet the IUCN protected area definition (Dudley
4 2008), and because most of their core areas overlap with other protected areas (UNEP-WCMC
5 and IUCN, 2016). Fifth, we excluded all PAs that had not been already designated before 1999
6 (as well as those that had no designation year reported in the WDPA), given that the temporal
7 period here considered is from 1999 to 2013 (see next section).

8 In addition, in order to compare changes within and around the PAs, we considered, around
9 each PA, a 10 km buffer zone that did not overlap with other PAs, hereafter referred to as the
10 unprotected 10-km buffer.

11 All analyses were performed by rasterizing the PAs and their unprotected buffers to a spatial
12 resolution of 1 km, which is the resolution of the layer on land productivity dynamics, as
13 described next.

14 *2.2. Land productivity dynamics*

15 The dataset used for the analysis of land productivity dynamics (LPD) in and around PAs is that
16 presented in the Global Land Outlook (Sommer et al., 2017) and in the World Atlas of
17 Desertification   (Cherlet   et   al.   ,   2018),   which   is   available   at
18 https://wad.jrc.ec.europa.eu/landproductivity. This is a global map product based on vegetation
19 phenological metrics that relate to the land's capacity to sustain primary production. It is derived
20 from time series of indices of vegetation photosynthetic activity, namely the Normalized
21 Difference Vegetation Index (NDVI), obtained from satellite data acquired by the SPOT
22 VEGETATION sensor (Ivits et al., 2013). Research has shown that time series of remotely sensed
23 vegetation indices, such as those used for deriving LPD, are correlated with biophysically
24 meaningful vegetation characteristics such as photosynthetic capacity and primary production.
25 These characteristics are closely related to global land surface changes and biomass trajectories
26 that can be associated with processes of land degradation and recovery (Yengoh et al., 2016).

27 The LPD map is a non-parametric combination of datasets derived from phenological metrics
28 based on the principle of convergence of evidence. The JRC software *Phenolo* (Ivits et al.,2013a)
29 provides the metrics for each year based on a vegetation index time series (here SPOT
30 Vegetation NDVI 1999-2013).

31 The long-term change in land productivity is captured by a steadiness index (Ivits et al., 2012)
32 combined with baseline levels and state change. The steadiness index combines the tendency
33 of change (slope) and the net change (Multi Temporal Image Differencing (MTID) method (Guo
34 et al. 2008)) of the growing season's NDVI integral (*Phenolo*'s Standing Biomass) over the
35 selected time period (here 1999-2013). The values of Standing Biomass averaged for the first
36 three years and classified into three levels give the baseline. The state change compares the
37 Standing Biomass at the beginning and the end of the time series (three-year average).

38 The recent status of the land productivity map derives from the Local Net Scaling (Prince 2004)
39 of the land productivity. The Local Net Scaling method compares an observed value with the
40 potential or maximal value within homogeneous land capability classes. The latter are spatial

1   units with similar patterns of seasonal phenology and productivity dynamics that reflect both
2   climate and land use conditions, called here Ecosystem Functional Types (EFTs) by Ivits et al.
3   (2014). Ivits et al. (2016) stratify the global land into 100 EFTs based on a cluster analysis of
4   phenological metrics from *Phenolo* run on NOAA GIMMS 3G NDVI time-series (1982-2010). The
5   comparison between the potential and actual land productivity is expressed in terms of the five-
6   year average of the potentially human appropriated vegetation production (*Phenolo*'s cyclic
7   fraction), based on SPOT Vegetation NDVI 2009-2013.

8   The long term change and the current status maps are combined and reclassified into the
9   following five classes in the LPD map, which contain information on persistent trajectories of
10   land productivity dynamics over 15 years, from 1999 to 2013, with a spatial resolution of 1 km:

11   1. Persistent severe decline in productivity
12   2. Persistent moderate decline in productivity
13   3. Stable, but stressed; persistent strong inter-annual productivity variations
14   4. Stable productivity
15   5. Persistent increase in productivity

16   For each PA and its unprotected buffer we calculated the percentage of the land area covered
17   by each of these five qualitative LPD classes. Areas with no photosynthetically active vegetation
18   (i.e., hyper-arid, arctic and very-high altitude mountain regions), for which no information on
19   land productivity trends is available, were also considered as they were part of the area covered
20   by the PAs or their buffers. Therefore, the sum of the percentage of the area covered by each of
21   the five productivity classes could be less than 100% because of the presence of unvegetated
22   areas. In addition, we calculated the percentage of all land (either protected or unprotected)
23   covered by the five LPD classes globally and in each country, as a reference for comparison of
24   the relative prevalence of each of the classes obtained in the PAs and their buffers. To
25   summarize the LPD results, we combined the first three classes into a single class referred to as
26   declining land productivity for brevity.

27   We aggregated the LPD results, both within and around PAs, at the level of continents using the
28   country groupings of the M49 standard of the Statistics Division of the United Nations
29   Secretariat, available at https://unstats.un.org/unsd/methodology/m49/ (accessed May 2019).
30   We used the classification field "region name" (here referred to as continents) in this standard,
31   which classified the world into 6 continents. Continental values are, therefore, influenced by
32   these country groupings, such as the Russian Federation being included in Europe (continent)
33   and Eastern Europe (region), or Greenland being included within the Americas (continent) and
34   Northern America (region), among other examples. We also calculated the aggregated LPD
35   values for the European Union (EU), considering the 28 countries within the EU when this
36   analysis was conducted (EU-28). Each PA, as well as its unprotected buffer, was considered to
37   belong to the country reported in the ISO3 field of the WDPA. Note that the ISO3 codes from
38   the WDPA include cases of territories under the sovereignty of other nations. Examples are
39   Reunion Island, a French overseas territory located in the Indian Ocean, and Greenland, a self-
40   governing territory that is part of the Kingdom of Denmark. In calculating EU values, we excluded
41   the PAs in territories whose reported ISO3 in the WDPA was different from those 28 countries,

1   even if under the sovereignty of a EU member state, as in the case of Greenland or Réunion

2   Island.

3   We also considered, for each PA, the information available in the WDPA regarding the

4   management category (as defined in Dudley, 2008) and summarized the LPD area values

5   separately for each category.

6   **3. Results**

7   *Global land productivity dynamics*

8   Globally, the extent of land with stable productivity from 1999 to 2013 is larger than that of

9   decreasing and increasing productivity combined (Figure 1). There is more land with increasing

10   than with decreasing productivity (Figure 1).

11   Global dynamics in land productivity within terrestrial and coastal PAs larger than 10 km^2 are

12   mainly stable (44% of the protected land), as shown in Figure 2. A similar results is found for the

13   10 km unprotected buffers surrounding the PAs (42%) (Figure 2). Persistent increases in

14   productivity are more common in the unprotected land within the 10 km buffers surrounding

15   PAs (32%) than within PAs (18%) (Figure 2). Decreasing productivity (combination of classes 1, 2

16   and 3 as described in Methods) is comparatively less common than stable or increased

17   productivity: 14% of the land in PAs and 12% of the land in the unprotected buffers shows a

18   decline in productivity (Figure 2).

19   *Continental land productivity dynamics*

20   The trends in land productivity within PAs are however unevenly distributed across continents.

21   In Europe, 38% of the PA network is stable in land productivity, which decreases to 32% for the

22   unprotected land surrounding PAs (Figure 2). These values decrease to 34% within PAs and to

23   30% around PAs, respectively, when focusing on the European Union (EU-28). These values are

24   all lower than the global average; there is less land with stable productivity in and around PAs

25   in Europe and in the EU than in any other continent (Figure 2). Africa is the continent with the

26   second lowest percentage of land with stable productivity: 41% within PAs and 45% in the 10-

27   km buffers around PAs (Figure 2). The highest percentage of land with stable productivity within

28   PAs is found, at the continental level, in Oceania (57%), Asia (52%) and the Americas (46%). In

29   all continents except Africa and the Americas, the percentage of land with stable productivity is

30   higher within than around PAs (Figure 2).

31   The highest percentage of land where productivity has experienced a persistent increase in

32   productivity from 1999 to 2013 is found within the unprotected 10 km buffer surrounding

33   European PAs (46%), which is considerably higher than the corresponding percentage of 32%

34   within European PAs (Figure 2). These values increase to 49% and 42%, respectively, when

35   considering only the countries belonging to the EU. The continent with the second highest

36   percentage of persistent increase in land productivity is Africa, with 27% of the land around PAs

37   and 22% of the land within PAs in this change class, followed by Asia and the Americas (Figure

1   2). The lowest values were found in Oceania, where only 9% of the unprotected land around PAs

2   and 8% of the land within PAs has experienced a persistent increase in productivity (Figure 2).

3   For all continents, the percentage of land with a persistent increase in productivity is higher in

4   the 10 km buffers around PAs than within PAs (Figure 2). Our results show a general pattern for

5   all continents where the increase in land productivity is always higher (almost 80% higher on

6   average) in the unprotected land surrounding PAs than within them, with a wide range of values

7   from 13% in Oceania to 108% in Asia or 44% higher in Europe.

8   The percentage of land with decreasing land productivity is generally similar within and around

9   PAs for all continents (Figure 2). Oceania is the continent where declines in land productivity are

10   more common both within (29%) and around PAs (26%; Figure 2), while the opposite is found

11   for Europe (Figure 2). The percentage of protected land with decreasing productivity is about

12   three times higher in Oceania than in Europe (Figure 2).

13   *Global land productivity dynamics across protected area management categories*

14   PAs with sustainable resource use (IUCN PA category VI), natural monuments (III) have the

15   highest percentages (all over 50%) of stable land productivity within PA (Figure 3). For all IUCN

16   categories, except wilderness areas (Ib) and national parks (II), there is more stability in the land

17   productivity inside PAs than in the unprotected surrounding 10 km buffer (Figure 3). The largest

18   difference in the percentage of stable land productivity between inside (61%) and outside (49%)

19   PAs is found in category III (Figure 3), while the smallest one is found in categories V and Ia

20   (Figure 3); for category Ia the percentage of land with stable productivity is the same inside than

21   outside PAs. For all the categories the percentage of land with increasing productivity is higher

22   outside PAs than within them (Figure 3). The percentage of protected land with decreasing land

23   productivity is highest in wilderness areas (Ib,32%), while increasing land productivity is most

24   widespread in protected landscapes (V, 31%).

25   **4. Discussion**

26   We found that 44% of the land in large (over 10 km^2) protected areas (PAs) globally has retained

27   the productivity at stable levels during the 15 year period here considered (from 1999 to 2013).

28   The percentage of land with stable productivity in the 10-km buffer zones surrounding PAs only

29   goes down to 42%. Our results, therefore, do not suggest any considerable difference between

30   the protected and unprotected land regarding the stability in land productivity globally.

31   There are large tracts of land that, although being protected, have experienced declines in land

32   productivity from 1999 to 2013. About one seventh of the protected land globally shows

33   declines in primary productivity of above-ground biomass. This decline in land productivity, as

34   here measured from satellite-based observations, may be related to a number of factors and

35   processes such as deforestation, desertification or climate change, and may point to ongoing

36   land degradation that may impact sustainability (Cherlet et al., 2018). Land degradation is

37   however a multifaceted and complex global phenomenon with distinct variations between

38   regions and across key land cover/land use systems which cannot be fully captured by a single

1 indicator such as the satellite-based observed changes of above-ground biomass here
2 considered, and would need to be explored in more detail in further research.

3 In the same way as declining trends in land productivity do not indicate land degradation per se,
4 increasing trends in land productivity do not necessarily indicate a recovery or positive outcome
5 from a conservation perspective (Cherlet et al., 2018). For instance, increased productivity is
6 sometimes achieved at the cost of other land resources, such as water (irrigation) or soil, or is
7 the result of the intense use of fertilizers associated with intensive agriculture (Bradford,
8 Lauenroth & Burke, 2005). It can be also driven as a consequence of nitrogen deposition, CO_2
9 enrichment fertilization, and climate change (Nemani et al., 2003; Boisvenue & Running, 2006;
10 Thomas et al., 2010; Pettorelli et al., 2012). In several of these cases it can lead to subsequent
11 degradation, which would be observable only in later stages. In addition, land cover and land
12 use changes, such as decrease of primary forest cover at the expense of fast-growing tree
13 plantations or highly-productive crops under intensive agricultural land use, can lead to an
14 increase in the observed productivity of above-ground vegetation while having significant
15 negative impacts on the conservation of natural resources, biodiversity and ecosystem services
16 (Bradford et al., 2005). In rangelands and savannah, increasing productivity may be a sign of bush
17 encroachment, which can modify the biodiversity and ecological functioning of grasslands (e.g.
18 Leitner et al, 2018). In other ecosystems, it may arise from invasions by native or alien plant
19 species.

20 For these reasons, the considerable percentage of land in PAs (18%) that has experienced an
21 increase in productivity may be interpreted as a signal of ongoing changes that in many cases
22 may not have benefits for the conservation objectives for which PAs have been declared. This
23 percentage is however substantially higher in the unprotected land surrounding PAs (32%),
24 globally almost 80% higher outside than inside. These findings may be indicative of a generally
25 positive conservation outcome of PAs, which have avoided in many areas long-term alterations
26 aimed to increase the productive capacity of land. The largest share of increased productivity
27 around than inside PAs may be also indicative of more human activity or human pressure outside
28 (Geldmann, Joppa & Burgess, 2014), related to more human settlements (De la Fuente et al.,
29 2019) and more energy availability (Luck, 2007) that drive a more intensive use of the land. It
30 may also be related to the fact that traditionally humans choose to settle in the most productive
31 land (O'Neill & Abson, 2009). Other potential drivers of increase in land productivity, such as
32 increased water supply from glacier melting or longer growing seasons in high-latitude areas
33 driven by climate change or long-term vegetation recovery from previous natural or human-
34 caused disturbances, may also play a significant role and may not be necessarily detrimental to
35 biodiversity. It is however out of the reach and scope of this study to disentangle and specifically
36 consider each of these processes, factors, and their complex interactions, which remains to be
37 tackled in further research. In any case, the fact that the percentage of land with increased
38 productivity is notably lower within than around PAs, as we found in this study, may be
39 understood as a positive indicator of the relative ability of PAs to prevent changes that may pose
40 a risk to their conservation objectives.

Interestingly, Europe is the continent with the lowest percentage of land with stable productivity levels in PAs and with the largest share of protected land with increasing land productivity. These results may be explained by the high population density and share of agricultural land use in protected areas, which is higher in Europe than in any other continent and may be associated to a significant part of the dynamics here observed (Weber & Sciubba, 2019). Also, the rural land abandonment processes have triggered the expansion of forests and woodlands in mountain areas and former agricultural lands in many European countries, often showing increasing land productivity in these areas as measured through the NDVI (Tang et al., 2011).

We emphasize that our analysis detects trends and areas with persistent declines in primary productivity that might point to ongoing land degradation, rather than areas which have already undergone degradation prior to the observation period and have reached a new equilibrium from which they do not further degrade within the observation period. Therefore, we acknowledge that our assessment may underestimate and leave unreported previous land degradation that may have occurred in PAs before 1999, which is the first year in our temporal analysis. On the other hand, the persistent land productivity changes here reported point to long-term alteration of the health and productive capacity of land. The primary productivity of a stable land system is not a steady state, but is often highly variable between different years and vegetation growth cycles due to natural variation and/or human intervention. This implies that land productivity changes cannot be assessed by comparing land productivity values of single reference years or averages of a few years. On the contrary, approaches must be based on longer term trends on multi-temporal change and trend analysis which are continuously repeated (persistent) in defined time steps using an extended time series, as is the case of the dataset and analyses used here. Despite the long-term perspective on persistent land productivity changes here adopted, we recognize that it is necessary to incorporate other factors different from biomass trends into the analysis of land degradation. To identify critical land degradation zones, land productivity must be analysed within the context of anthropogenic land use and other environmental changes.

In conclusion, we have provided a valuable assessment of land productivity dynamics in and around PAs worldwide that points to a generally positive effect of the protected area system on the conservation of land productivity. At the same time, we report that almost half of the land under protection has experienced changes (either declines or increases) in land productivity over the last 15 years. These changes may be related to a range of pressures and factors (from climate change to land use intensification) that may be detrimental for the long-term conservation of ecosystem health, biological diversity and ecosystem services. Additional and more detailed studies are needed to further analyse and disentangle the specific contribution to land productivity dynamics and potential land degradation of each of these drivers, processes and their complex interaction in different regions of the world.

Acknowledgements

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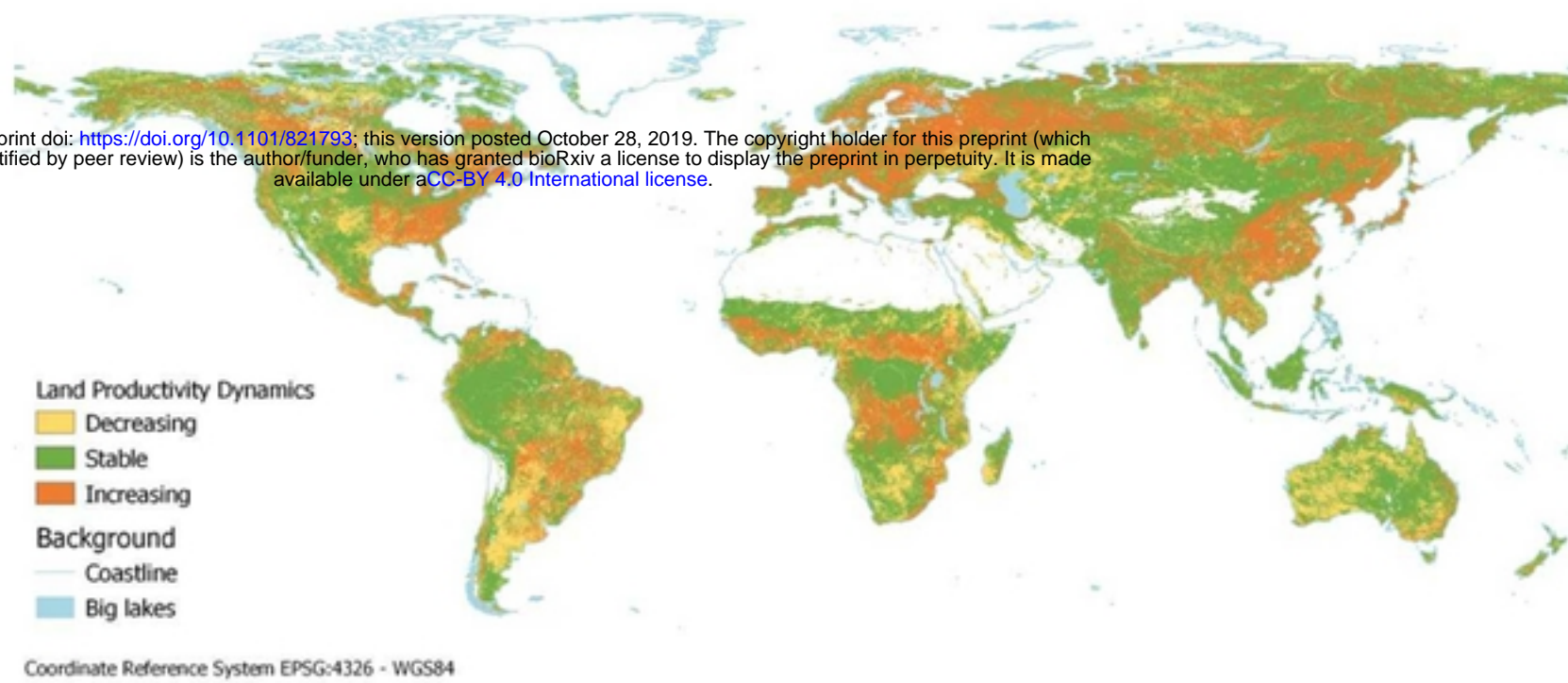13 (Springer, 2016), Springer Briefs in Environmental Science, DOI: 10.1007/978-3-319-24112-8.

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Figure 1. *Global map of land productivity dynamics showing the spatial distribution of the three Land Productivity Dynamics (LPD) classes (decreasing – stable – increasing). The decreasing class includes areas with persistent severe decline in productivity, with persistent moderate decline in productivity and with stable but stressed productivity (persistent strong inter-annual productivity variations), as described in Methods. Land areas with no photosynthetically active vegetation are shown in white.*
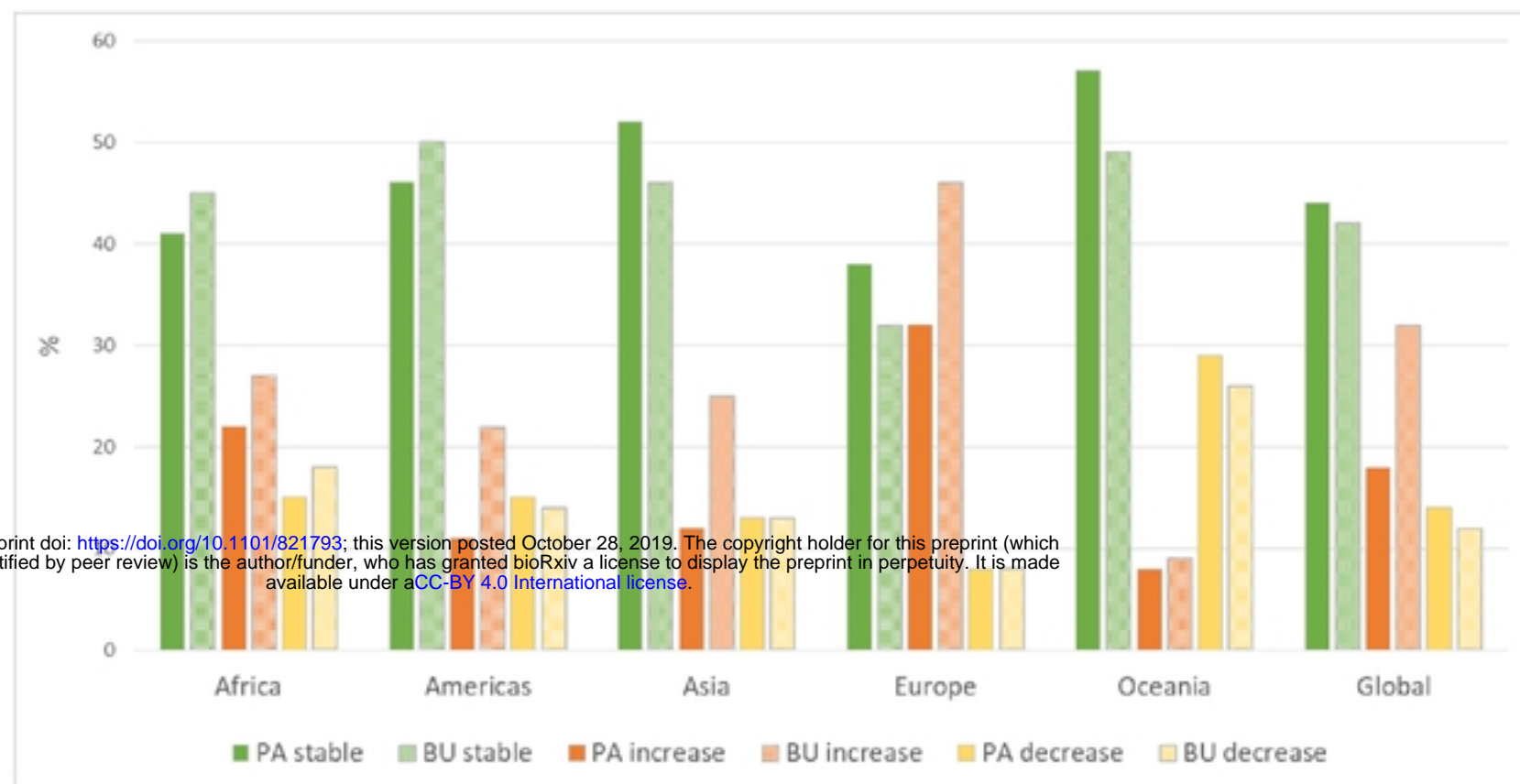
Figure 2. Percentage of land with stable (green), increased (orange) and decreased (yellow) land productivity between 1999 and 2013 in the protected areas (PA) and in their unprotected 10-km buffers (BU) for each continent and globally.
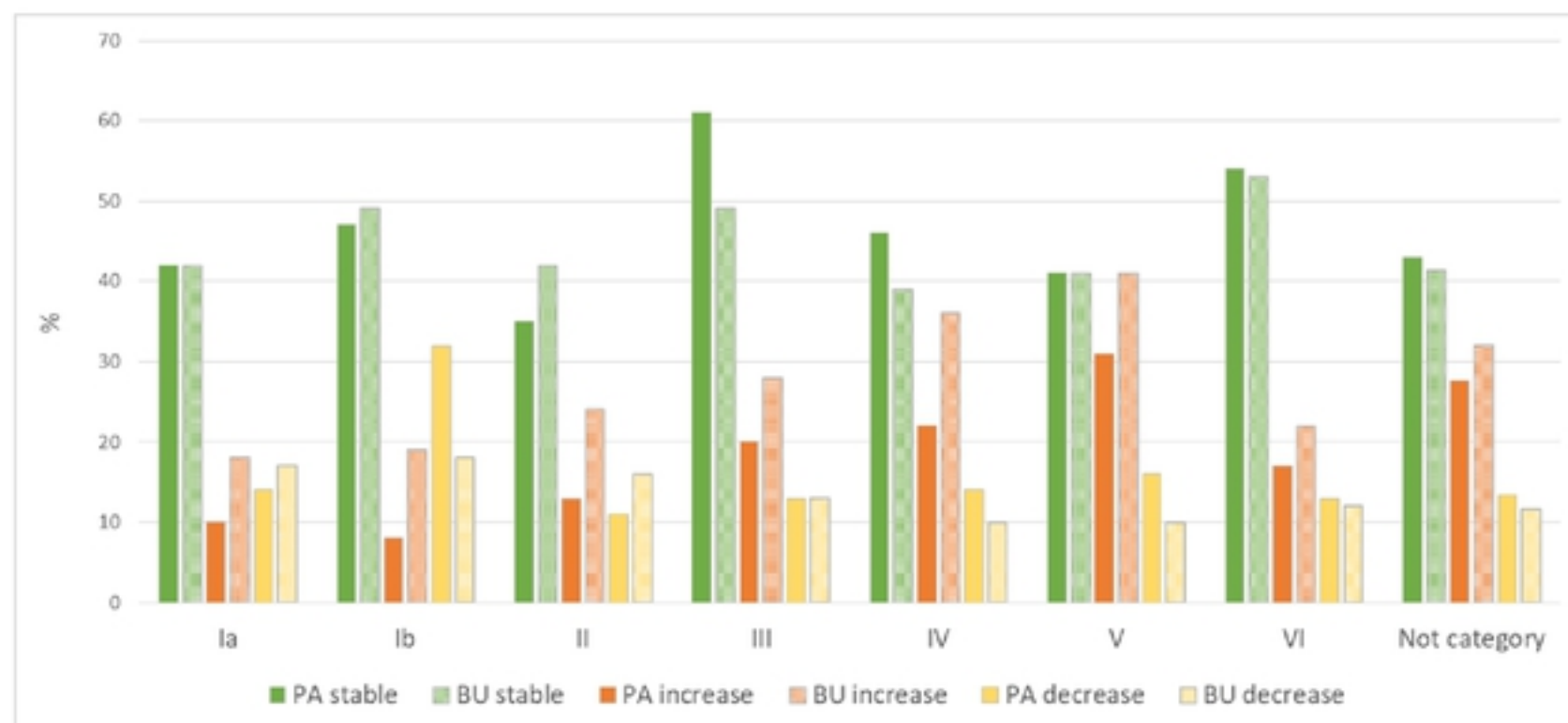

Figure 3. Percentage of land with stable (green), increased (orange) and decreased (yellow) land productivity between 1999 and 2013 in the protected areas (PA) and in their unprotected 10-km buffers (BU) for each IUCN management category of PAs.