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The Digital Observatory for Protected Areas (DOPA) Explorer 1.0

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Abstract

The Digital Observatory for Protected Areas (DOPA) has been developed to support the European Union's efforts in strengthening our capacity to mobilize and use biodiversity data, information and forecasts so that they are readily accessible to policymakers, managers, experts and other users. Conceived as a set of web based services, DOPA provides a broad set of free and open source tools to assess, monitor and even forecast the state of and pressure on protected areas at local, regional and global scale.

DOPA Explorer 1.0 is a web based interface available in four languages (EN, FR, ES, PT) providing simple means to explore the nearly 16,000 protected areas that are at least as large as 100 km². Distinguishing between terrestrial, marine and mixed protected areas, DOPA Explorer 1.0 can help end users to identify those with most unique ecosystems and species, and assess the pressures they are exposed to because of human development. Recognized by the UN Convention on Biological Diversity (CBD) as a reference information system, DOPA Explorer is based on the best global data sets available and provides means to rank protected areas at the country and ecoregion levels. Inversely, DOPA Explorer indirectly highlights the protected areas for which information is incomplete. We finally invite the end-users of DOPA to engage with us through the proposed communication platforms to help improve our work to support the safeguarding of biodiversity.

“We are drowning in information, while starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely.”

E. Wilson, 1998, Consilience

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Abstract

The Digital Observatory for Protected Areas (DOPA) has been developed to support the European Union's efforts *"to substantially strengthen the effectiveness of international governance for biodiversity and ecosystem services¹"* and more generally for *"strengthening the capacity to mobilize and use biodiversity data, information and forecasts so that they are readily accessible to policymakers, managers, experts and other users²"*. DOPA is conceived as a set of web based services to provide a large variety of end users with means to assess, monitor and possibly forecast the state of, and pressures on protected areas at local, regional and global scale.

In particular, DOPA aims to

- 1) **provide the best available material** (data, indicators, models) made available by a few key institutions (i.e. UNEP-WCMC, IUCN, WWF, the Joint Research Centre of the European Commission, and others) which can serve for establishing baselines for research and reporting;
- 2) **provide free analytical tools** to support the discovery, access, exchange and execution of web services (databases and modelling) designed to generate the best available material but also for research purposes, decision making and capacity building activities for conservation;
- 3) **provide an interoperable and, as far as possible, open source framework** to provide institutions with their own means to assess, monitor and forecast the state of, and pressures on protected areas, and to help these institutions to further engage with the organizations hosting critical biodiversity informatics infrastructures.

It is the purpose of this document to introduce the readers to **DOPA Explorer 1.0**. As a web based tool available in four languages (EN, FR, ES, PT) to everyone with access to the internet, DOPA Explorer provides a simple means to explore terrestrial, marine and mixed protected areas, identify those with the most unique ecosystems and species, and assess the pressures they are exposed to because of human development.

Main changes made in the DOPA Explorer 1.0 over the Beta version released in 2013 are:

1. A simplified interface **focusing more on reporting in support to decision makers**. The information has been organised to allow end users to work at the Ecoregion and Country levels using all protected areas (~214 000) and at the site level for all protected areas $\geq 100 \text{ km}^2$ (nearly 16,000). On the other hand, other information (e.g. ecosystem services) has been removed because of the current lack of consistency across the regions.
2. The DOPA Explorer 1.0 is documenting **more protected areas with more recent data**: the minimum size of the documented protected areas is $\geq 100 \text{ km}^2$ (instead of 150 km^2 for the Beta version) using the August 2014 version of the IUCN Red List of Threatened Species and the August 2014 version of the World Database on Protected Areas.
3. **Key indicators** on species and habitats have been significantly **improved** for both the terrestrial and marine protected areas.
4. The **ecological data** derived from near real-time earth observations (fires, NDVI, Water Bodies, rainfall) for Africa **have been removed for the sake of simplicity**. This information will be made available at the global scale and for more products (e.g. water bodies) in another interface planned for early 2016 (DOPA Analyst, Beta release).

¹ EC/COM/2006/0216 final

² UNEP/CBD/COP/10/27

Keywords: DOPA, protected areas, biodiversity, pressures, indicators, reporting, policy making, web services, OGC

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The feedback received from the following people has largely contributed to improving DOPA Explorer 1.0 over the previous Beta version: Dimitri Harmegnies, Philippe Mayaux, Enrico Pironio, Carlo Paolini, Mike Hoffmann, Erin Jamison, Graeme Buchanan, Thomas Brooks, Jane Smart, Stephen Peedell, Gráinne Mulhern, Paolo Roggeri and many others.

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The development of the underlying web services and modelling services have been supported by the institutional activities of the Land Resource Management Unit, the BIOPAMA project (<http://www.biopama.org/>) funded by the European Development Fund (2012-2016), the UncertWeb project (<http://www.uncertweb.org/>) funded by the DG CONNECT under the 7th Framework Programme (2010-2013) and by the EuroGEOSS project (<http://www.eurogeoss.eu/>) funded by DG RTD (2009-2012)



1. Introduction

1.1. DOPA, a service for strengthening decision making

Protected areas play a key role in conservation programmes and in the sustainable use of natural resources. Science-based conservation requires that one has access to a wealth of information on species, ecosystems and threats at the level of the protected area but also at the national and regional scale in order to assess priorities. This type and variety of information is frequently difficult to access and needs to be regularly verified.

The Digital Observatory for Protected Areas (DOPA) has been developed *“to substantially strengthen the effectiveness of international governance for biodiversity and ecosystem services (EC/COM/2006/0216 final)”* and more generally for *“strengthening the capacity to mobilize and use biodiversity data, information and forecasts so that they are readily accessible to policymakers, managers, experts and other users”* (UNEP/CBD/COP/10/27).

The DOPA is derived from an earlier effort where African protected areas were assessed using objective continent-wide data sets (Hartley et al., 2007) to provide decision makers with an African Protected Areas Assessment Tool (APAAT). This tool was used to assess the state of African protected areas, and to prioritize them according to biodiversity values and threats to support decision making and funding allocation processes. In contrast to the APAAT, where most of the data was collected only once and then processed to generate a static set of indicators published on a web site, the DOPA is built around a set of interoperable web services hosted at different institutions. This architecture greatly eases the overall update of the selected data sets and indicators and allows developers to propose an almost infinite number of web based tools for different end users. Last but not least, although focusing on developing countries, the DOPA covers protected areas worldwide and thus allows for global assessments (Dubois et al., 2009, 2010).

Assessing protected areas for biodiversity conservation at national, regional and international scale implies that methods and tools are in place to evaluate physical characteristics such as the protected areas' proximity to one another, their species assemblages (including the presence of threatened species), the uniqueness of their ecosystems, and the threats these areas are exposed to. Typical requirements for such analyses are data on protected areas, information on species distributions, abundance and status on the IUCN Red List of Threatened Species, and information on ecosystems which allows us to assess their irreplaceability and monitor changes. By integrating all these data consistently in the form of metrics and indicators, protected areas can not only be evaluated individually but may also be contrasted against each other for setting conservation priorities. In the current system, each protected area is characterized by a set of indicators summarising the uniqueness of its habitats and its species (currently computed for three taxa - mammals, birds and amphibians). The higher the values of these indicators, the higher the ranking of the protected area in any potential prioritization scheme. Similarly, pressure indicators estimating population, agriculture and road pressures within and around the protected area have also been derived. Given the huge amount of information potentially available, information systems need to be developed to ease the processes of collecting, preparing and integrating the data required for the computation of the indicators (Figure 1).

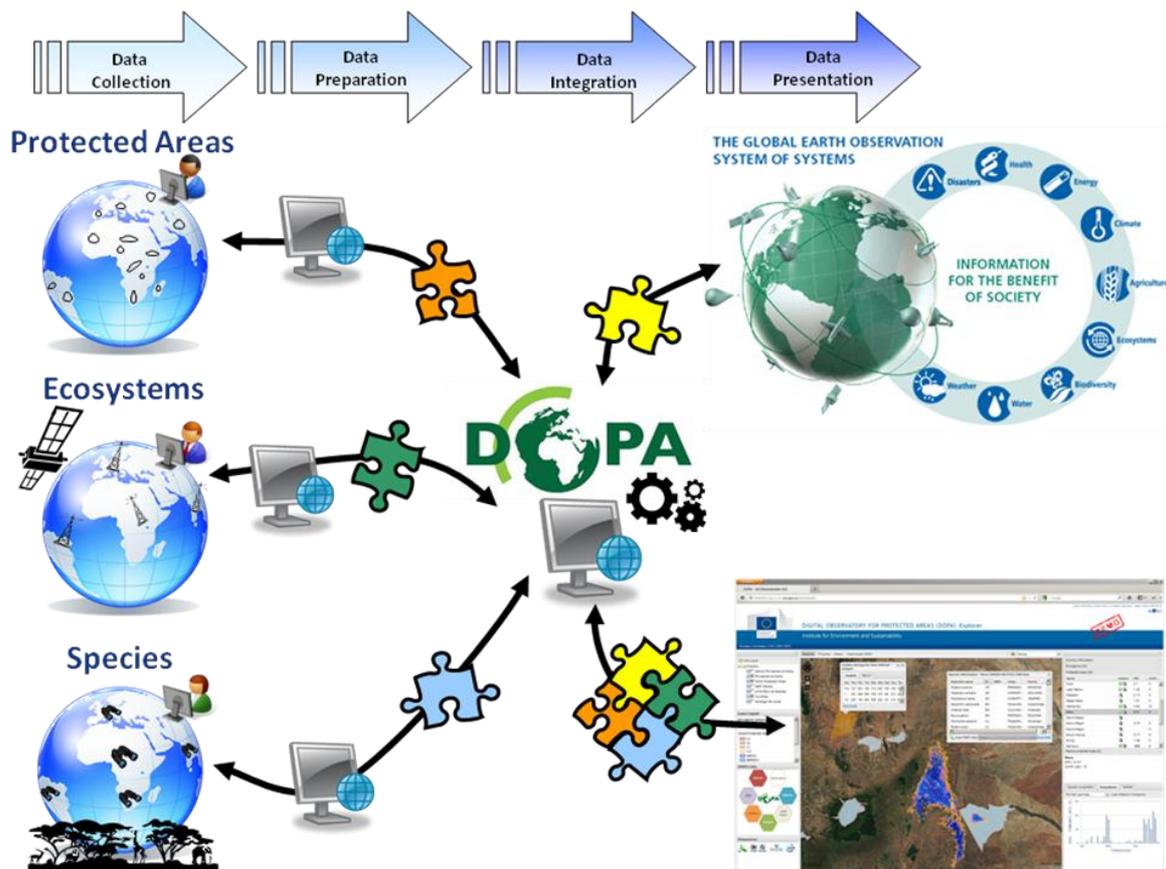


FIGURE 1. FROM GROUND BASED AND REMOTE SENSING OBSERVATIONS TO ENVIRONMENTAL INDICATORS: DATA NEED TO BE COLLECTED, PROCESSED AND PREPARED TO ALLOW THEIR COMBINED USE AND INTEGRATION

1.2. Open data and model services supporting DOPA

While most end users of services provided by DOPA are expected to access these over the internet, the development strategy and the **open source and interoperable framework** of the main functionalities of DOPA will allow the deployment of local instances of DOPA. This approach is expected to encourage, where needed, the adoption of a number of international standards that are already in use by the community and to facilitate engagement with the institutions that are responsible for the critical biodiversity data and model infrastructures. More than ever, the global dimension of biodiversity related issues requires that a common language is used for collecting, interpreting and synthesizing the information handled (Edwards, Lane and Nielsen, 2000).

By encouraging everyone to adopt an open approach to non-sensitive biodiversity data, in particular the **Conservation Commons** and **GEOS Data Sharing Principles**, we expect that the community of end users and data providers will significantly contribute to the improvement of the material made available. On the modelling side, the open source models (using mainly R and python) will also be more easily shared and tested, and eventually adapted to local needs where required.

For various technical, scientific and even managerial reasons, the architecture of the DOPA was organized around a set of fundamental data and model web services which have been discussed in (Dubois et al., 2013b). The architecture of these services will not be further discussed here and we invite web developers to visit the web site documenting the services underpinning the DOPA at the following address:

<http://dopa-services.jrc.ec.europa.eu/services/>

This directory of services is continually updated.

2. DOPA Explorer

The DOPA was developed in response to the European Parliament's call to support the ambitious Convention on Biological Diversity (CBD) mission for 2020: to halt the loss of biodiversity and to share the values and benefits of biodiversity and ecosystem services equitably. In decision X/2, the tenth meeting of the CBD Conference of the Parties (October 2010, Nagoya, Aichi Prefecture, Japan) adopted a revised and updated Strategic Plan for Biodiversity, including the Aichi Biodiversity Targets³, for the 2011-2020 period. This new plan is the overarching framework on biodiversity, not only for the biodiversity-related conventions, but for the entire United Nations system. It consists of five strategic goals, including twenty Aichi Biodiversity Targets which comprise both aspirations for achievement at the global level, and a flexible framework for the establishment of national or regional targets. Among the targets, Parties agreed to at least halve and where feasible bring close to zero the rate of loss of natural habitats including forests and they established a target of 17 % of terrestrial and inland water areas and 10 % of marine and coastal areas to be conserved through area-based conservation measures. Parties also agreed on a strategy on resource mobilization, with a substantial increase in the level of financial resources in support of implementation of the Convention. Parties agreed to translate this overarching international framework into National Biodiversity Strategies and Action Plans (NBSAPs) within two years.

The EU is strongly committed to further strengthening the CBD as the key international instrument for achieving global biodiversity targets and to making sure that it is effectively implemented. Because protected areas are the cornerstone of biodiversity conservation, DOPA has been developed by the Joint Research Centre of the European Commission to assess the state of, and pressures on protected areas on a global scale to support policy making. It can also help in prioritising protected areas according to their biodiversity and the pressures to which they are exposed, and consequently supports decision making and funding allocation processes. Built around the distributed computing technology discussed in the introductory chapter, DOPA has also the ambition to become a reference information system to assess, monitor and possibly forecast biodiversity in protected areas at the global scale with a focus on developing countries.

2.1. DOPA Explorer 1.0 versus DOPA Explorer Beta

Available to everyone with access to the internet, DOPA proposes a set of selected interfaces to access more easily the underpinning reference data and model services. Our first interface, DOPA Explorer (Beta, Rev. 3069), was released in October 2013 and **provided means to explore, analyse and compare the existing reference information on species and ecosystems that was available on protected areas at the country and ecoregion levels**. End users could use DOPA Explorer to identify the protected areas with the most unique ecosystems and species or assess the level of pressure coming from agriculture or population. DOPA Explorer Beta also included a monitoring system based on earth observations to assess every 10 days the situation on the ground for a number of critical variables (fires, NDVI, rainfall, etc.) in Africa.

DOPA Explorer 1.0 – the system documented in this report - has been released in February 2015 after a long process of revising the functionalities of the Beta version. Besides nearly doubling the number of protected areas that have been analysed, we have revised our core indicators and improved methodologies where possible, updated all possible datasets to the latest versions available, improved the underlying web services, and interacted with various end users to get a clearer picture of the core requirements. This process also led to the removal of a number of components which were less relevant to the main objective of the Explorer. Where possible, DOPA Explorer 1.0 exposes inconsistencies in the source data to help identify important uncertainties and

³ <http://www.cbd.int/sp/targets/>

further encourage subsequent improvements. For example, reported surfaces are often quite different from those calculated using the geometries of the protected areas. Another discrepancy frequently encountered is that the total surface protected in a country or an ecoregion may not match the sum of the individual surfaces of the protected areas because of large overlaps between areas with different legal designation types and/or management categories.

The main improvements made to the DOPA Explorer 1.0 over the Beta version released in 2013 are:

1. A simplified interface focusing **more on reporting**. The information has been organised to allow end users to work at the Ecoregion and Country levels using all protected areas (~214 000) and at the site level for all protected areas $\geq 100 \text{ km}^2$ (nearly 16,000).
2. The DOPA Explorer 1.0 is documenting **more protected areas with more recent data**: all protected areas $\geq 100 \text{ km}^2$ are documented (instead of 150 km²) using the August 2014 version of the IUCN Red List of Threatened Species and the August 2014 version of the World Database on Protected Areas.
3. The **key indicators** on species and habitats have been significantly **improved** for both the terrestrial and marine protected areas.
4. The ecological data derived from near real-time earth observations (fires, NDVI, Water Bodies, rainfall) for Africa have been removed for the sake of simplicity. This information will be made available at the global scale and for more products (e.g. water bodies) in another interface planned for early 2016 (DOPA Analyst, Beta release).

While DOPA Explorer 1.0 is trying to make the best out of global datasets and highlight those areas where additional improvements to the data are needed, the information presented still requires additional verification and data collection. **In its Beta version, it is essential to see DOPA Explorer 1.0 as a compass rather than a reference information system based on ground truthed data.** Most indicators presented suffer from high uncertainties in certain regions. The list of species potentially encountered in a protected area and the pressures to which the protected area is exposed are example indicators which could be greatly improved by higher quality data. A theoretical list of species extracted from the IUCN Red List of Threatened Species is provided for each protected area. However, as discussed later on, these range polygons are indicative of broad occurrence, and do not delineate in detail the areas where the species is found or not found. Therefore, although a species range polygon may overlap a protected area, the species may never have been observed in the protected area; either because no suitable habitat is actually found in the area or because the species has become extinct in that location. Also prone to large uncertainties are pressures on protected areas, which have been mainly derived from models using land cover maps that are notoriously outdated and/or inaccurate in many areas (see e.g. Gross et al., 2013, Tropek et al., 2014).

These uncertainties and inaccuracies are difficult to minimize without local case studies. It is therefore the objective to develop in a second stage the **DOPA Validator** which will allow registered users to update the information presented in DOPA Explorer 1.0. The tool should further **bring together actors on the ground** (i.e. park managers, rangers, researchers) **with people usually remotely located** who have an impact on the protected areas (i.e. funders, decision and policy makers)

A third component planned for 2016, **DOPA Analyst**, will be designed to allow end users to benefit more from modelling infrastructures to generate the indicators proposed here for any area specified by the end-user as well for performing more complicated analyses (e.g. connectivity analyses, climate change forecasts, etc.)

2.2. End users of DOPA Explorer

As with the earlier versions of our information systems (Hartley et al., 2007, Dubois et al., 2013b), DOPA Explorer 1.0 is intended to help decision makers when allocating funds in support to the sustainable management of our natural capital. In identifying the protected areas with the greatest need for attention, and the countries with the greatest potential to help meeting internationally agreed conservation goals, our aim is to encourage the more effective allocation of funds.

Typical end users of the DOPA Explorer are therefore expected to be those indicated below.

2.2.1. The European Commission (EC)

DG DEVCO. The Commission's Directorate-General (DG) for International Cooperation and Development is responsible for designing European international cooperation and development policy and delivering aid throughout the world. For the past 20 years, the European Commission has been an important donor for protected area conservation, especially in Africa. Commission projects and programmes aim to improve the management of protected areas and to develop conservation techniques. The EU also seeks to boost regional co-operation and help people to share information on good practice.

DG ENV. The DG Environment makes sure that Member States correctly apply EU environmental law. In doing so it investigates complaints made by citizens and non-governmental organisations and can take legal action if it deems that EU law has been infringed. The DG also finances projects that contribute to environmental protection in the EU. Since 1992, the EU's financial instrument for the environment, LIFE, has co-financed some 4 171 projects, contributing approximately €3.4 billion euros to the protection of the environment and climate⁴. DG Environment represents the EU in a number of environmental matters at international meetings, in particular the Convention on Biological Diversity, and also supports the work of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

EEAS. The European External Action Service (EEAS) is in charge of the day-to-day management of EC policies, programmes and projects since the devolution process, which aims to bring decision making and implementation closer to the beneficiaries.

For these Directorates, DOPA can provide valuable information both for programming at the national and regional level and for implementing programmes and projects at the local level.

2.2.2. UN organisations and Multilateral Environmental Agreements

National Biodiversity Strategies and Action Plans (NBSAPs) are the principal instruments for implementing the Convention on Biological Diversity (CBD) at the national level. The Convention requires countries to prepare a national biodiversity strategy (or equivalent instrument) and to ensure that this strategy is mainstreamed into the planning and activities of all those sectors whose activities can have an impact (positive and negative) on biodiversity. The United Nations Environment Programme (UNEP) is the United Nations system's designated entity for addressing environmental issues at the global and regional level. Its mandate is to coordinate the development of environmental policy consensus by keeping the global environment under review and bringing emerging issues to the attention of governments and the international community for action. The United Nations Development Programme (UNDP) is helping countries to develop policies, leadership skills, partnering abilities, institutional capabilities and build resilience in order to sustain development results. UNDP helps more than 140 countries to conserve and sustainably use biodiversity, and to secure ecosystem services.

⁴ <http://ec.europa.eu/environment/life/> (20 January 2014)

DOPA Explorer can support these organisations and agreements by facilitating access to integrated baseline information, providing the web services required to generate their information and contribute to the monitoring of progress towards the 2020 Aichi Biodiversity Targets. Similar contributions can be expected to support the International Platform on Biodiversity and Ecosystem Services (IPBES). The prioritization approach of DOPA Explorer can also help the Global Environment Facility (GEF), the financial mechanism of the CBD, in supporting developing countries and countries with economies in transition to achieve the objectives of the CBD and generate global environmental benefits in the area of biodiversity.

The CBD has been encouraging all the Parties (195 states and the EU) to make use of the DOPA⁵ when planning their work on protected areas.

2.2.3. Governments

Governments have their own local, national and international biodiversity conservation projects. National and regional services in charge of protected area management can easily access important information on biodiversity value and threats in a systematic way and prioritise their interventions in the same way than EC services or simply compare their indicators with those proposed here.

2.2.4. Non-Governmental Organisations (NGOs)

NGOs have a long history in contributing to biodiversity conservation - from local to global activities. DOPA Explorer provides a unique tool providing information at the level of individual protected areas, facilitating the definition of local priorities. Often active *in situ*, NGOs will find in DOPA Explorer simple access to reference information which can sometimes be very different from the reality. Local experts can therefore easily assess how well the local situation is represented and, in a second stage, can communicate with the data providers to correct the information used by the decision makers.

2.2.5. Researchers

We have paid much attention to needs of researchers who will want, as far as possible, to access the raw information. The information delivered in DOPA Explorer can be generally extracted in a variety of raw formats for further use. DOPA Explorer is also designed to ease, as much as possible, access to data which are usually time consuming to access and process. Finally, this report will provide all details about the use of the data, discuss any relevant issues and uncertainties, and clearly depict the processing workflow of each proposed indicator to ensure repeatability.

⁵ Ref.: SCBD/SAM/DC/SBG/LJ/84384 <https://www.cbd.int/doc/notifications/2015/ntf-2015-027-pa-en.pdf> , 9 March 2015

3. Using DOPA Explorer 1.0 in four steps

DOPA Explorer 1.0 (latest release February 2015) is our second version of DOPA Explorer and it is expected to be continuously updated and improved with the help of end users.

DOPA Explorer is available at <http://dopa.jrc.ec.europa.eu/explorer/> and cannot be used for commercial purposes considering the terms of use of the underlying datasets.

In the following, you will be quickly guided through the main functionalities of DOPA Explorer 1.0 which is quite similar to its earlier version.

In short, you will be first invited to select a country of interest, explore the standard information about the country and its ecoregions in terms of coverage by protected areas. A protected area can be further selected and compared against the other protected areas of the country or the ecoregion in terms of species, habitats and pressures. You will learn how to explore and identify systematically the protected areas which have, theoretically, the greatest value, in terms of biological resources, and those which are the most threatened by human development. We also provide the fundamental means to map and/or download the main information used for further reporting.

3.1. Step 1: Accessing DOPA Explorer and language selection

Open up your web browser, preferably **Google Chrome** or **Mozilla Firefox**, and go to <http://dopa.jrc.ec.europa.eu/explorer/>

After agreeing with the conditions of use of DOPA Explorer 1.0, an interface similar to the one shown below (Figure 2) will open up and display a map of the world with protected areas. The figures shown in this chapter are simplified when compared to the interfaces developed. Only two tabs are active, the interactive map and the one summarizing the main data sources and indicators proposed. The next step in your data exploration would be to either select a country or a protected area (see next section).

This mapping interface is the main interface to display various thematic information as map layers which are available from the lower window panel. Opening the left window panel, hidden by default, will allow you to view the map legends as well as to define the order and opacity of the displayed data. A right panel is hidden by default and will show information only once a protected area has been selected.

The default setting is English but you will find a selection of other possible languages (EN/FR/ES/PT) in the upper right corner of the browser (Figure 2). Note that selecting another language will reopen your web page, and will present the conditions of use, with which you need to agree, in the chosen language. Previous interactions with DOPA Explorer 1.0 will be reset.

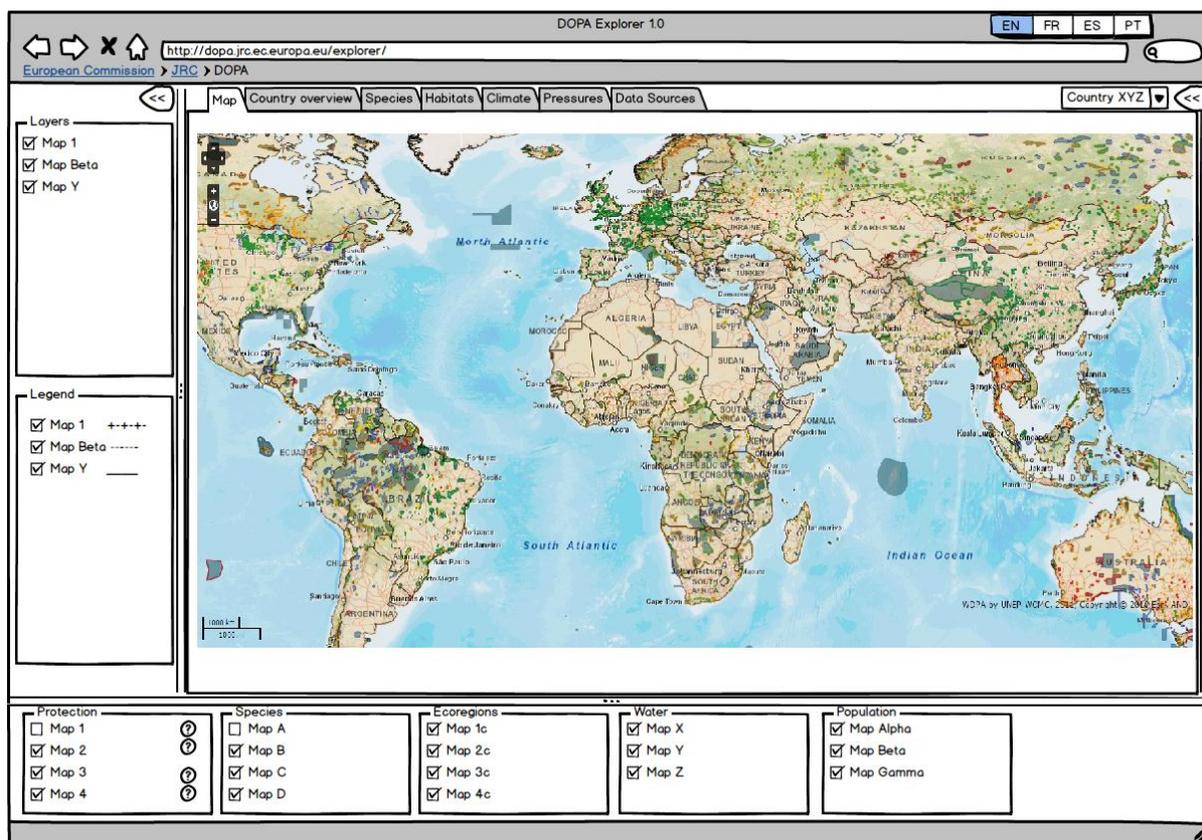


FIGURE 2. MOCK-UP REPRESENTATION OF THE MAIN INTERFACE OF DOPA EXPLORER 1.0. FIRST STEPS REQUIRE THE SELECTION OF A WORKING LANGUAGE (ENGLISH, FRENCH, SPANISH OR PORTUGUESE) AND THE SELECTION OF A COUNTRY OR PROTECTED AREA.

Tips:

You can increase/decrease the size of the text and figures from the interfaces by pointing the mouse to any region of the web browser and using Ctrl and + (magnifying) or Ctrl and - (minimising). This can be particularly useful if you are using a small screen.

The side panels (left and right) are opened/closed by clicking on the   found in corners of the interface. These panels can be resized by sliding the borders of the map windows with left button hold mouse click.

The lower panel allows you to select the maps displayed, while the left panel will show the legends of the active maps. The  button will allow you to add the selected layer and will turn into .

The order of the maps is essential, as the last one picked will be overlaid on the top of all other maps and become the one that can be interrogated with the mouse. The order of the maps can be changed by dragging the names of each layer to the desired level in the left panel. The transparency of the layer can be altered by selecting the map in the left panel and using the right click mouse button.

The “Add layer” button  opens a window with a short list of mapping resources available over the web.

The “information” icon  will display information about the selected layer as a tooltip.

Various map backgrounds (satellite images, open street map, physical map and the basic open layer) are available from the upper left corner of the map window.

The speed at which information is appearing in your browser will largely depend on the type and the source of the information shown. The Open Layer background will load faster than the other layers.

3.2. Step 2: Selecting the country of interest

DOPA Explorer 1.0 provides information at the country and the protected area level. Protected areas can be selected directly from the map or from the list of protected areas which appears after a country is selected from the dropdown list on the upper right corner of the main panel (Figure 3). In a later example, you will learn that protected areas can be selected by interacting with the charts and tables which show the various indicators on pressures and species.

As soon as a country is selected, the “Country Overview” tab becomes active and can be activated by clicking. Here you will see summary information and statistics. Besides a pie chart showing the percentage of protection of the country by the different IUCN Protected Area Management Categories, you will find on the right side a set of links to general reference information about the country that is available on the internet and, in the panel below, three tables summarizing the core information about protected areas in the country. These tables are discussed in detail later in the report and only a basic description of their contents is given here.

The first table “Protected areas ($\geq 100 \text{ km}^2$)” will provide you with the list of all the protected areas larger than 100 km^2 found in the country and analysed in DOPA Explorer 1.0. Each protected area is further characterized by 12 parameters and indicators.

The second table “Species protection statistics (all PAs)” presents protection statistics using all protected areas from the World Database on Protected Areas (WDPA, UNEP-WCMC & IUCN, 2004) for all birds, mammals and amphibians from the IUCN Red List of Threatened Species theoretically found in the country.

The third and last table “Ecoregions (all PAs)” shows protection statistics for all the ecoregions found in the country using all protected areas from the WDPA.

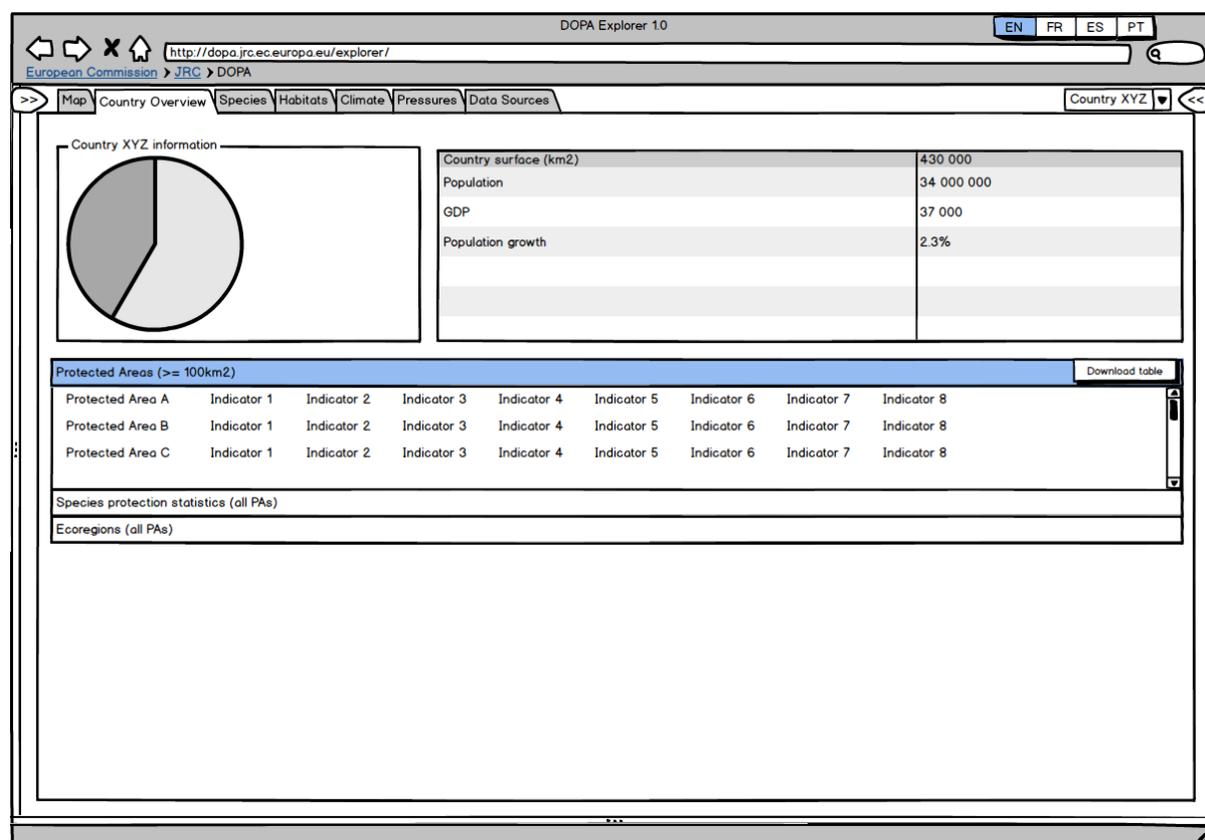


FIGURE 3. MOCK-UP REPRESENTATION OF THE DOPA EXPLORER 1.0 SHOWING THE “COUNTRY OVERVIEW” TAB WHICH BECOMES ACTIVE ONCE A COUNTRY HAS BEEN SELECTED. THIS TAB PROVIDES ACCESS TO THE CORE TABLES SUMMARIZING THE INDICATORS AND STATISTICS PROPOSED BY THE DOPA.

Tips:

Each column in the tables can be sorted alphabetically/numerically by a single mouse click on the header of each column. The order of columns can also be re-arranged by dragging and dropping columns. Each column can be resized by expanding the size of the header with the mouse.

All tables can be saved in an Excel format on your computer by using the download option available in the upper right corner of each table border. 

Note that the table headers also contain information about the total number of ecoregions and protected areas, including the number of marine, terrestrial or mixed protected areas.

3.3. Step 3: Selecting and analysing protected areas at the country level

Selecting a protected area can be done directly by clicking on it in the mapping interface, or by selecting a protected area from the list presented in the Country Overview tab. As soon as a protected area is selected, it will be highlighted in green in the tables and the right navigation panel will appear, showing the core information about the protected area in a radar plot. The panel below the radar plot indicates essential statistics about the ecoregion(s) found in the selected protected areas (highlighted in green). As for all panels, the right information panel can be opened or closed at any time using the arrow button  on the upper right corner of the window (Figure 4).

The radar plot can be considered as the “signature” of the protected area. It allows a user to contrast the values for a number of indicators computed in the protected area (in red) against the averages of the same indicators computed at the country level (in grey).

Once a protected area is selected, all tabs will become active, allowing end users to further explore each protected area in more detail regarding its species, habitats, climate and prevailing pressures.

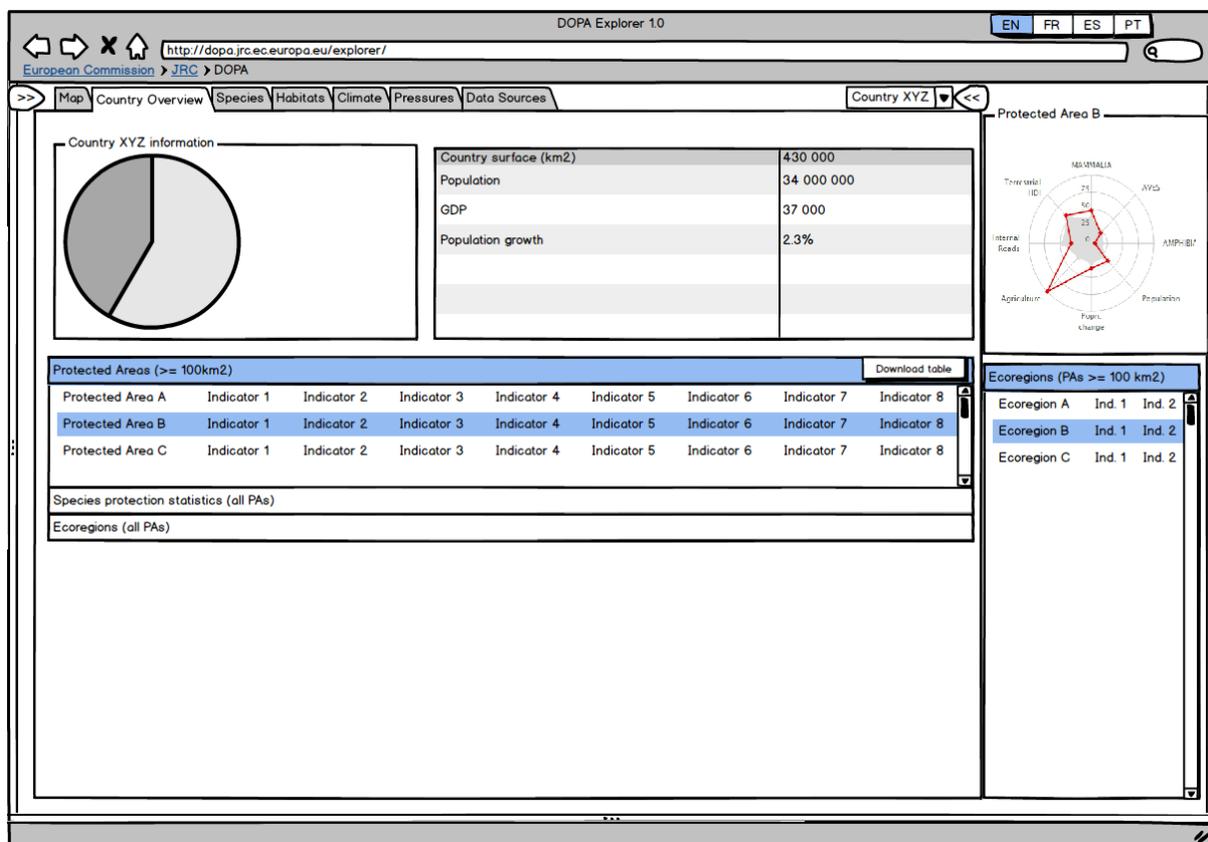


FIGURE 4. MOCK-UP REPRESENTATION OF THE DOPA EXPLORER 1.0 SHOWING THE RIGHT PANEL WHICH BECOMES ACTIVE WHEN A PROTECTED AREA IS SELECTED. THE RIGHT PANEL PRESENTS A RADAR PLOT ALLOWING END USERS TO EASILY CONTRAST THE INDICATORS OF THE PROTECTED AREA AGAINST THE AVERAGE VALUE OF THESE INDICATORS FOUND AT THE COUNTRY LEVEL.

Tips:

Once a protected area is selected, the mapping window will be centred on the selected area.

Individual ecoregions can be displayed on the map but only through the “Species” and the “Pressures” tab, as explained in the next section.

Radar plots may occasionally lack information for some indicators. This can happen when the indicator cannot be computed for logical reasons (no marine HDI is computed for a terrestrial protected area and vice versa) or because of geometrical issues encountered with the input data. Nearly 16,000 protected areas are described in DOPA Explorer 1.0 using automated processing components from the DOPA, and errors can be encountered when the geometry of the protected area is not properly defined.

3.4. Step 4: Thematic analyses of protected areas and ranking

Each selected protected area $\geq 100 \text{ km}^2$ is further documented at the site level according to:

Species: indicative list of species from the IUCN Red List of Threatened Species, indicators on species irreplaceability (SII) and species coverage (SCI)

Habitats: the percentage of coverage by different land cover classes is provided

Climate: monthly climatic trends and elevation profile.

Pressures: estimated pressures due to population density and population growth, agriculture and roads (internal and external).

These indicators are briefly described in the “Data sources” tab of the interface and documented further in this report.

When selecting one of these themes, histograms will present the ranking of the protected area against all the other protected areas found in the country (Figure 5). When further selecting one of the ecoregions from the lower right panel using the check boxes, the ranking will also be computed for all the protected areas found within the selected ecoregion, beyond the boundaries of the country. Figure X illustrates the interface displayed when investigating the Species Coverage indicator for a selected protected area at the country and ecoregion levels.

Most charts are interactive and can be used to identify other protected areas. Selecting, for example, the protected area with the highest score in terms of species irreplaceability in a histogram, will update the map, tables and charts to match the newly selected protected area.

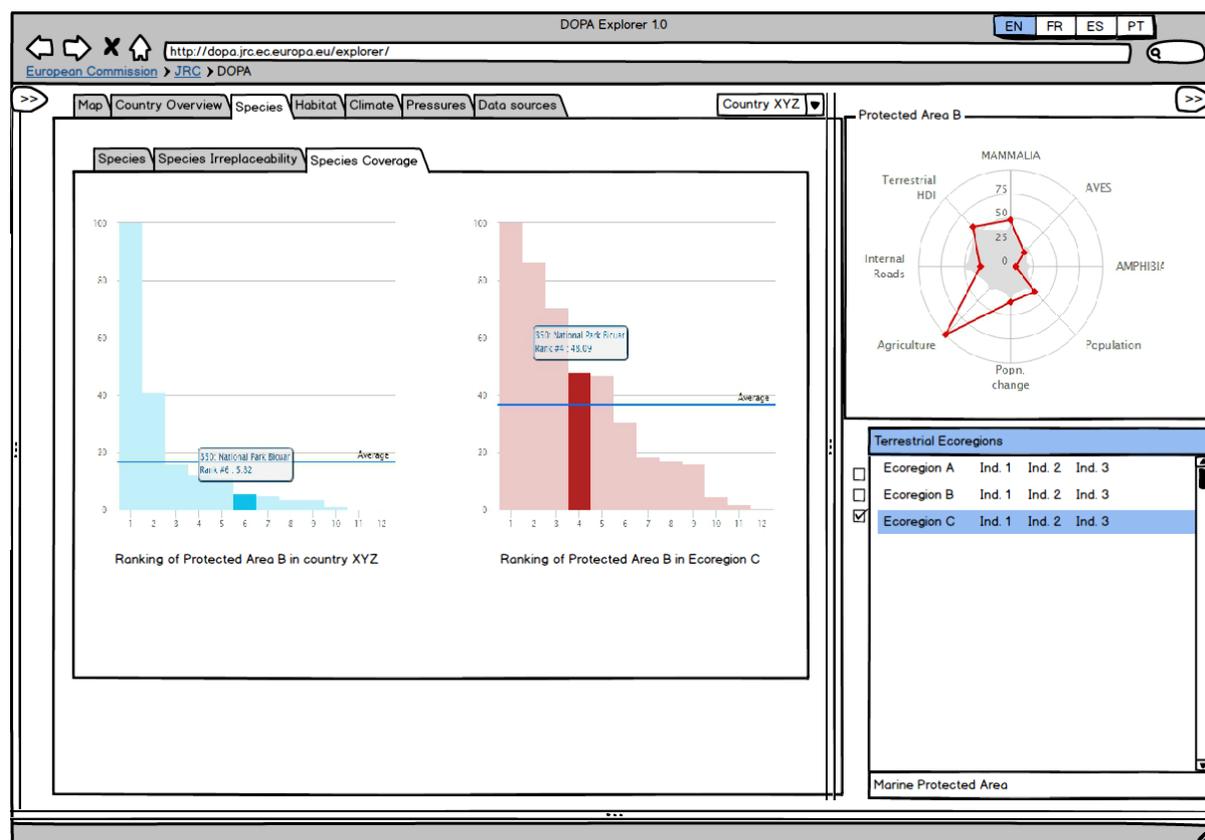


FIGURE 5. MOCK-UP REPRESENTATION OF THE DOPA EXPLORER 1.0 SHOWING BY MEANS OF HISTOGRAMS THE RANKING OF THE SELECTED PROTECTED AREA ACCORDING TO AN INDICATOR (HERE THE SPECIES COVERAGE INDICATOR) AT THE COUNTRY LEVEL AND AT THE LEVEL OF THE ECOREGION SELECTED IN THE RIGHT PANEL.

Tips:

When an ecoregion is selected, its boundaries will be displayed in red in the mapping window.

Note that road pressures are NOT computed at the ecoregion level because of the large discrepancies in the regional homogeneity of the road data.

The country-level histograms are based on the same indicator data that is included in the “Protected areas” summary table in the Country Overview tab. These histograms (or similar graphs) can therefore be easily recreated after downloading the “Protected areas” summary table.

4. Protected areas and coverage statistics

4.1 From raw data to summary indicators

To help identifying protected areas which have the greatest value, in terms of biological resources, and of those which are the most threatened by human development, access to raw data is not sufficient. This vast amount of data needs to be summarized into information that is useful for decision making.

Wherever possible, DOPA Explorer 1.0 uses existing indicators from the scientific literature, which we try to update when improved information becomes available. In other cases, where no indicators are known to us from the scientific literature, new proposals are made.

In the following, we will document the use of the raw data when producing three groups of indicators:

- 1) Indicators on the biological diversity and species irreplaceability in protected areas;
- 2) Indicators on the pressures to which protected areas are exposed;
- 3) Indicators on the ecological uniqueness of protected areas.

Where possible, we will refer to the literature for additional discussions on the methodologies.

4.2. Boundaries and coverage statistics

4.2.1. Use of the World Database on Protected Areas (WDPA)

The boundaries and IUCN management category of the protected area presented in DOPA Explorer 1.0 come from the **World Database on Protected Areas (WDPA)**⁶ managed by the UNEP World Conservation Monitoring Centre (UNEP-WCMC) that is the biodiversity assessment and biodiversity policy support arm of the United Nations Environment Programme (UNEP). Since 1981 UNEP-WCMC has been identifying and compiling information on the protected areas of the world to produce this comprehensive global spatial dataset known as the WDPA. UNEP-WCMC's work on protected areas is carried out in close collaboration with the IUCN World Commission on Protected Areas and the IUCN Programme on Protected Areas.

DOPA Explorer 1.0 is providing different information on two subsets of protected areas in the WDPA:

- **All designated protected areas recorded in the August 2014 version of the WDPA with defined boundaries or defined central point locations and a reported area** (around 206 000 protected areas) to document overall country and ecoregion statistics. In line with best practice (Juffe-Bignoli et al., 2014), we excluded all protected areas with a “proposed” or “not reported” status from these analyses, and we also excluded the UNESCO Man and Biosphere Reserves because many of their buffer areas do not meet the IUCN protected area definition.
- **As a subset of the above, all designated protected areas with defined boundaries and with a surface greater or equal to 100 km².** This subset of nearly 16,000 protected areas covers more than 95% of the total surface of the global protected area system and is documented in DOPA Explorer 1.0 in more detail at the site level in terms of species, habitats, climate and pressures.

Where applicable, the interface of DOPA Explorer 1.0 will indicate whether the statistics are derived from all protected areas or from the subset of protected areas that are larger than 100 km².

⁶ <http://www.protectedplanet.net/>

While we recognize the essential contribution of smaller areas in preserving biodiversity, and the importance of other types of conservation areas (in particular Indigenous Peoples' and Community Conserved Territories and Areas (ICCAs)) in preserving biodiversity, we have restricted ourselves for the time being to the processing of a limited amount of geospatial information. The threshold of 100 km² allows us to focus on the larger areas while covering at the same time 95% of all the protected land.

Note the latest information on protected areas is always available from the WDPA which is updated and released via www.protectedplanet.net on a monthly basis. The information provided includes the name of the protected areas, their status, designation and designation type, their year of designation, the reported surface and the IUCN management category. We elected to use the August 2014 version as this is known to be more thoroughly reviewed than other months, due to it being the basis of the Protected Planet report.

4.2.2. Marine, terrestrial and mixed protected areas

In contrast to the previous version, DOPA Explorer 1.0 makes a first attempt to classify automatically protected areas into three categories:

- 1) Terrestrial areas for those areas falling exclusively on land (including inland waters),
- 2) Marine areas for those areas falling exclusively in seas,
- 3) Mixed when the protected areas consist of parts falling in both categories.

Because we have converted all protected areas into grids of 1 km², the conversion process of vector information into grids leads inevitably to some uncertainties which we estimate to be of little impact on the summary information provided at country and ecoregion level.

End users of DOPA Explorer 1.0 will also find means to display a European subset of the WDPA, the Natura 2000 sites. Natura 2000 is an EU wide network of protected areas established under the 1992 Habitats Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. We distinguish in Natura 2000⁷ two types of sites which can be displayed independently in DOPA Explorer 1.0:

- 1) Sites of Community Importance (SCIs) for habitat types listed in Annex I and species listed in Annex II of the Habitat Directive;
- 2) Special Protection Areas (SPAs) designated by Member States under the 1979 Birds Directive to protect bird species listed in Annex I of the Directive as well as migratory species.

Data on Natura 2000 sites is maintained by the European Environment Agency (EEA). The EEA also reports this data to UNEP-WCMC for inclusion in the WDPA.

In summary, DOPA Explorer 1.0 provides end users with summary information for all protected areas that are larger than 100 km², i.e. nearly 16,000 protected areas across the globe, covering 95 percent of the area covered by all protected areas included in the WDPA.

Following our classification into marine, terrestrial and mixed areas, we have described in DOPA Explorer 1.0 a total of 15,814 protected areas, including

- 12,479 terrestrial protected areas
- 397 marine protected areas
- 2,938 mixed protected areas

⁷ See e.g. http://bd.eionet.europa.eu/activities/Natura_2000/index.html

Some protected areas (1,733) are reported in the WDPA with a central point location and a reported area but without exact boundaries. **These protected areas are displayed by circles in the DOPA Explorer map window and taken into account (as buffered points) only when generating country and ecoregion statistics (for all PAs) but excluded from all site level analyses** as the exact location is of high importance for the computation of protected area indicators.

One will also regularly encounter duplicates in the names of protected areas (e.g. two records for Virunga National Park). These duplicates can be errors within the WDPA coming from the reporting countries or may simply correspond to different legal designation types concerning the same area (e.g. Virunga National Park is also a World Heritage site).

4.3. IUCN Protected Area Management Categories

Protected areas are classified by the IUCN according to their management objectives (see Dudley, 2008). The IUCN Protected Areas Management Categories are recognised by international bodies such as the United Nations and by many national governments as the global standard for defining and recording protected areas and as such are increasingly being incorporated into government legislation. These management categories of protected areas are summarized hereafter⁸:

Ia Strict Nature Reserve

Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values.

Ib Wilderness Area

Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

II National Park

Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities

III Natural Monument or Feature

Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

IV Habitat/Species Management Area

Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

V Protected Landscape/ Seascape

A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its

⁸ http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/

associated nature conservation and other values.

VI Protected area with sustainable use of natural resources

Category VI is a more encompassing classification that is based on a mutually beneficial relationship between nature conservation and the sustainable management of natural resources in correspondence the livelihoods of surrounding communities. A wide range of socio-economic factors are taken into consideration in creating local, regional and national approaches to the use of natural resources.

Where the national authorities that submit protected area data to UNEP-WCM for inclusion in the WDPA do not provide information on management categories, these protected areas fall in the “not reported” or “not assigned” categories.

4.4. Country coverage statistics

The country information panel in DOPA Explorer shows the total number of protected areas in the country as reported in the WDPA. The statistics regarding the country average, however, are based exclusively on the protected areas in the country that are $\geq 100 \text{ km}^2$. In particular, we show the total surface of all these protected areas (in km^2), and the total surface of terrestrial vs marine protected areas (in km^2 and as % of the country’s land and sea area). A pie chart also highlights the contribution of the different management categories of protected areas (Figure 6).

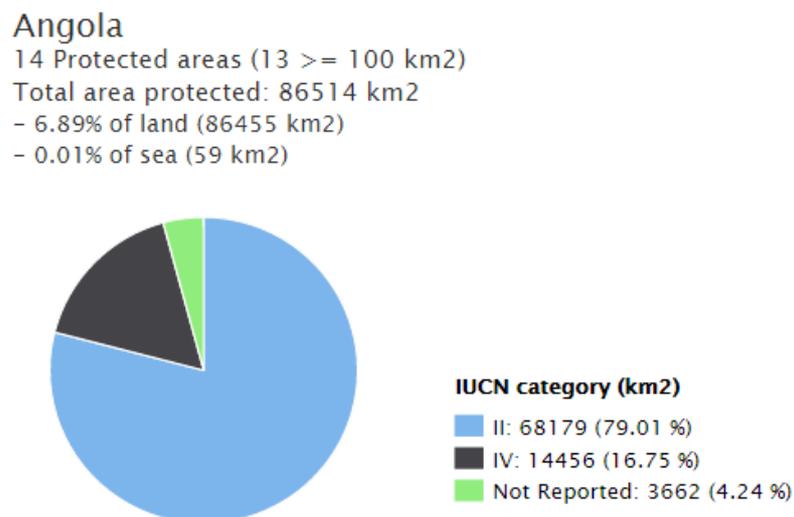


FIGURE 6. COUNTRY INFORMATION IN DOPA EXPLORER SHOWING THE TOTAL NUMBER OF PROTECTED AREAS, SURFACE OF THE COUNTRY AND THE SURFACE PROTECTED BY THE DIFFERENT MANAGEMENT CATEGORIES OF PROTECTED AREAS. THE PERCENTAGES NEAR THE SURFACES COVERED BY EACH MANAGEMENT CATEGORY CORRESPOND TO THE PERCENTAGES OF THE TOTAL PROTECTED SURFACE OF THE COUNTRY. WHERE DIFFERING PROTECTION LEVELS OVERLAP, THE AREA OF PROTECTION IS ATTRIBUTED TO THE PROTECTION LEVEL WITH THE HIGHER PRECEDENCE. FOR EXAMPLE IF AN IUCN CATEGORY II PA OVERLAPS A CATEGORY IV PA, THE AREA OF OVERLAP IS CONSIDERED AS LEVEL II AND IS NOT COUNTED IN THE LEVEL IV STATISTIC.

For the analyses we used a custom dataset to define the political boundaries, created with the World Maritime Boundaries, plus the boundaries from the 2008 Global Administrative Unit Layers (HarvestChoice, 2014) which were edited to include South Sudan. Coastlines were entirely defined by the ecoregion definitions (see next section).

The statistics regarding the protection of land cover both land and inland waters. The statistics corresponding to the seas have been calculated by looking at the percentage of protection of the marine area found within the 200 nautical miles (370 km) out from the coastal baseline, an area corresponding to the exclusive economic zone (EEZ) of the country.

Note that, following best practice, country and ecoregion statistics are all derived from dissolved layers because of possible spatial overlaps between protected areas in the database. Although we have tried to follow as much as possible the procedures used by UNEP-WCMC for protected area coverage analyses, our protection statistics can differ from other sources because of small differences in the datasets (e.g. country boundaries) and methods (e.g. projections, vector vs raster, rounding) used.

It is also important to stress that **the boundaries and names shown in the maps do not imply that these are officially endorsed by the European Commission.**

4.5. Ecoregion coverage statistics

4.5.1. The terrestrial and marine ecoregion maps

Protected area coverage was also calculated for terrestrial and marine ecoregions because these represent ecologically more meaningful entities to compare protected areas than administrative boundaries (e.g. comparing a protected area found in a rainforest with one falling in a dry area may not be very useful). The terrestrial and marine ecoregion boundaries used in DOPA Explorer 1.0 are provided by the WWF. The Terrestrial Ecoregions of the World (TEOW) data set⁹ identifies 827 ecoregions (Olson et al., 2001). The Marine Ecoregions of the World (MEOW) data set¹⁰ includes 232 ecoregions (Spalding et al., 2007).

4.5.2. Protection statistics of the ecoregions

The Ecoregion (all PAs) summary table provides statistics computed using all of the protected areas from the WDPA as described in section 4.2.1 (Figure 7).

Ecoregions (all PAs) (3)					
Name	% in country	% protected in country	% protected worldwide	% country covered	Country contribution
Atlantic mixed forests	5.70	14.67	19.68	66.87	4.25
Western European broadleaf forests	1.58	46.51	29.53	22.93	2.50
North Sea	0.56	36.74	15.43	10.20	1.34

FIGURE 7. ECOREGION INFORMATION IN DOPA EXPLORER DESCRIBING THE TERRESTRIAL AND MARINE ECOREGIONS FOUND IN THE COUNTRY, AND THE CONTRIBUTION OF THE COUNTRY TO THEIR PROTECTION. THE TABLE CAN BE DOWNLOADED IN AN EXCEL SPREADSHEET BY USING THE DOWNLOAD OPTION FOUND IN THE UPPER RIGHT CORNER OF THE INTERFACE

Using the terrestrial and marine ecoregions maps provided by the WWF, we analyse their level of protection at the global scale and at the country level. From left to right, the table will show

- The **Name** of the terrestrial and marine ecoregions as defined by the WWF. Marine ecoregions are highlighted in light blue in our tables.
- **% in country** indicates the percentage area of the ecoregion that is found in the country.
- **% protected in country** indicates the percentage of the ecoregion area in the country that is protected considering all of the PAs from the WDPA.
- **% protected worldwide** indicates the percentage of the global ecoregion area that is protected considering all of the PAs from the WDPA.
- **% country covered** shows for the selected country the percentage of the country's land and sea

⁹ <http://worldwildlife.org/publications/terrestrial-ecoregions-of-the-world>

¹⁰ <https://www.worldwildlife.org/publications/marine-ecoregions-of-the-world-a-bioregionalization-of-coastal-and-shelf-areas>

area (sea area from the coastal baseline to the outer limit of the marine ecoregions – usually the 200m isobaths) covered by the terrestrial and marine ecoregions respectively, so that the percentages for marine and terrestrial ecoregions each add up to 100%.

- **Country contribution** will show how much (in %) the country is contributing to the overall protection of the ecoregion (if an ecoregion is entirely restricted to one country, this will always be 100% if there are any protected areas covering the ecoregion in full or part).

5. Characterization and ranking of protected areas

The overall objectives of DOPA Explorer 1.0 are to:

1. contribute to a systematic identification of the protected areas which have the greatest value, in terms of biological resources, and of those which are the most threatened by human development;
2. contribute to the distribution of baseline information for subsequent validation;
3. propose means for repeated assessments in a pressure – state – response framework, where threats are “pressures”, species and habitats define “state” and the management decisions and actions are “response”;
4. provide means and tools for accessing raw data for further research, management and/or reporting purposes.

DOPA Explorer 1.0 summarizes most indicators computed at the site level by means of histograms, radar plots and tables at the country and ecoregion level, as these are most useful for decision making. For example, each protected area is characterized by a radar plot showing the “scores” of the indicators against the country average (Figure 8). Similarly, the same indicators are contrasted by means of histograms against the indicators of all other protected areas found within the same ecoregion. Should an indicator not be available for a given protected area, the red dot associated to this indicator will not be shown. This can occasionally happen for a number of computational reasons that are usually due to topological errors in the input datasets (remember that all indicators are computed automatically for all of the 16,000 protected areas).

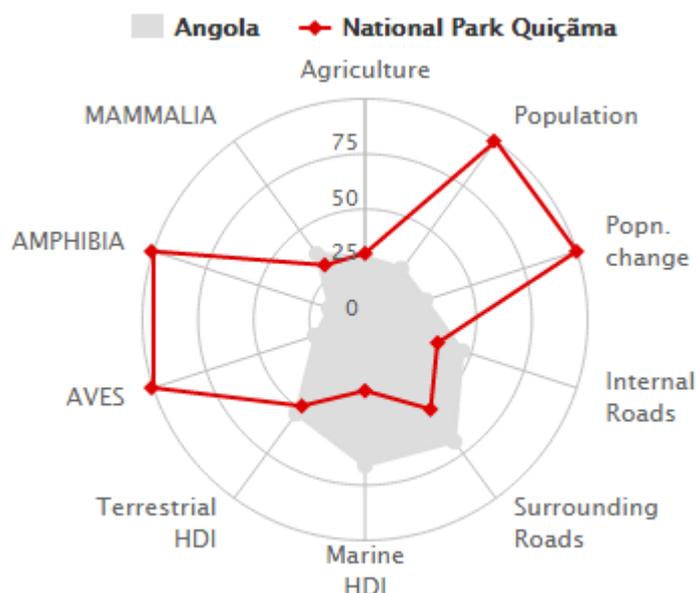


FIGURE 8. RADAR PLOT SHOWING 10 INDICATORS FROM 3 THEMATIC AREAS (SPECIES, HABITATS, PRESSURES) FOR A SELECTED PROTECTED AREA (IN RED) CONTRASTED AGAINST THE AVERAGE VALUES (IN GREY) OF THE SAME INDICATORS COMPUTED FOR ALL THE PROTECTED AREAS OF THE COUNTRY. EACH INDICATOR HAS BEEN SCALED FROM 0 (LOWEST) TO 100 (HIGHEST) TO ALLOW COMPARISON. THE RED DOTS INDICATE THE INDICATORS WHICH COULD BE COMPUTED (IN THIS CASE ALL INDICATORS COULD BE GENERATED). THE PRESENCE OF VALUES FOR BOTH THE TERRESTRIAL AND MARINE HDIs (HABITAT DIVERSITY INDICES) REPRESENTS A COASTAL PROTECTED AREA WITH A MODERATE ECOLOGICAL DIVERSITY. THE FIGURE CAN BE INTERPRETED AS A PROTECTED AREA THAT IS MOST IMPORTANT IN THE COUNTY FOR BIRDS AND AMPHIBIANS, BUT LESS IMPORTANT FOR MAMMALS. IN TERMS OF PRESSURES, THE AREA SEEMS TO BE EXPOSED TO LITTLE AGRICULTURAL PRESSURE BUT TO RELATIVELY HIGH POPULATION PRESSURE WHILE ROADS (WITHIN AND AROUND THE AREA) ARE ONLY MODERATELY CONTRIBUTING TO PRESSURES.

5.1. Comparing and ranking protected areas within a country

The Country Overview tab presents the list of PAs $\geq 100 \text{ km}^2$ that are found in the country. Each of these protected areas is described by 12 indicators and parameters which are at the core of the whole information system (Figure 9). The header of the table will indicate the number of the PAs $\geq 100 \text{ km}^2$ found in the country that are terrestrial, marine, or mixed (coastal areas). The indicators proposed here are discussed individually in the other chapters.

Protected areas ($\geq 100 \text{ km}^2$) - Total number : 26. Terrestrial (16), Marine (4), Mixed (6)												
Name	Area (km2)	Type	Segment no.	Terrestrial ...	Marine HDI	Species Irr.	Popn. Pres...	Agr. Pressure	Ext. Roads	Int. Roads	Popn Change	IUCN cat.
Belize Barrier Reef Reserve System	1158	TM	1	4.72	4.69	0	15.73	0.47	0.88	0.04	0.88	Not Assign
Chiquibul	1068	TE	3	2.88	-	0.56	6.64	4.24	7.77	3.1	7.77	VI
Rio Bravo Conservation & Management	1048	TE	2	1.95	-	0.07	7.4	8.53	10.45	4.93	10.45	IV
Corozal Bay	731	TM	1	6.41	3.12	0	18.59	5.85	4.85	0.44	4.85	IV
Columbia River	599	TE	1	1.28	-	0.17	4.36	4.97	8.11	7.07	8.11	VI
Chiquibul	598	TE	1	1.28	-	0.26	6.59	2.59	6.86	10.85	6.86	VI
Cockscomb Basin	495	TE	1	1.41	-	0.11	8.73	1.92	7.67	4.3	7.67	IV
South Water Caye	477	MA	1	31.63	2.43	0	-	0.96	2.01	0	2.01	IV
Mountain Pine Ridge	433	TE	2	3.02	-	0.12	8	2.69	8.39	17.28	8.39	VI
Bladen	405	TE	1	1.56	-	0.14	4	2.03	7.91	6.25	7.91	Ia
Port Honduras	404	TM	1	22.3	1.73	0	4	1.43	3.43	0	3.43	IV
Sibun	390	TE	2	3.2	-	0.1	8.47	2.18	8.66	3.82	8.66	VI
Sittee River	373	TE	1	1.64	-	0.06	9.82	2.01	7.69	0.26	7.69	VI
Manatee	364	TE	3	4.95	-	0.03	16.9	1.84	8.59	7.59	8.59	VI
Glover's Reef	327	MA	1	1.74	4.84	0	-	0	0	0	0	IV
Deep River	272	TE	2	3.83	-	0.03	4	1.78	6.4	19.73	6.4	VI

FIGURE 9. SUMMARY TABLE COMPILING THE INDICATORS OBTAINED FOR ALL THE DOCUMENTED PROTECTED AREAS FOR THE SELECTED COUNTRY. THE TABLE CAN BE DOWNLOADED IN AN EXCEL SPREADSHEET BY USING THE DOWNLOAD OPTION FOUND IN THE UPPER RIGHT CORNER OF THE INTERFACE

- **Name:** the name of the protected area as provided by the WDPA.
- **Area (km²):** the calculated surface of the protected area in km².
- **Type:** protected areas have been classified here as Terrestrial (TE), Marine (MA) or Mixed (TM) if both environments are found, a typical case for coastal areas. This classification is purely based on the geometrical properties of the protected area.
- **Segment no.:** the number of distinct habitats identified automatically following a segmentation process. The higher the number of segments, the more diverse is the environment. Obviously, the larger the protected area, the higher the likelihood to find different habitats. To compensate for the “size” impact, we propose additionally the Habitat Diversity Index (HDI).
- **Terrestrial HDI:** the Terrestrial Habitat Diversity Index (Terrestrial HDI) is a measure derived from the number of segments. To allow a comparison of the terrestrial habitats across a wide range of sizes, we compute the HDI for the terrestrial protected area by dividing its number of segments by the square root of the area (km²) and then multiply the result by 1000. Note that coastal areas will have both a Terrestrial and a Marine HDI.
- **Marine HDI:** the Marine Habitat Diversity Index (Marine HDI) is obtained by calculating the standard deviation of bathymetry. This measure has been used to identify habitats most likely to support a larger variety of species as topographic complexity is correlated to species diversity. The value presented as the HDI has been log-transformed in order to generate meaningful distinctions across a wide range of values. Note that coastal areas will have both a Terrestrial and a Marine HDI.
- **Species Cov:** the Species Coverage Index (SCI) is computed for each protected area to take into account the number of species from three taxa (birds, mammals, and amphibians). The higher the value of the SCI, the higher the number of endemic species in the protected area and the more important is the role of this area for conserving biodiversity.
- **Species Irr:** the Species Irreplaceability Indicator (SII) (adopted from Le Saout et al., 2013) takes into account the number of species and their endemism using three taxa (birds, mammals,

amphibians) from the IUCN Red List of Threatened Species. The higher the value, the higher the importance of the protected area for species conservation.

- **Pop. Pressure:** the Population Pressure Index (PPI) is the average population density in a buffer area representing 3 hours of travelling time around each protected area (Hartley et al., 2007). The higher the value, the higher the pressure on the PA.
- **Agr. Pressure:** the Agricultural Pressure Index (API) is based on the percentage of cropland found around (30 km buffer zone) protected areas. The higher the value, the higher the pressure on the protected area.
- **Ext. Roads:** External Road Pressures are calculated using information on the number of roads around (30 km buffer zone) protected areas. The pressure values are normalized by country only, not by ecoregion, due to differences between countries in the density and detail of the road data supplied. The higher the value, the higher the pressure on the protected area.
- **Int. Roads:** Internal Road Pressures are calculated using information on the number of roads within protected areas. The pressure values are normalized by country only, not by ecoregion, due to differences between countries in the density and detail of the road data supplied. The higher the value, the higher the pressure on the protected area.
- **Pop. Change:** The percentage of change in the population between 1990 and 2000, with the 1990 value as a baseline, calculated around PAs (30 km buffer zone). The higher the value, the higher the increase of the population and subsequent pressure on the PA.
- **IUCN Cat.:** The IUCN management category of the PA.

5.2. Comparing and ranking protected areas within an ecoregion

Below the radar plot of each protected area, one will find a summary table similar to the one discussed in section 4.5.2 showing the protected area coverage statistics for ecoregions. A notable difference is that those ecoregions that are covered, even partially, by the selected protected area, are highlighted in green (Figure 10).

Ecoregions (all PAs) (18)				
Name	% in c.	% prot.	T/M	% of c.
Namibian savanna woodlands	14.90	40.73	T	2.68
Angolan	100.00	0.07	M	72.14
Kaokoveld desert	45.64	41.44	T	1.67
Namib	10.03	0.33	M	11.37
Angolan Miombo woodlands	95.62	5.54	T	50.40
Western Congolian forest-savanna...	41.05	0.03	T	13.55
Zambeziian Baikiaea woodlands	49.69	11.51	T	10.49
Angolan scarp savanna and woodl...	100.00	11.60	T	5.94
Southern Congolian forest-savann...	10.32	0.00	T	4.70
Angolan Mopane woodlands	38.39	6.80	T	4.09
Central Zambeziian Miombo woodl...	3.45	0.25	T	3.26
Angolan montane forest-grassland...	100.00	0.00	T	2.04
Gulf of Guinea South	20.02	0.01	M	16.49

FIGURE 10. SUMMARY TABLE SHOWING KEY COVERAGE STATISTICS AT THE ECOREGION LEVEL. IN GREEN ARE HIGHLIGHTED THE ECOREGIONS ENCOUNTERED IN THE SELECTED PROTECTED AREA.

In the next sections, we describe the various indicators used to characterize each protected area. These indicators can be used to rank the protected areas at the country level, but also to rank these

at the ecoregion level. When an indicator is selected, end users will find again under each radar plot the table with the list of ecoregions with an additional check box on the left side (Figure 11). By selecting an ecoregion, the chart showing the ranking of the protected area for the selected indicator will be shown at the ecoregion level. This ranking can be obtained for the Species Coverage, Species Irreplaceability, Population Pressure, Population Growth and Agricultural Pressure indicators.

Ecoregions (all PAs) (18)					
Show	Name	% in c.	% prot.	T/M	% of c.
<input type="checkbox"/>	Namibian savanna woodlands	14.90	40.73	T	2.68
<input checked="" type="checkbox"/>	Angolan	100.00	0.07	M	72.14
<input type="checkbox"/>	Kaokoveld desert	45.64	41.44	T	1.67
<input type="checkbox"/>	Namib	10.03	0.33	M	11.37
<input type="checkbox"/>	Angolan Miombo woodlands	95.62	5.54	T	50.40
<input type="checkbox"/>	Western Congolian forest-savanna...	41.05	0.03	T	13.55
<input type="checkbox"/>	Zambeziian Baikiaea woodlands	49.69	11.51	T	10.49
<input type="checkbox"/>	Angolan scarp savanna and woodl...	100.00	11.60	T	5.94
<input type="checkbox"/>	Southern Congolian forest-savann...	10.32	0.00	T	4.70
<input type="checkbox"/>	Angolan Mopane woodlands	38.39	6.80	T	4.09
<input type="checkbox"/>	Central Zambezian Miombo woodl...	3.45	0.25	T	3.26
<input type="checkbox"/>	Angolan montane forest-grassland...	100.00	0.00	T	2.04

FIGURE 11 SUMMARY TABLE SHOWING KEY COVERAGE STATISTICS AT THE ECOREGION LEVEL. IN GREEN ARE HIGHLIGHTED THE ECOREGIONS ENCOUNTERED IN THE SELECTED PROTECTED AREA. WHEN AN ECOREGION IS SELECTED (LEFT CHECK BOX), THE SELECTED PROTECTED AREA WILL SHOW ITS RANKING FOR A GIVEN INDICATOR AGAINST ALL OTHER PROTECTED AREAS FOUND IN THE ECOREGION. THE ECOREGION WILL ALSO APPEAR ON THE MAP (LIGHT GREY SHADED POLYGON WITH RED BORDERS).

6. Species information

6.1. Species distribution

The indicators and information on species used in DOPA Explorer 1.0 are derived from the **IUCN Red List of Threatened Species**¹¹ which is the most comprehensive and authoritative source on the conservation status of biodiversity. The Red List is managed by the International Union for Conservation of Nature (IUCN) with the support of the Red List Partners, namely BirdLife International, Botanic Gardens Conservation International, Conservation International, Department of Animal and Human Biology, La Sapienza University of Rome, Microsoft Research, NatureServe, Royal Botanic Gardens, Kew, Texas A&M University, Wildscreen, and the Zoological Society of London.

Global species richness maps for birds, amphibians and mammals from the August 2014.2 version of the Red List have been made available in DOPA Explorer's mapping interface and the species range polygons for all species from the Red List have further been intersected with the boundaries of all protected areas to produce indicative species lists for the protected areas. In summary, the species distribution maps have been rasterized in the DOPA on a 1 km grid and used here in two ways:

- 1) the **globally assessed taxonomic groups of mammals, birds and amphibians** (20,463 species) have been used across all protected areas and are the data behind all species indicators used in DOPA Explorer 1.0, namely the Species Irreplaceability Indicator (SRI) and the Species Coverage Indicator (SCI);
- 2) **other taxonomic groups** (e.g. Insecta, Reptilia, Bivalvia, ...) from the Red List which have been **assessed mainly locally**, an additional set of 15,427 species, have been used for descriptive purposes only.

Overall, the species distribution maps used cover 35,890 species. These maps invariably represent current, known limits of distribution for individual species within their native historical range. Although these maps have many uses, they generally have a coarse resolution and consequent limitations. The species analyses are computed using the distribution range data for species that are categorized with the following attributes: the presence is either extant or probably extant; the origin is either native or introduced and the seasonality is breeding, non-breeding or resident.

Species included in the Red List are classified into the following nine Red List categories based on Red List criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation:

- Extinct (EX) – No known individuals remaining.
- Extinct in the Wild (EW) – Known only to survive in captivity, or as a naturalized population outside its historic range.

Threatened species fall into one of the following three categories:

- Critically Endangered (CR) – Extremely high risk of extinction in the wild.
- Endangered (EN) – High risk of extinction in the wild.
- Vulnerable (VU) – High risk of endangerment in the wild.

All other species fall in these last categories:

- Near Threatened (NT) – Likely to become endangered in the near future.

¹¹ <http://www.iucnredlist.org/>

- Least Concern (LC) – Lowest risk. Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category.
- Data Deficient (DD) – Not enough data to make an assessment of its risk of extinction.
- Not Evaluated (NE) – Has not yet been evaluated against the criteria.

The IUCN Red List of Threatened Species is complete for some groups (mammals, birds, amphibians, sharks and rays, mangroves, seagrasses, cycads, conifers, and selected marine, freshwater and invertebrate taxa), but not complete for many others (e.g., reptiles). We therefore have generated our key species indicators for the three globally assessed major taxonomic groups of birds, mammals and amphibians only.

Species ranges are mapped as generalized polygons which often include areas of unsuitable habitat, and therefore species may not occur in all of the areas where they are mapped. In general, for range-restricted taxa, ranges are mapped with a higher degree of accuracy, sometimes down to the level of individual subpopulations, compared with more widely distributed species (Hoffmann, 2014).

6.2. Species richness, protection and endemism

The IUCN Red List of Threatened Species providing conservation status, and distribution information on taxa that are facing a high risk of global extinction can be directly used as such to assess the number of threatened species encountered in a protected area or a country.

We define hereafter the percentage of **protected species** as the percentage of the species with distribution maps falling at least partly in a protected area and **endemic species** as the species with distribution maps falling exclusively in the country.

While the species lists made available for each protected area are derived from the distribution maps of all of the 35,890 species from the Red List we rasterized on a 1km grid, the country statistics are computed only for the three taxonomic groups that have been globally assessed by IUCN. Species lists for each protected area can be downloaded directly in an Excel format.

Currently, the IUCN Red List data is largely based on expert opinion and the range maps are broad approximations for many species (especially species of least concern). Mapping scales also vary between taxa and species. Amphibians with an extent of occurrence of a few kilometres are likely to be mapped more precisely than a mammal which has a range of thousands of kilometres.

6.2.1. Species statistics within the country

Using the range maps of the IUCN Red List of Threatened Species, we computed some generic statistics about the bird, mammal and amphibian species potentially encountered in the country (Figure 12).

Species protection statistics (all PAs)								
Class	No. species	% protected	No. Globally Threatened (GT)	% GT protected	No. Endemic (E)	% E protected	No. Threatened Endemic (TE)	% TE protected
Aves	992	95.87	53	75.47	13	92.31	2	50.00
Mammalia	405	87.65	41	68.29	78	58.97	12	25.00
Amphibia	162	84.57	30	60.00	44	56.82	22	54.55

FIGURE 12. SPECIES PROTECTION STATISTICS FOUND IN THE COUNTRY OVERVIEW.

- **Class:** we use three classes of vertebrates to document species potentially found in the country: birds (Aves), mammals (Mammalia) and amphibians (Amphibia).
- **No. species:** the number of species in each class having a distribution range overlapping at least some part of the country.

- **% protected:** the percentage of these species having a distribution range overlapping at least in part with a protected area using all protected areas from the WDPA.
- **No. Globally Threatened (GT):** the number of species in each class that are falling in the categories of threatened species: Vulnerable (VU), Endangered (EN) or Critically Endangered (CR).
- **% GT protected:** the percentage of the globally threatened species found in the country having a distribution range overlapping at least in part with a protected area using all protected areas from the WDPA.
- **No. Endemic (E):** the number of species in each class with a distribution range completely contained within the country selected.
- **% E protected:** the percentage of endemic species having a distribution range overlapping at least in part with a protected area using all protected areas from the WDPA.
- **No. Threatened Endemic (TE):** the number of endemic species in each class that are falling in the categories of threatened species: Vulnerable (VU), Endangered (EN) or Critically Endangered (CR).
- **% TE protected:** the percentage of threatened endemic species having a distribution range overlapping at least in part with a protected area using all protected areas from the WDPA.

6.2.2. Species statistics within the protected areas

A list of species from the IUCN Red List of Threatened Species has been generated for each protected area $\geq 100 \text{ km}^2$. End users can thus compare relative numbers of species in the taxonomic group that have been documented as well as in each Red List category (Figure 13a,b). Note that selecting a single taxonomic class can be done by selecting the related bar in the histogram. This will allow you to display the classes of threats as well as the list of species for the selected taxon only.

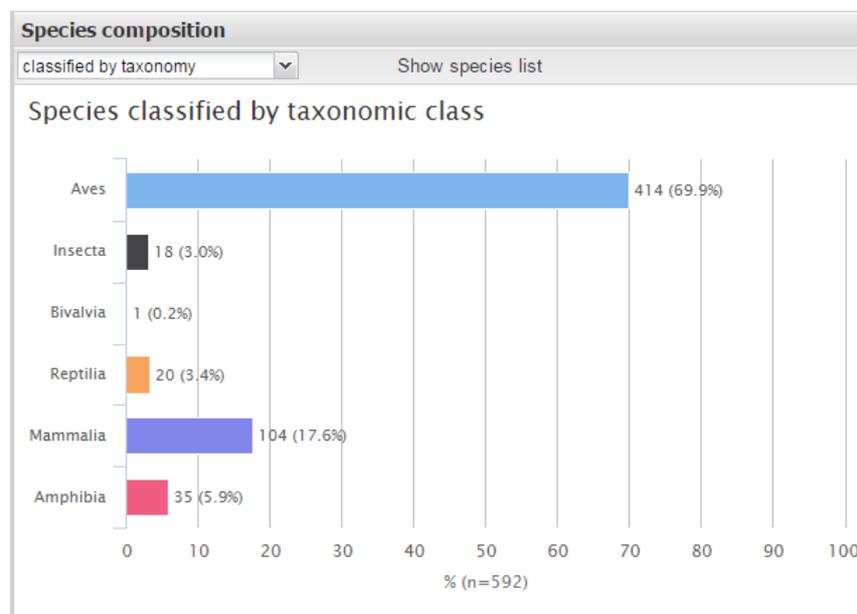


FIGURE 13A. INDICATIVE SPECIES COMPOSITION FROM THE IUCN RED LIST OF THREATENED SPECIES FOR A SELECTED PROTECTED AREA. THE CLASSIFICATION CAN BE DISPLAYED ACCORDING TO RED LIST TAXONOMY.

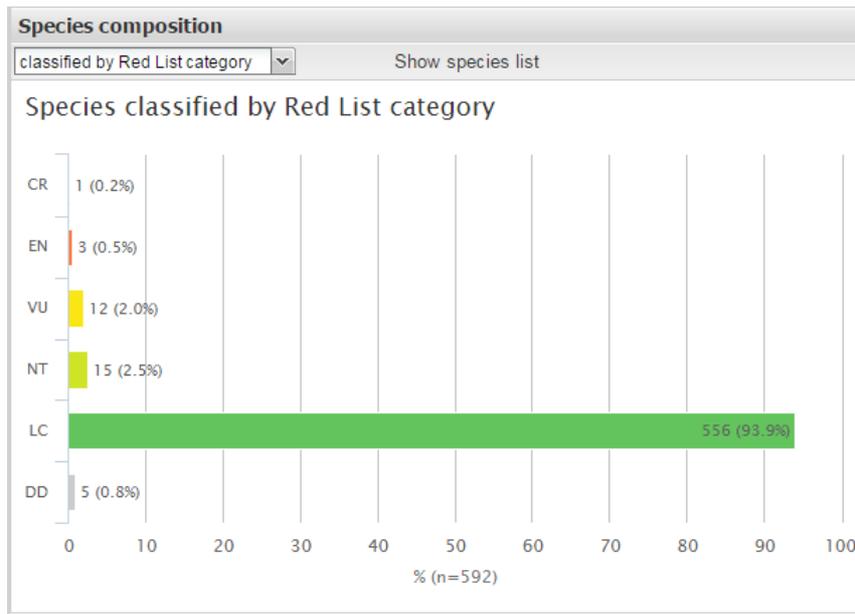


FIGURE 13B. INDICATIVE SPECIES COMPOSITION FROM THE IUCN RED LIST OF THREATENED SPECIES FOR A SELECTED PROTECTED AREA. THE CLASSIFICATION CAN BE DISPLAYED ACCORDING RED LIST CATEGORIES OF THREATS.

The “Show species list” option from the interface will display the species data. This table can be saved on your computer using the Download button found in the lower right corner of the window. Note that each column may be sorted by clicking on its header, thus re-ordering the whole table according to the values in that column (Figure 14).

Scientific name	Red List ...	Class	Order	Family
<i>Diceros bicornis</i>	CR	Mammalia	Perissodactyla	Rhinocerotidae
<i>Corbicula lamarckiana</i>	DD	Bivalvia	Veneroida	Corbiculidae
<i>Dasymys nudipes</i>	DD	Mammalia	Rodentia	Muridae
<i>Ichnotropis grandiceps</i>	DD	Reptilia	Squamata	Lacertidae
<i>Megalonitis bohemani</i>	DD	Insecta	Coleoptera	Scarabaeidae
<i>Trachylepis bayonii</i>	DD	Reptilia	Squamata	Scincidae
<i>Balearica regulorum</i>	EN	Aves	Gruiformes	Gruidae
<i>Gyps africanus</i>	EN	Aves	Accipitriformes	Accipitridae
<i>Necrosyrtes monachus</i>	EN	Aves	Accipitriformes	Accipitridae
<i>Accipiter badius</i>	LC	Aves	Accipitriformes	Accipitridae
<i>Accipiter minullus</i>	LC	Aves	Accipitriformes	Accipitridae
<i>Accipiter ovampensis</i>	LC	Aves	Accipitriformes	Accipitridae
<i>Accipiter tachiro</i>	LC	Aves	Accipitriformes	Accipitridae
<i>Acontias percivali</i>	LC	Reptilia	Squamata	Scincidae
<i>Acrocephalus arundinaceus</i>	LC	Aves	Passeriformes	Sylviidae
<i>Acrocephalus gracilirostris</i>	LC	Aves	Passeriformes	Sylviidae
<i>Acrocephalus rufescens</i>	LC	Aves	Passeriformes	Sylviidae
<i>Acrocephalus schoenobaenus</i>	LC	Aves	Passeriformes	Sylviidae
<i>Acrocephalus scirpaceus</i>	LC	Aves	Passeriformes	Sylviidae
<i>Acrotylus patruelis</i>	LC	Insecta	Orthoptera	Acrididae

FIGURE 14. INDICATIVE SPECIES COMPOSITION FROM THE IUCN RED LIST OF THREATENED SPECIES FOR A SELECTED PROTECTED AREA EXTRACTED IN A TABULAR FORMAT.

We cannot stress enough that species will not necessarily be present in the protected area, since the distribution maps are not depicting a homogeneous distribution of the species.

Species statistics at the country level are the result of a very theoretical exercise purely based on geometrical operations. Expert-based lists of species can significantly differ from the indicative lists provided here. Such expert-based lists are available for a number of countries from the IUCN.

6.3. The Species Coverage Indicator (SCI)

The Species Coverage Indicator (SCI) proposed by Hartley et al. (2007) was initially called Species Irreplaceability Indicator by the authors and implemented so in the DOPA Explorer Beta (Dubois et al., 2013b). DOPA Explorer 1.0 proposes now two distinct indicators: the Species Coverage Indicator (SCI) and the Species Irreplaceability Indicator (SII) as defined by Le Saout et al. (2013).

The SCI is calculated for each protected area by counting how many protected areas a species occurs in (n), and adding $1/n$ to the SCI of each of those protected areas. The same procedure is carried out for all species in a given taxon. The higher the value of the SCI for a protected area, the higher the number of species found in very few other protected areas and/or the higher the number of endemic species in the protected area. In other words, the higher the SCI, the more important is the role of this PA for conserving biodiversity within the current PA network. Any change to the PA network or the size of the protected areas will impact the SCI.

Further normalizing the SCI indicators on a scale of 1-100, one can have an idea of the relative conservation value of the protected area for each taxon by means of the radar plot or by a bar chart showing the ranking of each indicator of the protected area. The SCI suffers from the limitations indicated in Hartley et al. (2007) and Le Saout et al. (2013). Species with smaller ranges are more likely to trigger a higher SCI and species with large ranges will suffer from the fact that connectivity of protected areas is not taken into account and the critical role of corridors in maintaining viable habitats therefore not considered. There is also a concern that the species maps are sometime not accurate enough to be used in conjunction with small protected areas. Hartley et al. (2007) have tried various combinations of species maps and found that the ranking of protected areas based on the SCI is robust to changes in the species maps although this observation still needs to be further assessed with a multi-scale analysis of the SCI values, from country down to protected area level.

One should note that the SCI attributes the same weight to all species independently of their taxon or their threat category on the IUCN Red List of Threatened Species. Because threatened species tend to have smaller distributions, and are therefore found in fewer protected areas, they have a greater effect on the indicator score of the protected area. However, this will still give more emphasize to small endemic species in comparison to larger species which might need to be protected by larger areas and more protected areas, such as rhinoceros and lions.

6.4. The Species Irreplaceability Indicator (SII)

The Species Irreplaceability Indicator (SII) in DOPA Explorer 1.0 now corresponds to the one developed by Le Saout et al. (2013). These authors calculated an irreplaceability score for protected areas as an aggregated measure of the degree of dependence of species' on the protected area. Unlike in the SCI described above, this irreplaceability score for each protected area is independent of the degree of species coverage within other protected areas. Thus, within any given taxonomic group, irreplaceability values can be directly compared across sites worldwide.

In contrast to the SCI, the SII is dominated by species for which each protected area has the most responsibility, with little contribution by species that overlap the site by very small percentages. The SII highlights protected areas of particular importance for avoiding the extinction of species (those with relatively high fractions of species ranges within them). The results of the irreplaceability analysis by Le Saout et al. (2013) were used by IUCN to identify potential candidate sites for

inclusion in the natural World Heritage network (Bertzky et al., 2013).

6.5. Species records

We also provide end users with means to display local densities of species observations that have been reported to the Global Biodiversity Information Facility (GBIF) Secretariat which is facilitating free and open access to species data worldwide via the internet. GBIF provides currently access to more than 500 million records derived from specimen collections and field observations¹². This information is used mainly to visualize knowledge gaps and no further use is currently made of these data in the DOPA Explorer 1.0.

¹² <http://www.gbif.org/> (accessed 15 March 2015)

7. Ecological data

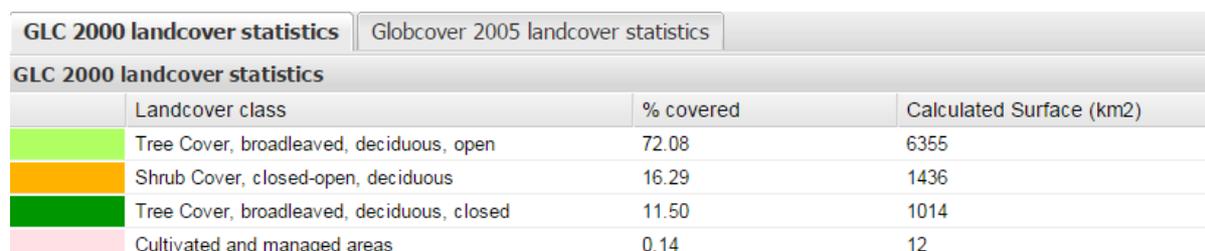
In the following, we will describe the ecological datasets used for mapping purposes and/or for generating the indicators and statistics used to characterize each protected area.

7.1. Land Cover

Each protected area can be characterized by its land cover. There are a few land cover maps available and we are proposing to use two global products which have a reasonable accuracy and global coherence, namely the Global Land Cover for the year 2000 (GLC2000, see Bartholomé & Belward, 2005) and the GlobCover product for the year 2005¹³ produced by the European Space Agency (ESA) in partnership with JRC, EEA, FAO, UNEP, GOFC-GOLD and IGBP.

Note that these two products have not only been generated for different years, but they have different classes and have been prepared on different sampling support. The resolution of GLC 2000 is of around 1 km while GlobCover 2005 has a resolution of 300 m.

The classes of land cover types found in each protected area, the relative surfaces (in %) of these classes and their surface in km² in the protected area can be displayed and downloaded in Excel format (Figure 15).



Landcover class	% covered	Calculated Surface (km2)
Tree Cover, broadleaved, deciduous, open	72.08	6355
Shrub Cover, closed-open, deciduous	16.29	1436
Tree Cover, broadleaved, deciduous, closed	11.50	1014
Cultivated and managed areas	0.14	12

FIGURE 15. EXAMPLE OF LAND COVER CHART FOR A PROTECTED AREA AS DISPLAYED IN THE HABITATS TAB OF DOPA EXPLORER.

All these maps were produced using different mapping standards and algorithms and we invite the users to read the specialized literature to select the dataset that is most appropriate (see e.g. Thibaut et al., 2011)

7.2. Soil map

Another important environmental information that has been made available in the interface is a global soil map made available by the FAO/UNESCO. The information can be found at the following address:

<http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faunesco-soil-map-of-the-world/en/>

7.3. Crops

The proposed crop map shows the cropland percentage map for the baseline year 2005 (Fritz et al., 2015). This new global cropland map from the IIASA-IFPRI combines multiple satellite data sources, reconciled using crowdsourced accuracy checks, to provide an improved record of total cropland extent as well as field size around the world. The data can be accessed from <http://www.iiasa.ac.at/web/home/about/news/150116-Cropland-Maps.html>

This information is used to assess agriculture pressure on protected areas as discussed in chapter 9.

¹³ <http://due.esrin.esa.int/globcover/>

7.4. Fires

Fires are central in the ecology of tropical ecosystems and can act as a threat or a regenerating factor depending on the ecosystem adaptations to it. Many ecosystems in the world are fire-dependent and for them fire is essential to maintain their functionalities and their biodiversity. Hardesty, Myers and Fulks (2005) have estimated that “around 84% of the ecoregions identified by scientists as critical for global conservation have altered fire regimes. This alteration can cause biodiversity loss and habitat degradation”. Besides its relevance for conservation, fire is also a common practice for land management. The information made available here is the active fire density measured over the last month made available by the MODIS team and hosted at NASA EarthData (<https://earthdata.nasa.gov/data/near-real-time-data/firms/active-fire-data>).

For a more detailed analysis of fires and burnt areas in protected areas in near real time, we refer to the Fire Monitoring Tool (Palumbo et al., 2013) which is available from <http://irm-maps.jrc.ec.europa.eu/firereport/>

7.5. Habitats

Defining funding priorities considering ecological features of a protected area is not an easy exercise as one needs to look at the various supporting, regulating, provision and cultural services provided by the ecosystems found in the protected areas. One also needs to look at the protected area as a part of a larger landscape. While large protected areas are more effective in conserving biodiversity, a small area can be critical as an element of a network of protected areas. Much remains to be done in DOPA as there are only a few indicators that have been adopted globally considering all the above issues. What we have proposed, so far, is to highlight those protected areas that have unique ecological features at the country and ecoregion level as these are more likely to host endemic species and most vulnerable considering the small likelihood of finding such ecological features elsewhere.

DOPA Explorer Beta used eHabitat (Dubois et al., 2013a; Skøien et al., 2013) to compute for each protected area the likelihood of finding anywhere in the ecoregion a set of ecological characteristics similar to the one found in that protected area. This approach is very similar to the one used for ecological niche modelling, where a set of selected thematic ecological maps (e.g. climatic and land cover data, elevation and slopes...) is used to identify areas where a given species has highest probability of being found. To compute for each pixel the similarity to a reference location, one popular approach is based on the Mahalanobis distance (Mahalanobis, 1936). Mathematically simple and fairly easy to understand, the model performs relatively well compared with most other models (Tsoar et al., 2007) and is computationally fast. For each protected area, a similarity map was thus presented highlighting areas that are most similar to those of the protected area. The final result allows end users to assess how ecologically isolated a protected area is as well as the internal ecological variability. One of the main limitations of this approach was that protected areas with heterogeneous landscapes led to an overestimation of the probabilities of finding similar areas elsewhere, because the statistical approach considers an “average habitat” over the whole surface of the analysed protected area. The variables characterizing the “average habitat” may be represented by a range of values that is too broad, leading consequently to a high variance in the final results (Dubois et al., 2013a).

The approach proposed in DOPA Explorer 1.0 is based on a segmentation process that automatically decomposes each protected area into a set of independent areas, representing habitat types, which are then assessed individually in terms of the probability of finding elsewhere similar ecological conditions. By reducing the variability within landscape patches, similarity values can be considered to be more accurate. Implemented in eHabitat+ (Martínez-López et al., *in prep.*), this segmentation step was applied to all protected areas as large as 100 km² and the number of segments are reported in the DOPA Explorer 1.0. We have also computed for each segment a map of ecological

similarities but this information will be made available in a different interface, the DOPA Analyst, that is currently in development.

The segmentation algorithm used requires two main parameters, a minimum patch size and a similarity threshold, that were here optimized. The minimum patch size was set to be the square root of the total bounding box area of the park, to avoid obtaining segment sizes that were too small to represent any manageable functional habitat types, and the similarity threshold (ranging from 0 to 1) was set to 0.5 to obtain segments representing medium scale landscape patches. An example of the outcome of this segmentation process is illustrated in Figure 16 where the segments of the Udzungwa Mountains National Park (Tanzania) are shown.

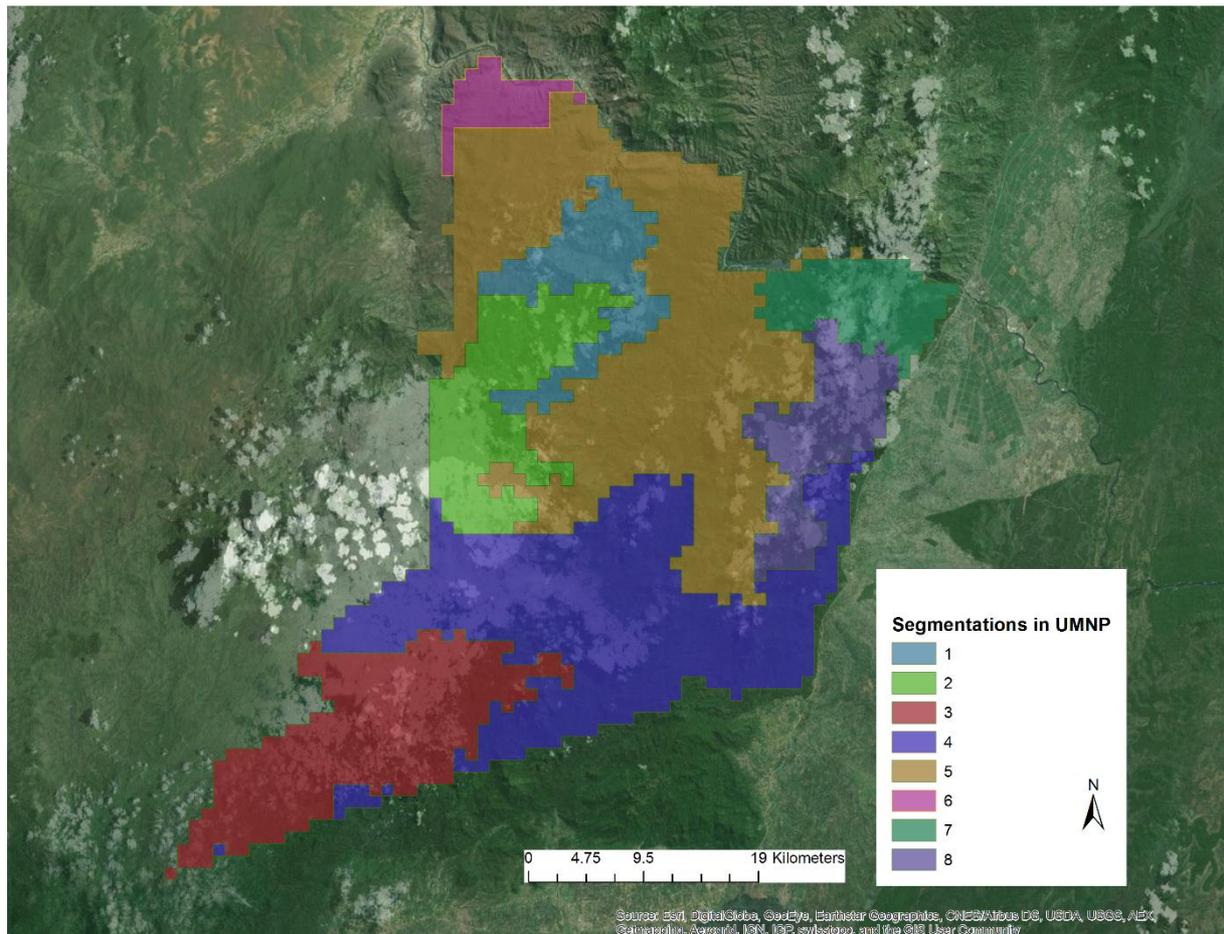


FIGURE 16. EXAMPLE OF RESULT OF THE AUTOMATIC ECOLOGICAL SEGMENTATION FOR THE UDZUNGWA MOUNTAINS NATIONAL PARK IN TANZANIA. SEGMENTATION IS USED IN DOPA EXPLORER 1.0 AS A PROXY OF HABITAT COMPLEXITY

7.5.1. The Habitat Diversity Index (HDI)

To summarize the information provided by the segmentation step in DOPA Explorer 1.0 we simply indicate for each Protected Area the number of segments, a proxy for the habitat types encountered in the protected area, and this number can further be used to assess the ecological complexity of the park (see e.g. McCoy and Bell, 1991).

A large number of segments alone is not sufficient to highlight the ecological variability of the protected area as it indirectly favours large protected areas. Therefore, we also propose a Habitat Diversity Index (HDI) which is defined here as the number of distinct segments or habitat types divided by the square root of the surface of the protected area (in km²) and then multiplied by 1000.

For marine protected areas, the HDI is defined as simply as the standard deviation of bathymetry. This variable provides information on the vertical relief variability and has been used to identify

habitats most likely to support a larger variety of species as topographic complexity is often considered positively associated to biodiversity (see e.g. Thrush et al., 1997, 2001). The value presented as the HDI has been log-transformed in order to generate meaningful distinctions across a wide range of values.

Note that the HDI for terrestrial and marine ecosystems are both systematically shown in the radar plot characterizing each protected area but values for both HDIs will only be found for mixed protected areas, namely those with a marine and terrestrial component.

7.5.2. Biophysical data used by eHabitat+ for characterizing Protected Areas

Altogether, we are using percentage of tree cover, percentage of grassland cover, bathymetry, slope, aridity, biotemperature, precipitation, aridity, Normalized Difference Vegetation index (NDVI Max. and Min.) and Normalized Difference Water index (NDWI), some of them representing long term annual averages for the terrestrial ecosystems, and the bathymetry for the marine ecosystems.

% woody vegetation and grassland cover

This is derived from the Vegetation Continuous Fields collection which contains proportional estimates for vegetative cover types: woody vegetation, herbaceous vegetation, and bare ground. Only the first two variables are used as the third one is a function of the first two. The product is derived from all seven bands of the MODerate-resolution Imaging Spectroradiometer (MODIS) sensor on board NASA's Terra satellite (DiMiceli et al., 2011). These data have been accessed from <http://glcf.umd.edu/data/vcf/>

Normalized Difference Vegetation Index (NDVI)

The MODIS Normalized Difference Vegetation Index (NDVI) data set used is available on a 16 day basis for a ten year period between 2001 and 2010. The product is derived from bands 1 and 2 of the MODerate-resolution Imaging Spectroradiometer on board NASA's Terra satellite (Carroll et al., 2004). These data have been accessed from <http://glcf.umd.edu/data/ndvi/>

Slopes

The relief (slope) on land is derived from the Shuttle Radar Topography Mission (SRTM 30) (USGS, 2004) data accessed from <http://www2.jpl.nasa.gov/srtm/>

Bathymetry

Marine data have been extracted from the General Bathymetric Chart of the Oceans (GEBCO) maintained by the British Oceanographic Data Centre on behalf of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The dataset is a global 1 minute grid generated by combining quality-controlled ship depth soundings with interpolation between sounding points guided by satellite-derived gravity data. When available, data sets generated by other methods have been included to improve local accuracy.

Digital data accessed 1 July 2014 from

http://www.gebco.net/data_and_products/gridded_bathymetry_data/

Annual bio-temperature, Surface Temperature, annual precipitation, annual evapotranspiration/precipitation ratio

See the next section on Climate and elevation data.

8. Climate and elevation data

Climate variables (monthly and annual temperature, bio-temperature (the $T > 0^{\circ}\text{C}$) and evapotranspiration/precipitation ratio) have been derived from WorldClim (Hijmans et al., 2005). The variables have been computed according to the definitions of Holdridge (1947). The original data can be accessed from <http://www.worldclim.org/>

WorldClim¹⁴ provides gridded maps of current (1950-2000) and future climate variables at different latitude-longitude resolutions, i.e., 10 minutes, 5 minutes, 2.5 minutes and 30 seconds. The dataset for current climate (Hijmans et al., 2005) is the result of a spatial interpolation process using splines applied to measurements from climate stations. The 30 seconds resolution adopted here corresponds to grid cells of 0.86 km² at equator, usually referred to as a 1 km grid.

The WorldClim data base gives long term monthly averages of precipitation and minimum, mean and maximum temperatures for each pixel. These variables are then averaged for each protected area and for each month (Figure 17).

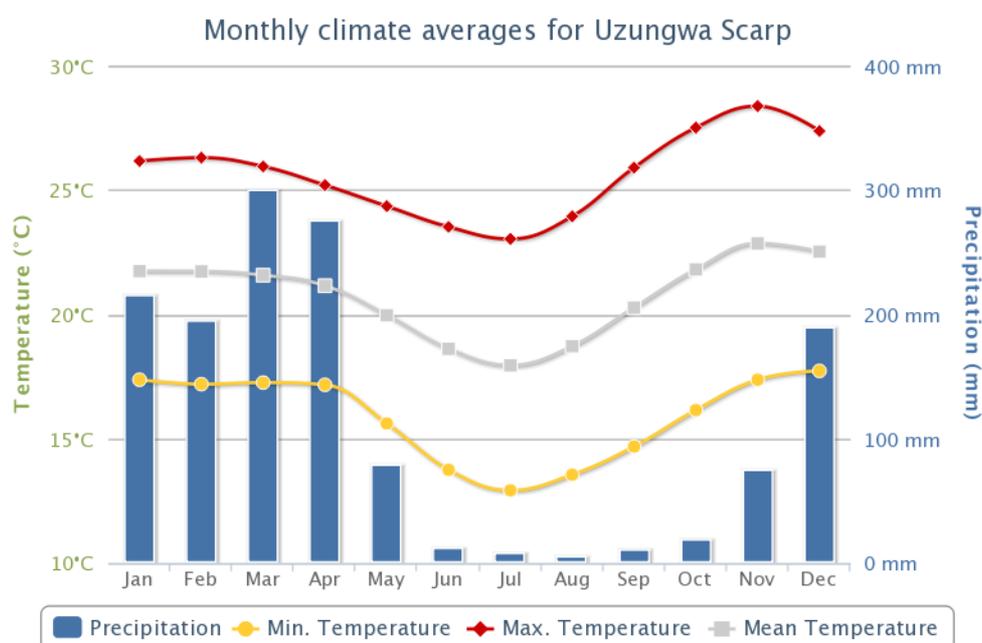
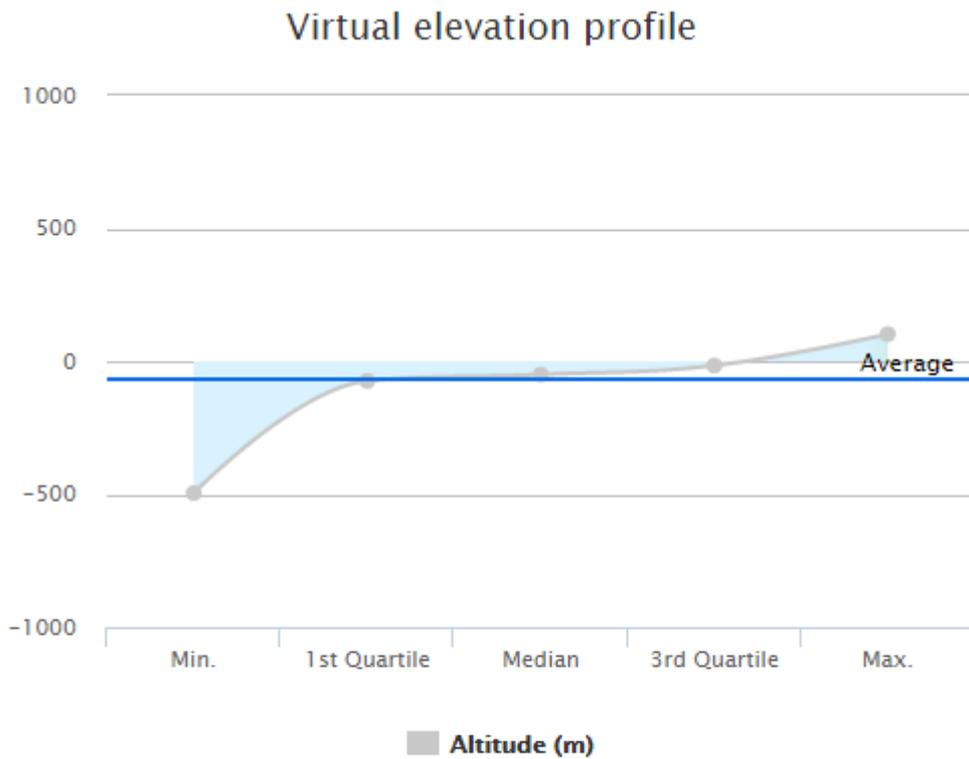


FIGURE 17. EXAMPLE OF CLIMATE CHART FOR A PROTECTED AREA AS DISPLAYED IN THE CLIMATE TAB OF DOPA EXPLORER.

Protected areas with climatic information will often report the climate of low altitudes, which might be different from the variables we present in DOPA. We therefore provide a virtual elevation profile to highlight the changes in the relief as an additional explanatory variable for the climatic data, since all those variables are usually dependent on the elevation.

Note that marine and mixed protected areas will have a profile showing both the elevation and the bathymetry, as shown in Figure 18.

¹⁴ <http://www.worldclim.org/>



Min.	1st Qtl.	Median	3rd Qtl.	Max.
-496	-74	-50	-16	102

FIGURE 18. EXAMPLE OF THE VIRTUAL ELEVATION PROFILE AND ASSOCIATED STATISTICS (IN METERS) FOR A MIXED PROTECTED AREA AS DISPLAYED IN THE CLIMATE TAB OF DOPA EXPLORER.

9. Pressure Information

This component of DOPA Explorer 1.0 tries to quantify theoretical pressures on protected areas, in particular by looking at population, roads and agricultural activities inside and in proximity to protected areas. The higher the density of population, roads and agriculture in the vicinity of a protected area, the greater is the risk for encroachment, land conversion, deforestation, poaching, pollution and invasive alien species. The ranking of the protected area in terms of pressures due to population and agriculture can be visualized at the country and the ecoregion levels while pressures from roads are ranked at the country level only, because of large differences in the detail level of available road data between countries.

9.1. Population pressure

Population data were obtained from the Gridded Population of the World data version 3 (GPWv3), which depicts the distribution of human population across the globe. GPWv3 provides globally consistent and spatially explicit human population information and data in a raster format. The data set is constructed from administrative units of varying resolutions and the native grid cell resolution is 2.5 arc-minutes, or ~5 km at the equator, although aggregates at coarser resolutions are also provided. We use here separate grids made available for population count and density per grid cell.

Population data estimates are provided for 1990, 1995, and 2000, and projected (in 2004, when GPWv3 was released) to 2005, 2010, and 2015.

The data are made available by the Socioeconomic Data and Applications Center (SEDAC) <http://sedac.ciesin.columbia.edu/data/collection/gpw-v3>

9.1.1. Population Pressure Index

Population pressures on a protected area were estimated using the Gridded Population of the World map for the year 2000 and a cost-distance function to quantify accessibility to the protected area and a buffer zone around each protected area. The cost distance function was derived from information on slopes, roads, rivers, land cover and international boundaries to compute a travel time from each point of the boundary of the protected area (Nelson, 2008). In other words, thematic maps were converted into gridded data where each cell receives a weight reflecting the pressure level on the protected area. A land cover map, for example, can be used to derive an accessibility map to a protected area by attributing high values to obstacles (rivers, mountains, hills) and low values when the terrain can be easily crossed (e.g. savannahs, grassland) as illustrated in Figure 19. As a result, a buffer area representing 3 hours of traveling could be delineated around each protected area and further used to calculate the average population density. This average population density in the buffer area is the Population Pressure Index.



FIGURE 19. EXAMPLE OF AN ACCESSIBILITY MAP FOR A PROTECTED AREA (GREY POLYGON) WHERE LAND COVER CLASSES ARE USED TO DERIVE WEIGHTS AND GENERATE A COST-DISTANCE FUNCTION. HIGH VALUES ARE CORRESPONDING TO OBSTACLES WHILE EASIER ACCESS IS CORRESPONDING TO LOW VALUES.

9.1.2. Index of change in population pressure

The Population Pressure Index is available at different time steps, and this allows us to evaluate changes in population pressure around a PA. Here, PAs are ranked by the percentage change in population pressure between 1990 and 2000. The percentage population change is the percentage change in this computed metric between 1990 and 2000, with the 1990 value as a baseline.

9.2. Agricultural pressure

The Agricultural Pressure Index is based on the average percentage of cropland in 1 km raster cells within a 30 km buffer zone around protected areas, aggregated to a single metric using an inverse distance weight function. The IIASA-IFPRI cropland percentage map for the baseline year 2005 (Fritz et al., 2015) was used to identify the percentage of cropland in each cell within the buffer

9.3. Pressure from roads

Data on roads was derived from the Global Roads Open Access Data Set (CIESIN, 2013). The data is generated by the Center for International Earth Science Information Network - CIESIN - Columbia University, and Information Technology Outreach Services - ITOS - University of Georgia and available from <http://sedac.ciesin.columbia.edu/data/set/global-roads-open-access-v1>

The road data was rasterised to 500 m resolution and then used to identify roads globally. Road pressures were calculated based on the percentage of cells with presence of roads inside protected areas (Internal Roads Pressure Index) as well as within a 30 km buffer zone around protected areas (External Roads Pressure Index), using an inverse distance weight function. The pressure values are normalized by country only, not by ecoregion, due to differences between countries in the density and detail of the road data supplied.

10. Current status, known issues and next steps

10.1. Current status

Capitalizing on the experience gained in developing our previous protected area assessments tools (Hartley et al. 2007, Dubois et al., 2013b), we have developed a new set of web services, adopting the same continent-wide and consistent methodology for assessing the value of, and pressures on protected areas across the globe. The assessment is based on quantifiable and objective measures using global information hosted by major Institutions.

DOPA Explorer 1.0 (version 2015-04-07) is our second attempt to make global information provided by these web services available to a wide range of potential end users, from park managers to the researchers and decision-makers. In addition to reference statistics on the level of protection of the ecoregions and countries, DOPA Explorer 1.0 further provides simple means to explore terrestrial and marine protected areas with a minimum surface of 100 km², to identify those with the most unique ecosystems and species, and to assess the pressures they are exposed to because of human development.

10.2. Known issues

Inevitably, DOPA Explorer 1.0 also suffers from a number of limitations.

Overlapping and/or 'duplicated' protected areas: End users of DOPA Explorer will notice in the maps and tables a non-negligible number of overlapping and/or 'duplicated' protected areas coming from the WDPA. This is usually the case where an area is covered by different legal designation types and/or IUCN management categories, and thus has multiple records in the WDPA (see also the box in Section 4.2.2 and the example of Virunga National Park therein). Exceptionally there may also be true duplicates that are erroneously included in the WDPA. To avoid double counting, any spatial overlaps between protected areas have been removed in the coverage statistics that one can find in the DOPA Explorer for the country and ecoregion level.

Missing indicators / local anomalies: The complexity of our indicators and the frequent problems encountered when processing geospatial data containing errors inevitably leads to wrong results which cannot always be easily traced. We processed large datasets for nearly 16,000 protected areas and 35,890 species and validating the information for each protected area is impossible in the short term. It is also the purpose of the forthcoming DOPA Validator to provide the experts with means to report errors and correct the information from DOPA Explorer.

Information differing with other sources: we have taken great care in generating information according to current best practice and using standard datasets and methods as documented, but one will still find differences to the information presented by other organisations. For some analyses there is still little or no standardisation about the way to process spatial data, and different choices in map projections, for example, will have an impact on the final results. We are trying to minimize these differences as far as possible by sharing experience with other organisations. In general, one would expect data provided by the countries to be more accurate (but maybe not easily comparable to other countries) than those managed by international organisations working on larger scales.

Wrong information: Most information provided in DOPA depends on datasets produced by third parties. We are aware of a number of errors in these datasets and DOPA Explorer is also conceived to help users to spot these where possible. A number of global datasets are also quickly outdated (i.e. road and land cover maps). We encourage everyone to contribute to the verification and validation of the information presented, and it will be the main objective of the forthcoming DOPA Validator to provide end users with means to improve the existing information.

Access and speed: Using the DOPA Explore requires that you have access to the internet and that our web services are capable of quickly computing your requests for data and figures that are generally computed on the fly. Access to DOPA Explorer can, under some conditions, be very slow and we are doing our best to try to provide a service running 24h/24, any day of the year.

10.3. Next improvements to DOPA Explorer

The number of improvements planned for the DOPA Explorer is too long to be listed here in full and we will mention only the main ones on which we are currently working.

Versioning of the datasets used: we are currently not providing in the web client or REST services any information on the versions of the databases used. This is critical when regular assessments are made and such functionality will be provided in the next versions.

We have started working on a new service of DOPA, eConservation (den Braber et al., 2015), that is developed to map ongoing project activities in the field of conservation in protected areas. This information is essential to identify the various actors on the ground as well as to identify the areas where information and actors are scarce. We will therefore include a new section providing information on current and, if possible, past projects. eConservation can be accessed from <http://econservation.jrc.ec.europa.eu/>

DOPA Explorer 1.0 provides much information that is useful for reporting purposes but there is still significant scope for improvement. We plan to significantly ease the accessibility and reusability of the data and maps, and to increase the speed with which the information is computed and displayed.

10.4. From DOPA Explorer to DOPA Validator and DOPA Analyst

As highlighted in the introduction, there is much room to reduce uncertainties and inaccuracies in the information presented in DOPA Explorer. As global data become increasingly freely available and portray the world at higher resolution, the information on protected areas will require in situ validation. This can only be achieved by federating and sharing the knowledge of all local actors, from park rangers to local NGOs, researchers and even visitors in single platform. It is therefore our objective to develop the **DOPA Validator** (first Beta version planned for end 2015) which will allow registered users to update/validate/refute the information presented in DOPA Explorer 1.0. DOPA Validator has the ambition, not only to become a bidirectional information exchange system which can bring together actors on the ground, but also to provide a platform connecting those local actors among themselves as well as with the people who are often remotely located but have an impact on the protected areas (i.e. funders, decision and policy makers). This is very much the spirit of the Regional Observatories, put in place in African, Caribbean and Pacific (ACP) countries by the BIOPAMA project¹⁵, which are technically supported by the DOPA but which are also designed to support local needs by capturing local information. The first version of DOPA Validator will focus on threats, species (types and abundance), funding and the validation of land cover data.

A third component planned for 2016, **DOPA Analyst**, will allow end users to benefit more from our modelling infrastructure to compute, for example, the impact of a climate change scenario on the habitats of a selected species (Skøien et al., 2013) or to dynamically calculate the indicators proposed here for any area specified by the end-user. DOPA Analyst will also provide a set of remotely sensed ecological data obtained in real time to allow end users to monitor fires, vegetation activity, rainfall, water bodies, etc. Environmental anomalies in the monitored variables can be

¹⁵ The Biodiversity and Protected Areas Management (BIOPAMA) project aims to address threats to biodiversity in African, Caribbean and Pacific (ACP) countries, while reducing poverty in communities in and around protected areas. BIOPAMA is a four year-initiative (2012-2016) funded by resources from the intra-ACP envelope of the 10th European Development Fund (EDF). <http://www.biopama.org/>

detected by contrasting the environmental data against historical records every 10 days. These anomalies can be characterized by their strength, their duration and their deviation from their expected occurrence in time, something typical of seasonal changes (Dubois et al., 2009, 2011).

By deploying specific tools constructed around a few reference services developed for a broad range of end users, from park rangers to policy makers, we hope to contribute to a better communication between funding agencies and the actors on the ground, between researchers and policy-makers. It is the main purpose of the technology developed in DOPA to support communication between everyone willing to contribute to the safeguarding of biodiversity.

11. Help and Feedback

End users of DOPA Explorer will find below various ways to get more information about the DOPA Explorer.

11.1. DOPA Wiki

This document is made available from the Wikispace of DOPA, <http://dopa.wikispaces.com/>

Should you be interested in contributing scientifically, technically or as an end-user of DOPA, we would be happy to welcome you on our Wiki to discuss our work. The Wiki also provides information on latest news, major developments as well as the access to official documentation.

11.2. Distribution list

We invite interested users to subscribe to our distribution list to get automatically information about the main changes to DOPA Explorer. The mailing list is expected to be used every 2 months to circulate information on the latest changes, bugs and improvements.

To subscribe to this distribution list, visit <http://irelay.jrc.it/cgi-bin/majordomo> and enter the email you would like to use in "your e-mail address" field. Then click on "FIND" and enter "dopa-explorer" on the field next to it, then click on "go". After the page loads, click in the field next to the padlock symbol and click on "apply". To unsubscribe, follow the same procedure using your existing email, unclick the field next to the padlock, and then click "apply"

Alternatively, you can send a message to <Majordomo@jrc.ec.europa.eu> with the following command in the body of your email message:

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unsubscribe dopa-explorer
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If you ever need to get in contact with the owner of the list (e.g. if you have trouble unsubscribing, or have questions about the list itself), send an email to <owner-dopa-explorer@jrc.ec.europa.eu> .

11.3. Contact

For any other issues, you can contact

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