

A COLLABORATION BETWEEN



AND



# Mapping the collaboration between Europe and Latin America/Caribbean for Research on Biodiversity

AN ANALYSIS OF COLLABORATION NETWORKS  
BASED ON PUBLICATIONS INVOLVING ERA  
AND LAC RESEARCHERS (2003-2013)



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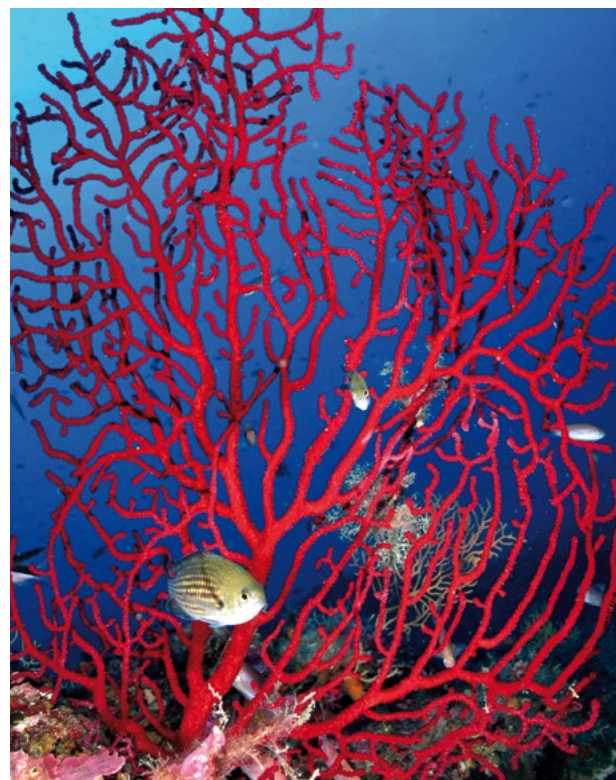
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# INTRODUCTION

Political leaders in Europe and in Latin America and the Caribbean (LAC) have long recognised the importance of knowledge generation for proposing solutions to the challenges raised by biodiversity loss and ecosystem degradation to societies from local to global scale<sup>[1, 2]</sup>. Proposing knowledge-based solutions to these challenges is increasingly needed with the creation in April 2012 of the Intergovernmental Platform on Biodiversity and Ecosystem Services<sup>[3]</sup> and the need for the European Research Area (ERA) to explore Nature-based solutions<sup>[4]</sup>. As Europe and LAC countries both harbour a great proportion of the world's biodiversity<sup>[5]</sup>, cooperation to tackle these challenges should be of common interest.

For many years, ERA-LAC collaboration for research on Biodiversity has been mainly promoted by bilateral schemes promoting research between one European country and one LAC country. For instance, Brazil and Mexico were part of the 14 countries for which the French National Research Agency (ANR) dedicated a bilateral scheme in 2014, while the German Research Foundation (DFG) has operated for several years a joint funding program with Brazilian partner organisations FAPESP in the state of São Paulo, and FAPEMIG in the state of Minas Gerais, on the basis of bilateral cooperation agreements. In parallel, and in the context of the EU Strategy to stand as a strong global actor, the European Commission (EC) has promoted the ties between the EU and Latin America and the

Caribbean in the field of science, technology and innovation. For instance, more than 750 participations of Latin American and Caribbean researchers have been funded in collaborative projects with European partners for a total €100 million through the 7<sup>th</sup> Framework Program for research and innovation ([www.eeas.europa.eu/lac](http://www.eeas.europa.eu/lac)). The main areas of common interest were renewable energies, climate services, bio-economy, marine research, ICT and health. Recently, the EC has supported the bi-regional project ALCUE NET ([www.alcuenet.eu](http://www.alcuenet.eu)) with the main objective to establish a bi-regional platform between actors involved in Research and Innovation, relevant stakeholders from the public and private sector and the civil society, so that a long-standing EU-LAC dialogue on science and technology could be implemented. The EC also supported the ERANet-LAC (<http://eranet-lac.eu>) which is a network of European Union, Latin America and the Caribbean countries on Joint Innovation and Research Activities that strengthens bi-regional partnership in Science, Technology and Innovation by planning and implementing concrete joint activities. However, the outcome of all these approaches to promote ERA-LAC research collaboration on a hot topic like biodiversity remains to be evaluated. In parallel, it is increasingly expected that major networks of the ERA such as BiodivERsA ([www.biodiversa.org](http://www.biodiversa.org)) promote the international dimension of research cooperation beyond the ERA.



## COLLABORATION BETWEEN ALCUE NET AND BIODIVERSA FOR MAPPING THE RESEARCH LANDSCAPE

ALCUE NET and BiodivERsA have developed a collaboration to reinforce the mapping of the research landscape on biodiversity and ecosystem services and pave the way to future possible activities.

**ALCUE NET** aims at establishing a bi-regional platform between European Union and Latin America and the Caribbean (EU-CELAC) bringing together actors from 18 countries involved in R&I orientation, funding and implementation, as well as other relevant stakeholders from the public and private sector and the civil society, in an effort to support the international Science, Technology and Innovation (STI) dimension of the Europe 2020 Strategy and Innovation Union Flagship Initiative. It focuses on the following priorities: Energy; Information and Communications Technology; Bioeconomy; Biodiversity & Climate change.

**BiodivERsA** is an ERAnet in its third phase (2015-2019) bringing together a network of 32 organisations from 19 European countries, including 6 overseas partners, that fund and program research on biodiversity and ecosystem services. The intention is to promote coordinated and effective pan-European research for the conservation and sustainable management and use of biodiversity and ecosystem services, and to inform policy-makers and other stakeholders at European and international levels.

Bibliographic analyses are a relevant tool to quantify scientific bi-regional cooperation<sup>[6, 7]</sup>. In particular, as scientific publications are the product of collaboration among researchers and institutions, they can give an overview on the structure and dynamics of research networks. Therefore, the results of efforts to promote international research collaboration can be assessed by analysing co-authoring networks, their temporal trends, their geographical footprint and the domains they cover.

In this brochure, we report the results obtained from the analysis of the publications involving authors from the ERA and LAC published between 2003 and 2013 to study bi-regional research collaboration on biodiversity. Biodiversity is defined here according to the United Nations Convention on Biological Diversity, as “*the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological*

*complexes of which they are part; this includes diversity within species, between species and of ecosystems*”. We evaluate the relative importance of ERA-LAC collaboration regarding other inter-continental collaborations for LAC and for the ERA in this domain, the temporal evolution of the importance of ERA-LAC collaboration, the leadership of the publications (in term of corresponding authors), and the research domains covered. We discuss the implications of the results to guide further development of ERA-LAC research collaboration in the future. In addition, another publication presents the results from a similar analysis but focuses on the biodiversity and climate change interface<sup>[8]</sup>. The final objective is to promote coordinated actions and avoid overlaps in biodiversity research in order to strengthen and sustain the bi-regional dialogue on Science and Technology between the ERA and Latin American and Caribbean countries.





# METHODOLOGY







# METHODOLOGY

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## BIBLIOGRAPHIC SURVEY

We used the Web of Science version of the Thomson Reuters citation databases (WoS, [www.webofknowledge.com/](http://www.webofknowledge.com/)) and conducted a search of the peer-reviewed literature (articles and reviews) on biodiversity for the ERA and LAC countries over the 2003-2013 period. The Web of Science platform consists of several online databases, three of which were particularly relevant for our search: the Science Citation Index (SCI; 7,100 journals), the Social Science Citation Index (SSCI; 2,100 journals), and the Arts & Humanities Citation Index (AHCI; 1,700 journals). Nearly no additional references (<1%) were recorded when using other databases such as SciELO, Scopus, Social Science Research Network, BioOne and MUSE.

We retrieved all the publications with at least one author affiliated in a country of LAC (33 countries: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Jamaica, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela) and all the publications with at least one author affiliated in a country of the ERA (28 countries from EU plus 14 associate members: Austria, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom, plus Albania, Bosnia, Croatia, Faroe Islands, Israel, Iceland, Liechtenstein, Macedonia, Montenegro, Moldova, Norway, Serbia, Switzerland, Turkey). The publications with at least one author affiliated in a country of LAC and at least one author from a country of the ERA were considered as an ERA-LAC co-publication, as publications authored by at least one scientist affiliated to both ERA and LAC organizations. For this report, publications involving both researchers from mainland Europe (e.g. the Netherlands or France) and researchers from

oversea territories linked to European countries (e.g. Dutch Antilla or French Guyana) were not included as ERA-LAC collaboration in this study.

As biodiversity is a broad, multi-faceted concept, we used the following profile of keywords to identify the publications corresponding to these facets: TOPIC = (biodivers\*, biological diversity, species richness, species diversity, taxonom\*, phylogen\*, animal diversity, mammal diversity, bird diversity, fish diversity, reptile diversity, amphibian diversity, frog diversity, insect diversity, plant diversity, weed diversity, microbial diversity, bacteria\* diversity, fung\* diversity, virus diversity, ecosystem diversity, habitat diversity, landscape diversity, biological conservation, species conservation, habitat conservation, genetic resource\*, invasive species, biological invasion\*, functional diversity, functional trait\*, functional type\*, functional group\*).

All records were imported into an Excel dynamic database. Each record was tagged with its corresponding WoS section, SCI, SSCI or AHCI, which is a repeatable attribute because a relatively high level of record duplication exists between the three sections. The database was cleaned to avoid duplications and remove errors and inconsistencies (e.g. in the country name, in the affiliations and address fields).





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## ANALYSIS AND MAPPING OF CO-AUTHORING NETWORKS

The international networks of researchers were analysed based on the countries identified in the addresses of papers' authors. The information on the countries of scientists co-authoring a given paper was transformed into a link between countries collaborating in this paper. Finally, a triangular matrix was computed to identify the links between each pair of countries based on the number of papers co-authored by these countries. Co-publication network analysis and mapping were performed using the open source Gephi software<sup>[9]</sup> (<http://gephi.org>).

Two-dimension spatial mappings of ERA-LAC co-authorship networks were performed using the Force-Atlas 2 algorithm in Gephi. This algorithm creates a visual representation of nodes (countries) connected by edges based on co-authorship according to the following rules: 1) node size represents the number of publications, 2) all nodes are attracted to the center, i.e. the country with the highest number of publications, 3) all nodes repel each other to prevent visual overlapping of the nodes, 4) all nodes that are connected by an edge attract each other, according to the weight of the edge, i.e. the number of publications with co-authorship between the two countries/regions.

Two nodes are thus spatially closer if they strongly publish together.

We also created two-dimension maps of the co-publication networks at the global level (i.e. collaborations between the different continents: LAC, ERA, Others Europe, North America, Africa, Asia, Oceania). As these networks were drawn on a world map background, only node size and edge weight were represented. Finally, we computed two indicators to evaluate the role of each country within the ERA-LAC co-publication network<sup>[10]</sup>: (i) the betweenness centrality (BC), normalized by the maximum value observed, which indicates how a country acts as a bridge with other countries in the ERA-LAC network; and (ii) the scientific production level, i.e. the number of publications produced, normalized by the maximum number observed.

## AUTHORSHIP, RESEARCH AREAS AND INTERDISCIPLINARITY

The country of the corresponding authors of all the ERA-LAC publications were identified to provide a view on which countries were the main scientific leaders of these publications. The proportion of ERA-LAC publications on biodiversity corresponding to five major scientific areas (Biological Sciences, Earth Science, Technology, Human Sciences, Medicine) and several disciplines (e.g. for the Earth Science discipline: geography, geology, oceanography, atmospheric sciences, and water resources) were also computed to assess the implication of different scientific communities in the ERA-LAC collaboration effort to address biodiversity issues. Several research areas or disciplines could be attributed to a single publication.













# RESULTS

## ERA-LAC PUBLICATIONS ON BIODIVERSITY : NUMBER AND TEMPORAL TREND

We retrieved 6,741 papers on biodiversity published over 2003-2013 corresponding to co-publication with at least one author affiliated in a LAC country and one affiliated in an ERA country. We observed an exponential increase of the number of ERA-LAC co-publications on biodiversity throughout the 2003-2013 period from over 200 papers per year in early 2000 up to over 1100 papers in 2013. This increase is higher than the one observed for all ERA-LAC publications (Figure 1).

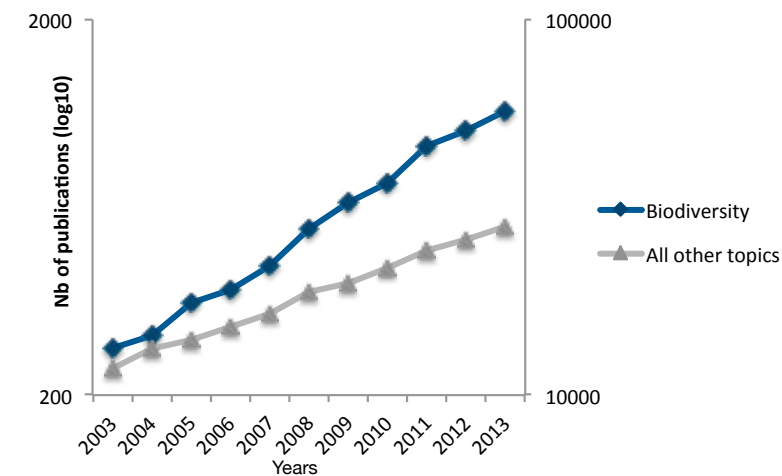


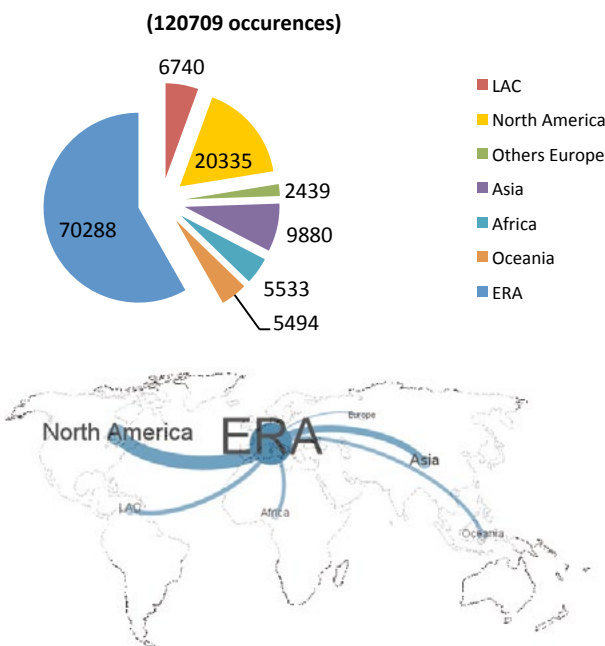
Figure 1. Temporal evolution of the number of scientific publications on biodiversity (diamonds; Y axis on the left) and of all other publications (triangles; Y axis on the right) involving collaboration between Latin America/Caribbean and the European Research Area during the 2003-2013 period. Note that the two Y axes use a log scale.

## IMPORTANCE OF ERA-LAC COLLABORATIONS FOR RESEARCH ON BIODIVERSITY

Over the 2003-2013 period, European researchers published on biodiversity mainly through intra-Europe research networks (Figure 2, left), and to a lesser extent with North American researchers. Collaboration with LAC was comparable to collaborations with either Asia, Africa, or Oceania.

LAC scientists also published mainly with only other LAC countries. But collaboration with ERA countries or with North America was equally important (Figure 2, right). Collaboration with Oceania and Asia, and even more Africa, was much less important.

### Distribution of ERA publications



### Distribution of LAC publications

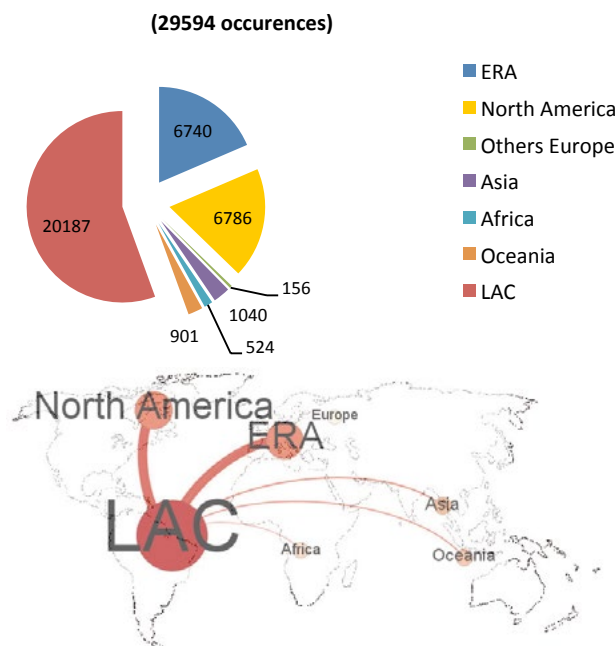


Figure 2. Distribution of all the publications on biodiversity according to the type of intercontinental collaboration involved (2003-2013 period). Top-Left: distribution of intra or inter-continental collaborations for the 121,000 publications generated in the ERA; Top-Right: distribution of intra or inter-continental collaborations for the 30,000 publications generated in LAC. Bottom: Maps of inter-continental co-publication links (node sizes are not comparable between the two panels).



When considering all the ERA publications on biodiversity, the importance of ERA-LAC co-publication tended to increase over time, i.e. from 2.5% in 2003 to 7% in 2013 (Figure 3, left). In parallel, when considering all the LAC publications on biodiversity, the proportion of ERA-LAC co-publication was pretty stable over the 2003-2013 period (Figure 3, right), ERA-LAC publications representing slightly more than 20% of the total number of LAC publications since 2003.



Figure 3. Left: temporal evolution of the part of copublication with LAC within all the ERA publications on biodiversity. Right: temporal evolution of the part of copublication with ERA within all the LAC publications on biodiversity.

## MAIN RESEARCH AREAS AND DISCIPLINES COVERED

The main large research area represented in ERA-LAC publications on biodiversity is Biology, while Earth Sciences, Technology, Human Sciences and Medicine are also represented but to a lesser extent (Figure 4).

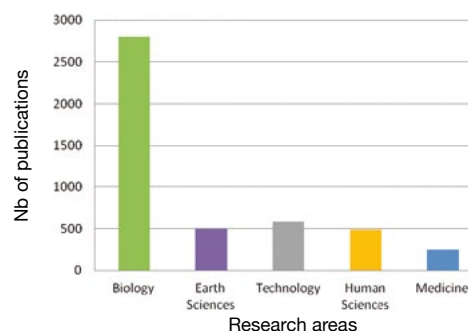


Figure 4. Number of ERA-LAC publications on biodiversity per large research area over the 2003-2013 period.

The research discipline mainly covered is “Environmental sciences and ecology” (Figure 5). Plant sciences, zoology and evolutionary biology were also well represented, as conservation, genetics, molecular biology, microbiology and freshwater biology although to a lesser extent (Figure 5).

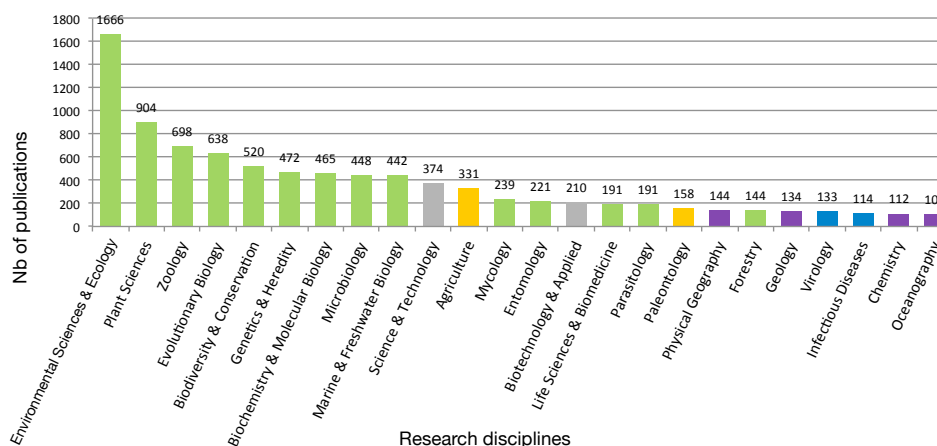
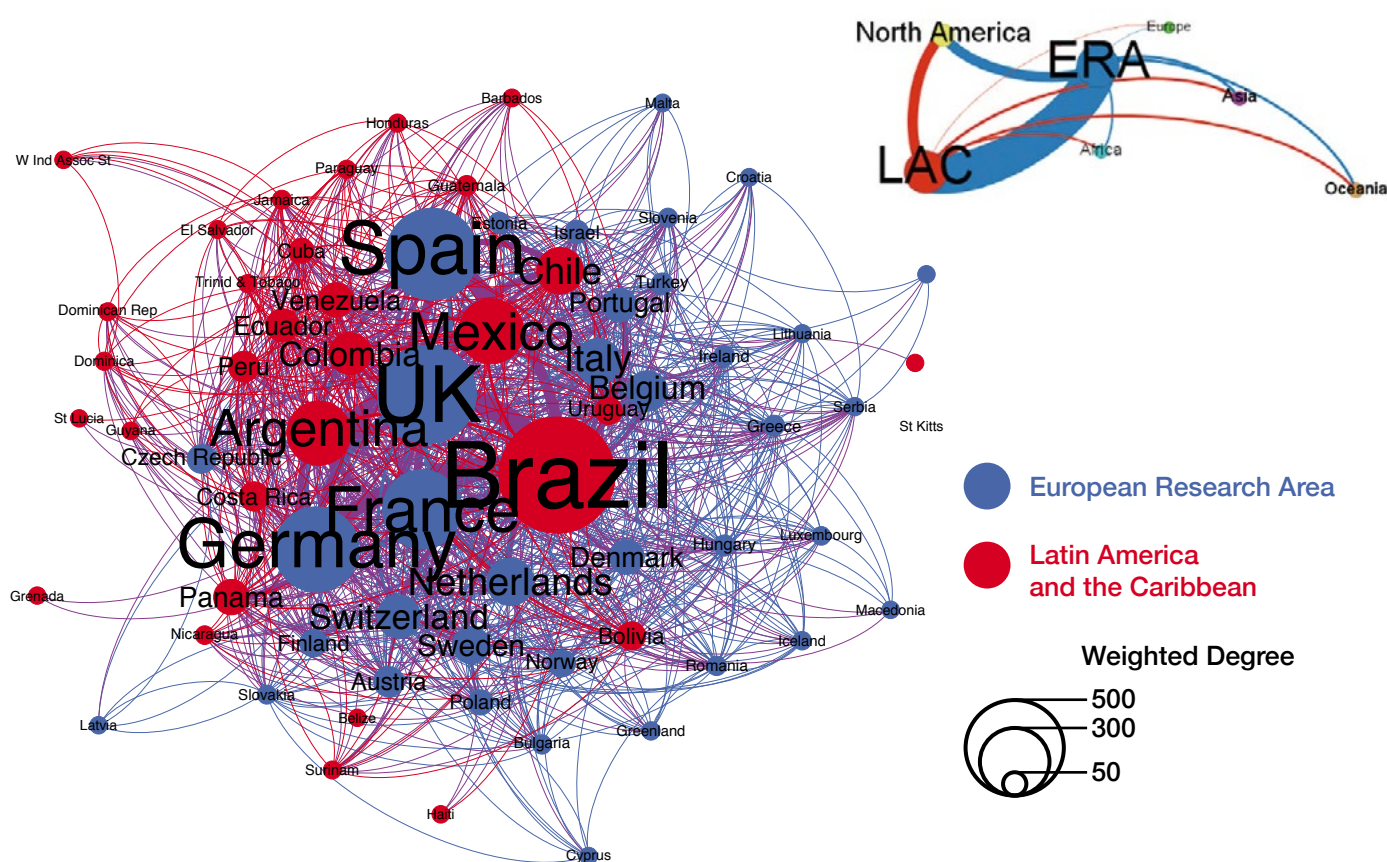


Figure 5. Number of ERA-LAC publications on biodiversity per research discipline over 2003-2013.

## MAIN FEATURES OF TRANS-NATIONAL RESEARCH COLLABORATION ON BIODIVERSITY

The publication network analysis revealed a well interconnected, bi-regional cooperation between ERA-LAC, with Brazil, UK, Spain, Germany, France, Mexico, and Argentina being the main countries involved in the cooperation in both regions (Figure 6). North America was involved in almost half of the ERA-LAC publications on biodiversity.



**Figure 6.** Cooperation network between countries from the European Research Area and Latin America/Caribbean (ERA-LAC). Top-Right: visualization of the ERA-LAC research network. Disc size corresponds to the Weighted Degree, which is the number of countries to which a country is linked, weighted by the number of publications represented by each link. The inset (top right) highlights the importance of collaboration with other continents part of the ERA-LAC research network.



We analysed the intra-regional networks that appear when considering ERA-LAC publications on biodiversity (Figure 7), i.e. analysing which countries from a given continent collaborate within the larger ERA-LAC collaboration. This corroborates the leading position of UK, Germany, Spain and France for the ERA; and the leading position of Brazil, and to a lesser extent Mexico, Argentina but also Colombia for LAC.

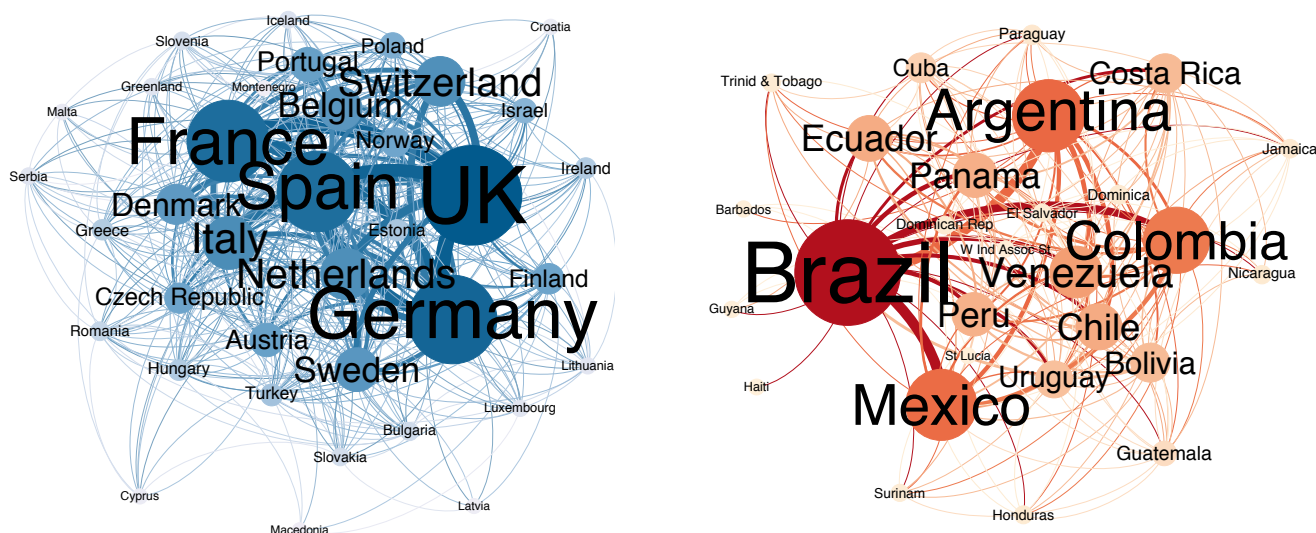


Figure 7. Intra-regional networks involved within ERA-LAC cooperation. Left: collaborations within European Research Area countries that exist in the context of a larger ERA-LAC collaboration. Right: collaborations within countries from the Latin America and the Caribbean that exist in the context of a larger ERA-LAC collaboration.

In addition, we found that there was no major temporal evolution of the Cooperation network between countries from the European Research Area and Latin America/Caribbean between the 2003-2008 and 2008-2013 periods (Figure 8). There was however a trend for a decreasing prominence of UK and increasing prominence of Brazil in the ERA-LAC network when comparing the second period to the first one.

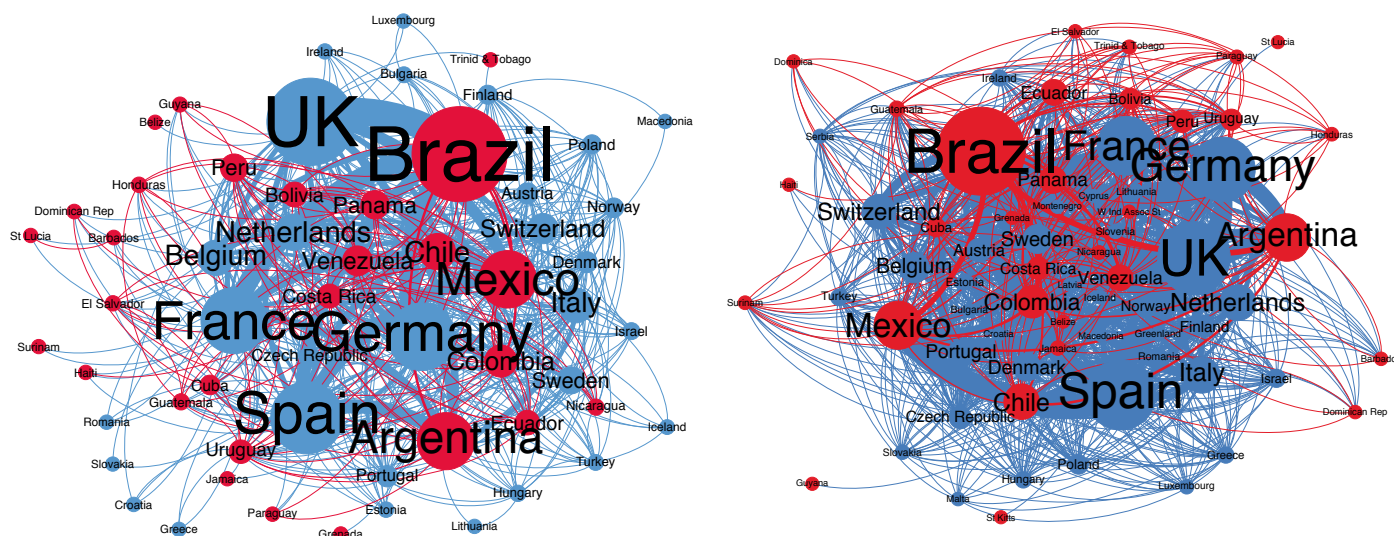
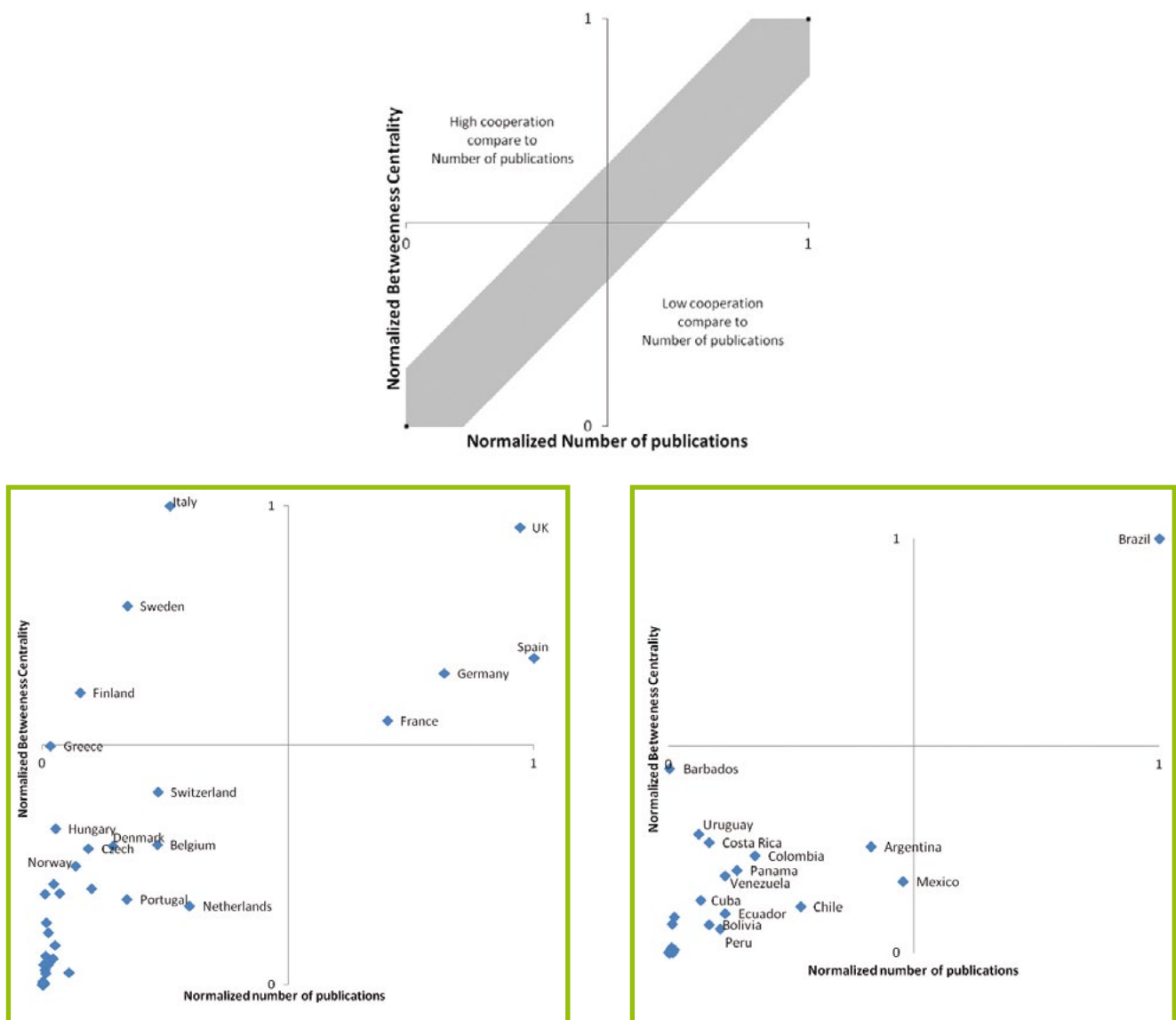


Figure 8. Temporal evolution of the intra-regional network of countries involved in ERA-LAC research cooperation on biodiversity for (Left) the 2003-2008 period, and (Right) the 2008-2013 period.



To further evaluate how countries contribute to the ERA-LAC cooperation network, we compared for each country an indicator of regional cooperation (Betweenness Centrality, which indicates how a country acts as a bridge with other countries in the network, the index being normalized by the maximum value observed) and the number of ERA-LAC papers produced (normalized by the maximum number observed). The average expected level of regional cooperation regarding the number of publication is represented as a grey large line in top [Figure 9](#).

Some countries like Italy and Sweden were particularly efficient in promoting collaborations with other countries as regards to the number of papers published. In contrast, Mexico tended to have less collaboration with other countries despite a good publication level ([Figure 9](#)).



**Figure 9.** Index of cooperation within each regional network (Normalized Betweenness Centrality) as a function of the normalized number of publications involving ERA-LAC cooperation for the different countries. Top: Interpretation graph. Bottom-Left: results for countries from the European Research Area. Bottom-Right: results for countries from Latin America and the Caribbean.

# CORRESPONDING AUTHORS OF ERA-LAC PUBLICATIONS

Nearly half of ERA-LAC publications on biodiversity are led by a European scientist, and more than a third by a LAC's scientist (Figure 10). In addition, 16% of the ERA-LAC publications are led by a researcher from North America, while leaderships by researchers from another continent are marginal.

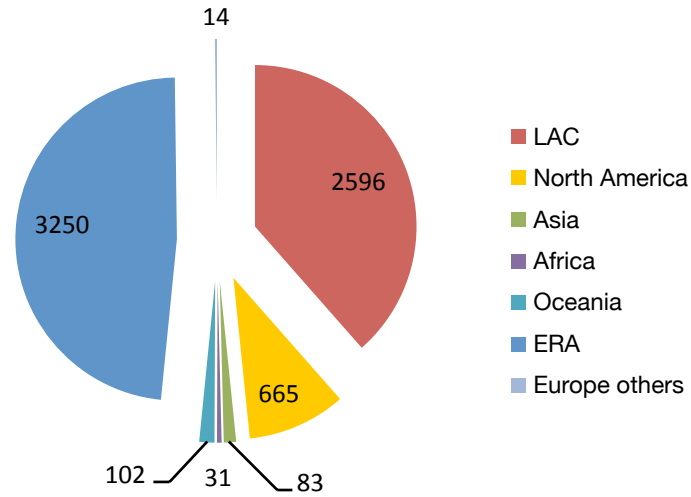


Figure 10. Geographic distribution of the corresponding authors of ERA-LAC publications on biodiversity.

# MAIN RESEARCH INSTITUTES IDENTIFIED IN ERA-LAC PUBLICATIONS ON BIODIVERSITY

Two US research institutions are the most represented in ERA-LAC publications, namely the Smithsonian Institution and the University of California, followed by the French CNRS, the University of Sao Paulo (Brazil), the Spanish CSIC, the Argentinian CONICET, and the University of Mexico (Figure 11).

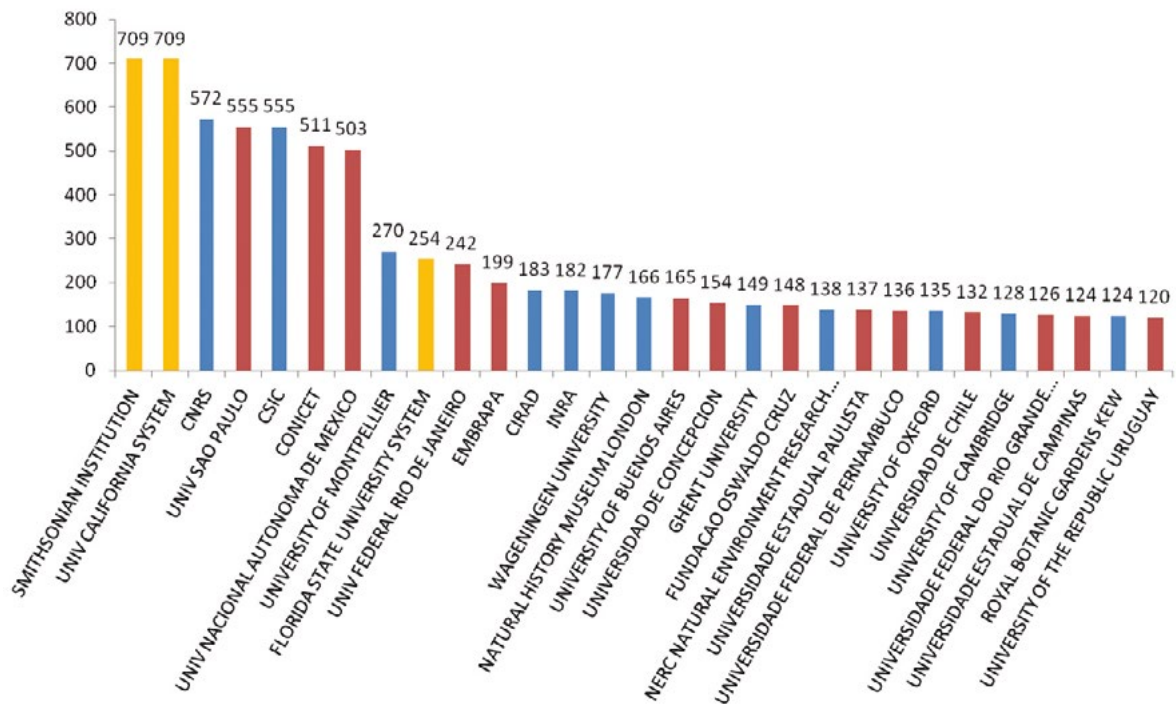


Figure 11. Main research organizations indicated in the affiliation of the authors of ERA-LAC co-publications on biodiversity.





# CONCLUSIONS AND PERSPECTIVES







# CONCLUSIONS AND PERSPECTIVES

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Both the LAC and Europe regions harbour an outstandingly rich diversity of species and ecosystems whose capacity to deliver essential services to society is already under severe pressure<sup>[11, 12]</sup>. While a sound management of biological resources may strengthen human well being in these regions, their mismanagement often accelerates environmental degradation, food and water insecurity, and health and social problems. Joining forces is needed to properly tackle issues such as documenting the changes in biodiversity and ecosystems induced by anthropogenic pressures, developing and assessing efficient conservation policies, and promoting Nature-based solutions to maintain and restore resilient socio-ecological systems in face of global change<sup>[13]</sup>.

Our results reveal that the ERA-LAC scientific community has appreciated the importance of this challenge, as the growth in the number of papers on Biodiversity involving ERA-LAC collaboration has been exponential over the last 10 years, increasing faster than other domains. However, although EU development policy aims to support Latin American regional integration<sup>[14]</sup>, our study also reveals strong differences in international collaboration patterns within LAC: co-publications were mostly deficient with low- and lower middle-income countries and privileged with emerging countries like Argentina, Mexico and even more Brazil. These two main characteristics of the ERA-LAC co-publication on biodiversity (i.e. steady increase in production and marked differences among countries) have already been reported in other studies on international scientific cooperation, both between EU-LAC regions<sup>[7]</sup> and worldwide<sup>[15]</sup>.

Various explanations have been given for the rise of international scientific cooperation<sup>[15]</sup>. Among them, the development of 'big science' including global biodiversity projects (e.g., GLORIA, CTFS), historical relationships including former colonial ties (e.g., within the Spanish-speaker communities), and the development of national research and training funding programmes (e.g., in Brazil or Ecuador) have likely contributed to the expansion of the

ERA-LAC co-publication network on Biodiversity. It is noteworthy that while no individual European country reached the levels of co-authorship of the US with LAC, the ERA as a whole equalled North America as scientific partner of LAC (Figure 2, Bottom-Right).

Over the last twenty years, the EU and Latin American countries have committed themselves to consolidating their links through a strategic partnership. One objective of these reinforced links is to develop capacity building of nations for knowledge generation and promote academic productivity and excellence. Consequently parameters like journals' impact factors and corresponding authors' metrics could be incorporated to future bibliometric analyses to better understand whether the way ERA-LAC collaboration has recently developed fulfils this goal.

Last but not least, the present analysis does not include overseas countries and territories and outermost regions linked to European countries and located in the LAC region: this is the case of, e.g. French Guyana, Martinique, Guadeloupe, Dutch Antilla and Montserrat. Because some of the corresponding local governments are now members of BiodivERsA, it will be of major importance to rely on the skills of these local actors to further reinforce the ERA-LAC collaboration for research on biodiversity. An additional mapping specifically highlighting the role of these overseas countries and territories and outermost regions in the transcontinental research collaboration networks could be very valuable. This could pave the way to new approaches to promote regional and inter-continental research collaboration.



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