Science Review 2012

GLOBAL
BIODIVERSITY
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Research using data accessed through the Global Biodiversity Information Facility

Foreword

In 2012, GBIF came of scientific age. It experienced a veritable explosion in the scientific use of the world's biodiversity data that it serves freely and openly. The remarkable growth in GBIF-enabled science – more than 230 recorded papers in 2012, up from 170 in 2011 – is the strongest possible demonstration of the return on investment that GBIF participant countries have made in building the GBIF informatics infrastructure, and in mobilizing the knowledge discovered during the 300-year biological exploration of the planet. Reporting the research citing GBIF as a data source, this Science Review is a fitting companion to the 2012 GBIF Annual Report.

The subject areas encompassed by this research range from the impacts of climate change and development, to modelling the dangerous spread of invasive alien species and disease organisms, to the conservation of species and protected areas. Other researchers used GBIF-mediated data to analyse the roles of biodiversity in sustaining food, biofuels and farming. And many studies deployed GBIF-served data to advance understanding of life on Earth in a variety of ways.

Cumulatively, GBIF-enabled science is helping to build the knowledge base required to fulfil the mission of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), and to meet the Aichi Targets included in the United Nations 2011-20 Strategic Plan for Biodiversity.

To continue serving the needs of science and society, GBIF counts on the scientific community in two crucial areas. First, authors should diligently cite and acknowledge the use of GBIF-mediated data in all studies, so that GBIF data publishers see first-hand the rewards of sharing their data. Second, scientists should use every opportunity to demonstrate to each participant country – and to those countries not yet participating in GBIF – the scientific importance of continued investment in GBIF's fundamental enterprise.

LEONARD KRISHTALKA
CHAIR, GBIF SCIENCE COMMITTEE

A NOTE ON THIS REVIEW

All of the research articles included in the main sections of this review from page 2 to page 30 assert some use of GBIF-mediated data. They were extracted from a continuing programme by the GBIF Secretariat to monitor scientific literature and tag papers according to use, discussion and mention of GBIF, through the Mendeley academic archiving platform. This archive is freely available at http://www.mendeley.com/groups/1068301/gbif-public-library/.

The categories used for this review are designed to help navigate the major subject areas covered by GBIF-assisted research. However, inevitably some papers will cover multiple areas and the distinctions may appear arbitrary in places. The countries assigned to authors are based on the location of the institutions given in the author information. The free-text descriptions given to some papers in each category are for illustration only – they do not imply greater importance being attached to those papers as opposed to others cited in the review.

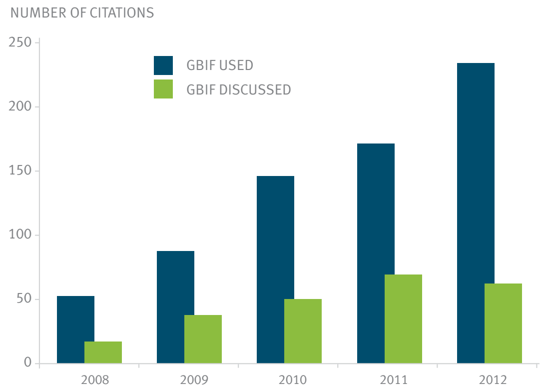


FIGURE 1. A SUMMARY OF GBIF CITATION IN PEER-REVIEWED PUBLICATIONS, 2008–2012.

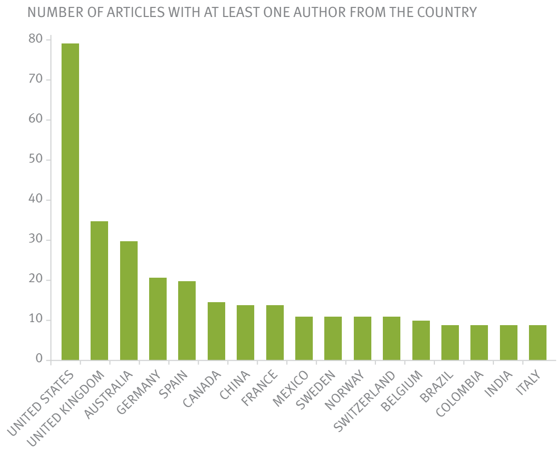


FIGURE 2. NUMBER OF SCIENTIFIC PUBLICATIONS IN 2012 CITING USE OF GBIF-MEDIATED DATA, RANKED BY COUNTRY ACCORDING TO AFFILIATION OF AUTHOR. TOP 17 COUNTRIES ONLY SHOWN.

Contents

Invasive alien species

The critical issue of invasive alien species and their impact on biodiversity and human livelihoods was the main subject of more than 40 research papers using GBIF-mediated data in 2012. These papers investigated a range of questions including the potential future spread of these species and the factors that determine whether alien species become established in a new environment. Most of the studies used records of the occurrence of the species in their native and/or introduced ranges, discovered and accessed via GBIF, to generate ecological niche models and thus predict which areas are at risk of invasion.

Some examples

LANTANA CAMARA © JOAQUIM ALVES GASPAR

FROM ORNAMENT TO WEED – CONTROLLING *LANTANA CAMARA*

Taylor, S. *et al.*, 2012. Climate Change and the Potential Distribution of an Invasive Shrub, *Lantana camara* L A. J. Cannon, ed. *PLoS ONE*, 7(4), p.e35565. Available at: http://dx.plos.org/10.1371/journal.pone.0035565

Bhagwat, S. a *et al.*, 2012. A Battle Lost? Report on Two Centuries of Invasion and Management of *Lantana camara* L. in Australia, India and South Africa A. Traveset, ed. *PLoS ONE*, 7(3), p.e32407. Available at: http://dx.plos.org/10.1371/journal.pone.0032407

Invasions of the woody, flowering shrub *Lantana camara* have had significant economic and environmental impacts in many tropical and subtropical regions since the plant was introduced from the Americas as an ornamental garden plant in the mid-19th century. It is now ranked among the world's top ten invasive species by the Global Invasive Species Information Network. In the first of these studies, Taylor *et al.* investigated the potential future distribution of the plant, based on a model of suitable habitats under present and future climate conditions. The model used more than 1,700 occurrence records obtained through GBIF, along with other data.
The study identified areas of North Africa, Europe, Australia and New Zealand where *L. camara* could potentially expand its range, and recommended monitoring of these areas by biosecurity agencies for early signs that the plant was becoming invasive.

In the second study, Bhagwat *et al.* also generated a global model of areas climatically suitable for invasion by *L. camara*, using data obtained through GBIF. After examining historical records of previous invasions and attempts to manage them, the researchers concluded that aggressive efforts by governments in Australia, India and South Africa had been largely unsuccessful. They suggest that in future, the best response to some invasive species may be adaptive management, rather than using available resources to fight a losing battle aimed at eradication.

Additional associated studies

Lu-Irving, P. & Olmstead, R.G., 2012. Investigating the evolution of Lantaneae (Verbenaceae) using multiple loci. *Botanical Journal of the Linnean Society*, online. Available at: http://doi.wiley.com/10.1111/j.1095-8339.2012.01305.x

Taylor, S., Kumar, L. & Reid, N., 2012. Impacts of climate change and land-use on the potential distribution of an invasive weed: a case study of *Lantana camara* in Australia. *Weed Research*, online. Available at: http://doi.wiley.com/10.1111/j.1365-3180.2012.00930.x

Taylor, S. & Kumar, L., 2012. Potential distribution of an invasive species under climate change scenarios using CLIMEX and soil drainage: A case study of *Lantana camara* L. in Queensland, Australia. *Journal of Environmental Management*, online. Available at: http://www.ncbi.nlm.nih.gov/pubmed/23164541

Taylor, S. & Kumar, L., 2012. Sensitivity Analysis of CLIMEX Parameters in Modelling Potential Distribution of *Lantana camara* L. *PLoS ONE*, 7(7), p.e40969. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22815881

Author countries: **Australia, Norway, UK, USA**

BROWN MARMORATED STINK BUG (*HALYOMORPHA HALYS*) © USGS BEE INVENTORY AND MONITORING

MAPPING INVASION RISK FROM AN AGRICULTURAL PEST

Zhu, G. *et al.*, 2012. Potential Geographic Distribution of Brown Marmorated Stink Bug Invasion (*Halyomorpha halys*) B. Fenton, ed. *PLoS ONE*, 7(2), p.e31246. Available at: http://dx.plos.org/10.1371/journal.pone.0031246

This research explored the climatic niche occupied by a pest causing widespread agricultural damage, with a rapidly expanding range in North America and Europe. To model the potential spread of the bug, it used occurrence records from its native range in east Asia, obtained partly from databases in Japan, South Korea and Taiwan publishing data through GBIF.

Using these models, the study mapped areas at risk of invasion from the pest in northern Europe, northeastern North America, southern Australia, North Island-New Zealand, Angola and Uruguay. The study aimed to provide critical information for management strategies.

Author country: China

POLYPEDATES LEUCOMYSTAX © JOACHIM S. MÜLLER

WHY SOME ALIENS MAKE THEMSELVES AT HOME

Rago, A., While, G.M. & Uller, T., 2012. Introduction pathway and climate trump ecology and life history as predictors of establishment success in alien frogs and toads. *Ecology and Evolution*, online. Available at: http://doi.wiley.com/10.1002/ece3.261

What determines whether an alien species will successfully establish itself in the new environment where it is introduced? An Oxford University team set out to answer this question by testing a range of parameters, using data from 408 occurrence records of 99 frog and toad species accessed through GBIF. The research concluded that alien amphibians were most likely to become established if the climate in the area of introduction was similar to that in the native range; if they were introduced deliberately rather than accidentally; and if they were introduced on islands rather than continental environments. Other studies have found that some species traits, such as how many offspring are produced and whether tadpoles live independently of adults, influence the risk of amphibians becoming extinct, but this research found little evidence that such traits were important in determining whether they survived as alien species.

Author Country: UK

Other research relating to invasive species citing use of GBIF-mediated data

Title	Journal	Authors	Author countries	URL
Predicting the current distribution and potential spread of the exotic grass *Eragrostis plana* Nees in South America and identifying a bioclimatic niche shift during invasion.	*Austral Ecology*	Barbosa, F.G. *et al.*	Brazil, South Africa	http://doi.wiley.com/10.1111/j.1442-9993.2012.02399.x
Climate suitability and human influences combined explain the range expansion of an invasive horticultural plant.	*Biological Invasions*	Beans, C.M., Kilkenny, F.F. & Galloway, L.F.	USA	http://www.springerlink.com/index/10.1007/s10530-012-0214-0
The potential global distribution of the invasive weed *Nassella neesiana* under current and future climates.	*Biological Invasions*	Bourdôt, G. *et al.*	Australia, New Zealand	http://www.springerlink.com/index/10.1007/s10530-010-9905-6
Predicting the impact of climate change on the invasive decapods of the Iberian inland waters: an assessment of reliability.	*Biological Invasions*	Capinha, C., Anastácio, P. & Tenedório, J.A.	Portugal	http://www.springerlink.com/index/10.1007/s10530-012-0187-z
Geographical variability in propagule pressure and climatic suitability explain the European distribution of two highly invasive crayfish.	*Journal of Biogeography*	Capinha, C., Brotons, L. & Anastácio, P.	Portugal, Spain	http://doi.wiley.com/10.1111/jbi.12025
Does adding multi-scale climatic variability improve our capacity to explain niche transferability in invasive species?	*Ecological Modelling*	Fernández, M. *et al.*	USA	http://linkinghub.elsevier.com/retrieve/pii/S0304380012003742
Cryptic extinction of a common Pacific lizard *Emoia impar* (Squamata, Scincidae) from the Hawaiian Islands.	*Oryx*	Fisher, R. & Ineich, I.	France, USA	http://journals.cambridge.org/abstract_S0030605310001778
Spread dynamics and agricultural impact of *Sorghum halepense*, an emerging invasive species in Central Europe.	*Weed Research*	Follak, S. & Essl, F.	Austria	http://doi.wiley.com/10.1111/j.1365-3180.2012.00952.x
The grass may not always be greener: projected reductions in climatic suitability for exotic grasses under future climates in Australia.	*Biological Invasions*	Gallagher, R.V. *et al.*	Australia	http://www.springerlink.com/index/10.1007/s10530-012-0342-6
Invasive species distribution models – how violating the equilibrium assumption can create new insights.	*Global Ecology and Biogeography*	Gallien, L. *et al.*	France, Switzerland	http://doi.wiley.com/10.1111/j.1466-8238.2012.00768.x
Potential distribution of the American bullfrog (*Lithobates catesbeianus*) in Ecuador.	*South American Journal of Herpetology*	Iñiguez, C.A. & Morejón, F.J.	Ecuador	http://www.bioone.org/doi/abs/10.2994/057.007.0211
Population structure of the melon fly, *Bactrocera cucurbitae*, in Reunion Island.	*Biological Invasions*	Jacquard, C. *et al.*	Belgium, France	http://www.springerlink.com/index/10.1007/s10530-012-0324-8
Using avatar species to model the potential distribution of emerging invaders.	*Global Ecology and Biogeography*	Larson, E.R. & Olden, J.D.	USA	http://doi.wiley.com/10.1111/j.1466-8238.2012.00758.x
Oviposition preference and larval development of the invasive moth *Cydalima perspectalis* on five European box-tree varieties.	*Journal of Applied Entomology*	Leuthardt, F.L.G. & Baur, B.	Switzerland	http://doi.wiley.com/10.1111/jen.12013
Modelling the geographical range of a species with variable life-history.	*PLoS ONE*	Macfadyen, S. & Kriticos, D.J.	Australia	http://dx.plos.org/10.1371/journal.pone.0040313
Geographic spread of *Pyramica hexamera*.	*Terrestrial Arthropod Reviews*	MacGown, J.A. & Wetterer, J.K.	USA	http://www.ingentaconnect.com/content/brill/tar/2012/00000005/00000001/art00002

Title	Journal	Authors	Author countries	URL
Geographic spread of *Gnamptogenys triangularis* (Hymenoptera: Formicidae: Ectatomminae).	*Psyche: A Journal of Entomology*	MacGown, J.A. & Wetterer, J.K.	USA	http://www.hindawi.com/journals/psyche/2012/571430/
Buffel grass (*Cenchrus ciliaris*) as an invader and threat to biodiversity in arid environments: a review.	*Journal of Arid Environments*	Marshall, V.M., Lewis, M.M. & Ostendorf, B.	Australia	http://linkinghub.elsevier.com/retrieve/pii/S0140196311003399
Potential distribution of the Australian native *Chloris truncata* based on modelling both the successful and failed global introductions.	*PLoS One*	Michael, P.J., Yeoh, P.B. & Scott, J.K.	Australia	http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3407094&tool=pmcentrez&rendertype=abstract
Invasion hotspots for non-native plants in Australia under current and future climates.	*Global Change Biology*	O'Donnell, J. *et al.*	Australia	http://doi.wiley.com/10.1111/j.1365-2486. 2011.02537.x
First record of the onion psyllid *Bactericera tremblayi* (Wagner, 1961) in France (Insecta: Hemiptera: Sternorrhyncha: Psylloidea), new symptoms on leek crops and reassessment of the *B. nigricornis* – group distribution.	*EPPO Bulletin*	Ouvrard, D. & Burckhardt, D.	Switzerland, UK	http://doi.wiley.com/10.1111/epp.12005
Evidence of a climatic niche shift following North American introductions of two crane flies (Diptera; genus Tipula).	*Biological Invasions*	Petersen, M.J.	USA	http://www.springerlink index/10.1007/s10530-012-0337-3
Glacial history of a modern invader: phylogeography and species distribution modelling of the Asian tiger mosquito *Aedes albopictus*.	*PLoS ONE*	Porretta, D. *et al.*	Italy, Thailand	http://dx.plos.org/10.1371/journal.pone.0044515
A review of the life history, invasion process, and potential management of *Clavelina lepadiformis* Müller, 1776: a recent invasion of the northwest Atlantic.	*Management of Biological Invasions*	Reinhardt, J. & Hudson, D.	USA	http://www.reabic.net/journals/mbi/2012/Issue1.aspx
Potential spread of recently naturalised plants in New Zealand under climate change.	*Climatic Change*	Sheppard, C.S.	New Zealand	http://www.springerlink.com/index/10.1007/s10584-012-0605-3
Distribution of *Candidatus* Phytoplasma prunorum and its vector *Cacopsylla pruni* in European fruit-growing areas: a review.	*EPPO Bulletin*	Steffek, R. *et al.*	Austria, France, UK	http://doi.wiley.com/10.1111/epp.2567
Future pest status of an insect pest in museums, *Attagenus smirnovi*: distribution and food consumption in relation to climate change.	*Journal of Cultural Heritage*	Stengaard Hansen, L. *et al.*	Denmark, Norway, Sweden	http://linkinghub.elsevier.com/retrieve/pii/S1296207411000549
Humans introduce viable seeds to the Arctic on footwear.	*Biological Invasions*	Ware, C. *et al.*	Australia, Norway	http://www.springerlink.com/index/10.1007/s10530-011-0098-4
Worldwide spread of Emery's sneaking ant, *Cardiocondyla emeryi* (Hymenoptera: Formicidae).	*Myrmecological News*	Wetterer, J.K.	USA	http://www.myrmecologicalnews.org/cms/images/pdf/volume17/mn17_13-20_non-printable.pdf
Worldwide spread of the African big-headed ant, *Pheidole megacephala* (Hymenoptera: Formicidae).	*Myrmecological News*	Wetterer, J.K	USA	http://www.myrmecologicalnews.org/cms/images/pdf/volume17/mn17_51-62_non-printable.pdf

Title	Journal countries	Authors	Author	URL
Worldwide spread of the Moorish sneaking ant, *Cardiocondyla mauritanica* (Hymenoptera : Formicidae).	*Sociobiology*	Wetterer J.K.	USA	http://scholar.google.com/url?hl=en&q=http://antcat.org/documents/5737/wetterer_2012_sociobiology-worldwide-spread-of-cardiocondyla-mauritanica.pdf&sa=X&scisig=AAGBfm3rLOObzXAT1DLFopVIOhJiaSAbJw&oi=scholaralrt
Worldwide spread of *Cerapachys biroi* (Hymenoptera: Formicidae: Cerapachyinae).	*Myrmecological News*	Wetterer, J.K., Kronauer, D.J.C. & Borowiec, M.L.	USA	http://www.myrmecologicalnews.org/cms/images/pdf/volume17/mn17_1-4_non-printable.pdf
A qualitative ecological risk assessment of the invasive Nile tilapia, *Oreochromis niloticus* in a sub-tropical African river system (Limpopo River, South Africa).	*Aquatic Conservation: Marine and Freshwater Ecosystems*	Zengeya, T. A. *et al.*	South Africa	http://doi.wiley.com/10.1002/aqc.2258

Impacts of climate change

A large body of research using GBIF-mediated data during 2012 looked at various aspects of how climate change is likely to affect the survival of species, both positively and negatively, and to alter their future distributions. This included investigation of the impacts of past climatic changes on the evolution and distribution of species, helping to understand the mechanisms of the climate-biodiversity relationship and thus improve our projections for the future.

Some examples

ARCTIC FOX (*VULPES LAGOPUS*) © ALGKALV

MODELLING THE IMPACT OF CLIMATE CHANGE ON ARCTIC AND SUBARCTIC SPECIES

Hof, A.R., Jansson, R. & Nilsson, C., 2012. Future climate change will favour non-specialist mammals in the (sub) arctics. *PLoS ONE*, 7(12), p.e52574. Available at: http://www.ncbi.nlm.nih.gov/pubmed/23285098

This paper, by researchers from Umeå University in Sweden, suggests that climate change will favour most mammals currently occupying Arctic and subarctic Europe, so long as they are able to disperse to suitable areas. The conclusion runs contrary to the expectation that species in high latitudes will be especially susceptible to a warming climate.

Anouschka Hof, one of the presenters at the 2012 GBIF Science Symposium and lead author of this paper, together with Roland Jansson and Christer Nilsson, modelled future distributions for mammal species currently resident in the far north of Europe, as well as some potential colonizers from further south. Occurrence records for 61 species were gathered from national databases in Norway, Sweden and Finland, and from the GBIF data portal.

The results, based on climate scenarios for 2080, indicated that 43 out of the 61 species studied would expand and shift their ranges, mainly to the northeast, assuming they were fully able to disperse to suitable areas. Nevertheless, species specializing in alpine habitats, such as Arctic fox, Norway lemming and wolverine, would likely see their ranges contract. If the ability to disperse is severely limited, for example due to roads or industrial developments, most mammal species would lose range, but none is projected to become extinct due to climate change.

Additional associated study

Hof. A. *et al.*, 2012. How biotic interactions may alter future predictions of species distributions: future threats to the persistence of the arctic fox in Fennoscandia. *Diversity and distributions*. Available at: http://doi.wiley.com/10.1111/j.1472-4642.2011.00876.x

Author country: Sweden

BOG BLUEBERRY (*VACCINIUM ULIGINOSUM*) © OLE HUSBY

HOW CLIMATE CHANGE MAY AFFECT GENETIC DIVERSITY WITHIN SPECIES

Alsos, I.G. *et al.*, 2012. Genetic consequences of climate change for northern plants. *Proceedings of the Royal Society B: Biological Sciences*, online (January). Available at: http://www.ncbi.nlm.nih.gov/pubmed/22217725

This research, also led by a presenter at the 2012 GBIF Science Symposium, investigated how loss of range for many species due to climate change may affect genetic diversity, crucial to their long-term persistence. It analysed the genetic diversity of 27 northern plant species, using nearly 10,000 DNA samples from 1,200 populations. Among other data, it used validated GBIF-mediated occurrence points for those species to predict the loss of range and genetic diversity by 2080, employing a number of models and scenarios. The projected loss of genetic diversity varied widely among species, depending partly on the ability of plants to disperse over long distances. According to at least one scenario, all 27 species were predicted to lose genetic diversity.

Author Countries: **Norway, Austria, France**

ASTERIAS FORBESI © PAUL MORRIS

THE IMPACT OF RISING TEMPERATURES ON COLD-BLOODED ANIMALS

Sunday, J.M., Bates, A.E. & Dulvy, N.K., 2012. Thermal tolerance and the global redistribution of animals. *Nature Climate Change*, 2(6), pp.1-5. Available at: http://www.nature.com/doifinder/10.1038/nclimate1539

A team from Canada and Australia analysed the way in which the distribution ranges of ectotherms (cold-blooded animals) were likely to be affected by climate change. They found significant differences between the response of marine and terrestrial species, with animals in the ocean shifting much more predictably towards the poles as temperatures warmed.

The research compared tolerance of animals to extremes of heat and cold, as revealed by experiments, with actual geographic distributions of 142 species based on primary literature and online occurrence data accessed mainly via GBIF. It found that marine species tended to occupy the full range of latitudes predicted by the limits of 'tolerable' temperature – and thus shifted away from the Equator at both the colder and warmer edges of their range as the climate warmed. Terrestrial ectotherms, on the other hand, tended not to occupy the whole of the warmest part of their range as predicted purely by temperature tolerance.

The study suggested that climate change impacts on land would be less predictable, with range boundaries remaining more stagnant closer to the Equator while they would expand towards the poles at their colder limits. The resulting 'stretching' of terrestrial species distributions could lead to unpredictable impacts due to new combinations of species, shifting connectivity and ecological surprises.

Author countries: **Australia, Canada**

AMAZON RAINFOREST © CIFOR

CLIMATE CHANGE AND AMAZON PLANTS

Feeley, K.J. *et al.*, 2012. The relative importance of deforestation, precipitation change, and temperature sensitivity in determining the future distributions and diversity of Amazonian plant species. *Global Change Biology*, online. Available at: http://doi.wiley.com/10.1111/j.1365-2486.2012.02719.x

This study aimed to establish the most important factors that would determine the future diversity and distribution of plants in the Amazon region. Using herbarium records obtained through GBIF and SpeciesLink (http://splink.cria.org.br), the research modelled current and future distributions of nearly 3,000 Amazonian plant species, under different scenarios related to the magnitude and extent of forest disturbance as well as the response of species to changes in temperature, precipitation and concentrations of carbon dioxide in the atmosphere.

It concluded that the future diversity of the Amazon would depend primarily on the ability of species to tolerate or adapt to rising temperatures: if thermal niches are relatively fixed, climate change will overshadow the impacts of deforestation and potentially cause massive biodiversity loss; but even if plants can tolerate warmer temperatures, the impacts of greater seasonal water stress may be of similar magnitude to those of deforestation in the Amazon.

Additional associated study

Feeley, K.J., 2012. Distributional migrations, expansions, and contractions of tropical plant species as revealed in dated herbarium records. *Global Change Biology*, 18(4), pp.1335–1341. Available at: http://doi.wiley.com/10.1111/j.1365-2486.2011.02602.x

Author countries: USA, UK

CANNONBALL TREE (*COUROUPITA GUIANENSIS*) © BRIAN GATWICKE

Other research relating to climate change citing use of GBIF-mediated data

Title	Journal	Authors	Author countries	URL
Climate downscaling effects on predictive ecological models: a case study for threatened and endangered vertebrates in the southeastern United States.	*Regional Environmental Change*	Bucklin, D.N. *et al.*	USA	http://www.springerlink.com/index/10.1007/s10113-012-0389-z
Distribution of the threatened lace hedgehog cactus (*Echinocereus reichenbachii*) under various climate change scenarios.	*The Journal of the Torrey Botanical Society*	Butler, C.J., Wheeler, E.A. & Stabler, L.B.	USA	http://dx.doi.org/10.3159/TORREY-D-11-00049.1
Not-so-splendid isolation: modeling climate-mediated range collapse of a montane mammal *Ochotona princeps* across numerous ecoregions.	*Ecography*	Calkins, M.T. *et al.*	USA	http://doi.wiley.com/10.1111/j.1600-0587.2011.07227.x
Near-tropical Early Eocene terrestrial temperatures at the Australo-Antarctic margin, western Tasmania.	*Geology*	Carpenter, R.J. *et al.*	Australia	http://geology.gsapubs.org/cgi/doi/10.1130/G32584.1
Modelling distribution in European stream macroinvertebrates under future climates.	*Global Change Biology*	Domisch, S. *et al.*	Denmark, Germany, Portugal, Spain	http://doi.wiley.com/10.1111/gcb.12107
Predicting present and future intra-specific genetic structure through niche hindcasting across 24 millennia.	*Ecology Letters*	Espíndola, A. *et al.*	Switzerland	http://doi.wiley.com/10.1111/j.1461-0248.2012.01779.x
Heathlands confronting global change: drivers of biodiversity loss from past to future scenarios.	*Annals of Botany*	Fagúndez, J.	Spain	http://aob.oxfordjournals.org/cgi/doi/10.1093/aob/mcs257
Chilled but not frosty: understanding the role of climate in the hybridization between the Mediterranean *Fraxinus angustifolia* Vahl and the temperate *Fraxinus excelsior* L. (Oleaceae) ash trees.	*Journal of Biogeography*	Gérard, P.R. *et al.*	Croatia, France	http://doi.wiley.com/10.1111/jbi.12021
Using diverse data sources to detect elevational range changes of birds on Mount Kinabalu, Malaysian Borneo.	*The Raffles Bulletin of Zoology*	Harris, J.B.C. *et al.*	Australia, Singapore, Malaysia, USA, UK	http://rmbr.nus.edu.sg/rbz/biblio/s25/s25rbz197-247.pdf
On the brink of extinction? How climate change may affect global chelonian species richness and distribution.	*Global Change Biology*	Ihlow, F. *et al.*	Germany	http://doi.wiley.com/10.1111/j.1365-2486.2011.02623.x
Hydroclimatic and hydrochemical controls on Plecoptera diversity and distribution in northern freshwater ecosystems.	*Hydrobiologia*	Kruitbos, L.M. *et al.*	Canada, Sweden, Switzerland, UK, USA	http://www.springerlink.com/index/10.1007/s10750-012-1085-1
Frequency of local, regional, and long-distance dispersal of diploid and tetraploid *Saxifraga oppositifolia* (Saxifragaceae) to Arctic glacier forelands.	*American Journal of Botany*	Müller, E. *et al.*	Norway	http://www.ncbi.nlm.nih.gov/pubmed/22371855
Shrinking forests under warming: evidence of *Podocarpus parlatorei* (pino del cerro) from the Subtropical Andes.	*Journal of Heredity*	Quiroga, M. *et al.*	Argentina	http://dx.doi.org/10.1093/jhered/ess031
Effects of re-oligotrophication and climate warming on plankton richness and community stability in a deep mesotrophic lake.	*Oikos*	Pomati, F. *et al.*	Switzerland, the Netherlands	http://doi.wiley.com/10.1111/j.1600-0706.2011.20055.x

Title	Journal	Authors	Author countries	URL
Predicted range shifts in North American boreal forest birds and the effect of climate change on genetic diversity in blackpoll warblers (*Setophaga striata*).	*Conservation Genetics*	Ralston, J. & Kirchman, J.J.	USA	http://www.springerlink.com/index/10.1007/s10592-012-0418-y
Potential changes in benthic macrofaunal distributions from the English Channel simulated under climate change scenarios.	*Estuarine, Coastal and Shelf Science Online*	Rombouts, I., Beaugrand, G. & Dauvin, J.	France	http://linkinghub.elsevier.com/retrieve/pii/S0272771411005488
Past climate change and plant evolution in western North America: a case study in Rosaceae.	*PLoS ONE*	Töpel, M. *et al.*	Sweden, UK	http://dx.plos.org/10.1371/journal.pone.0050358
Do bioclimate variables improve performance of climate envelope models?	*Ecological Modelling*	Watling, J.I. *et al.*	USA	http://linkinghub.elsevier.com/retrieve/pii/S0304380012003468
Thermal variability increases the impact of autumnal warming and drives metabolic depression in an overwintering butterfly.	*PLoS ONE*	Williams, C.M. *et al.*	Canada, USA	http://dx.plos.org/10.1371/journal.pone.0034470

Species conservation and protected areas

Among the key practical uses of the biodiversity data published through the GBIF network is the development of policies and priorities for protecting threatened and endemic species and habitats. A number of research papers published during 2012 made extensive use of GBIF-mediated data to advance the science informing such policies and priorities — demonstrating the value to policy makers of investing in a global open data infrastructure.

Some examples

OXBOW LAKE, YASUNI NATIONAL PARK, ECUADOR © GEOFF GALLICE

PRIORITIES FOR PROTECTING PLANT SPECIES DIVERSITY IN SOUTH AMERICA

Ramirez-Villegas, J., Jarvis, A. & Touval, J., 2012. Analysis of threats to South American flora and its implications for conservation. *Journal for Nature Conservation*. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1617138112000830

In this study, researchers from Colombia, the United Kingdom and the United States used a large volume of data published through GBIF to identify critical areas for conservation of plant diversity across South America. The team analysed more than half a million GBIF-mediated records of 16,000 plant species, and developed a map showing 'virtual parks' where a large number of threatened and locally-unique species occurred within a 100km area. These were found to correspond well with real, existing protected areas: by prioritizing 24 protected areas, the researchers argue, up to 70 per cent of South American plant species diversity will be conserved. They also reveal gaps in existing coverage, suggesting new measures to conserve 200 plant species not currently included in any protected area. Critical areas to monitor, expand and strengthen are mainly located in the Ecuadorian and Colombian Andes, southern Paraguay, the Guyana shield, southern Brazil, and Bolivia.

Author countries: **Colombia, UK and USA**

IDENTIFYING KEY AREAS FOR BIRDS IN A BIODIVERSITY HOTSPOT

Ríos-Muñoz, C.A. & Navarro-Sigüenza, A.G., 2012. Patterns of species richness and biogeographic regionalization of the avifaunas of the seasonally dry tropical forest in Mesoamerica. *Studies on Neotropical Fauna and Environment*, (November 2012), pp.1–12. Available at: http://www.tandfonline.com/doi/abs/10.1080/01650521.2012.734175

César Antonio Ríos-Muñoz, winner of the 2011 GBIF Young Researchers Award, and Adolfo G. Navarro-Sigüenza from the National Autonomous University of Mexico (UNAM) investigated patterns of bird distributions in the seasonally dry lowland tropical forests of Mexico and Central America. The study analysed biogeographic relationships of 650 resident bird species of the forests, among the most endangered ecosystems in the world. About 40 per cent of the bird species are only found in this habitat.

The research used occurrence data from scientific literature, museum specimens, field guides and online scientific collection databases accessed through GBIF, to produce maps of species richness and areas of endemism (clusters of unique species), helping identify key locations for the conservation of birds in the region.

Author country: **Mexico**

ORANGE-STRIPED TRIGGERFISH (*BALISTAPUS UNDULATUS*) © HANS HILLEWAERT

SELECTING MARINE PROTECTED AREAS ALONG MADAGASCAR'S COAST

Allnutt, T.F. *et al.*, 2012. Comparison of Marine Spatial Planning Methods in Madagascar Demonstrates Value of Alternative Approaches R. K. F. Unsworth, ed. *PLoS ONE*, 7(2), p.e28969. Available at: http://dx.plos.org/10.1371/journal.pone.0028969

This paper aimed to help the government of Madagascar to implement plans to increase the coverage of marine protected areas off its coastline by more than one million hectares. It compared four different methods to select areas for protection based on fishing pressure, exposure to climate change and biodiversity. All results favoured the creation of protected areas in parts of the northern, central and southern zones of the island's western coastal waters.

The calculation of biodiversity value was based on occurrence records for 274 fish species, published by the Ocean Biogeographic Information System (OBIS), and accessed using GBIF.

Author countries: **Canada, France, Madagascar, New Caledonia, South Africa, USA**

SETTING PRIORITIES FOR PLANT CONSERVATION

Miller, J.S. *et al.*, 2012. Addressing target two of the Global Strategy for Plant Conservation by rapidly identifying plants at risk. *Biodiversity & Conservation*, online. Available at: http://www.springerlink.com/index/10.1007/s10531-012-0285-3

This study addressed the challenge of meeting the target, under the Global Strategy for Plant Conservation (GSPC), to assess the conservation status of all known plants by 2020. Because the existing IUCN Red List process currently assesses only a small proportion of known plant species, the study compared and contrasted two streamlined methods for rapidly assessing which species could be considered under some degree of risk, using herbarium records with locality data. It analysed more than two thousand species native to the island of Puerto Rico, using records accessed through GBIF and the New York Botanical Garden's Virtual Herbarium. The analysis identified 570 of Puerto Rican species as being at some risk of extinction. While the authors do not propose the methods as an alternative to the Red List process, they argue that they could be an efficient means of meeting the GSPC target and identifying priority areas for conservation of plants.

Author countries: **USA**

WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) © SCOTT BAUER / USDA

ESTIMATING SPECIES DENSITY FROM OCCURRENCE RECORDS

Yañez-Arenas, C. *et al.*, 2012. Modelling geographic patterns of population density of the white-tailed deer in central Mexico by implementing ecological niche theory. *Oikos*, online (March). Available at: http://doi.wiley.com/10.1111/j.1600-0706.2012.20350.x

In this paper, a team from Mexico proposed and tested a new system of estimating the relative abundance of a species based only on data about where it occurs, combined with models of the ecological niche it occupies. Field research in two regions of Central Mexico on the white-tailed deer, a popular game species, were combined with occurrence records of the species obtained through GBIF and its Mexican partner Conabio. The researchers used these data to generate a model of the predicted range of the deer based on a set of nine environmental variables (an ecological niche model). For each pixel within the area of environmental suitability for the species, the 'distance to the niche centroid' (DNC) was calculated – a multi-dimensional value representing how close any location is to the optimal set of conditions for the deer. This value was used to predict the density of deer across the two regions, and was found to correlate significantly with measures of actual density from the field studies. The authors suggest this could be a valuable tool for sustainable management and conservation of white-tailed deer and other species by estimating relative population density even when records of abundance are not available.

Author country: **Mexico**

Other research related to species conservation and protected areas, citing use of GBIF-mediated data

Title	Journal	Authors	Author countries	URL
Modelling geographic distribution and detecting conservation gaps in Italy for the threatened beetle *Rosalia alpina*.	*Journal for Nature Conservation*	Bosso, L. *et al.*	Italy, Portugal, UK	http://linkinghub.elsevier.com/retrieve/pii/S1617138112001021
Distribución potencial del jaguar *Panthera onca* (Carnivora: Felidae) en Guerrero, México: persistencia de zonas para su conservación.	*Revista de biologia tropical*	Cuervo-Robayo, A.P. & Monroy-Vilchis, O.	Mexico	http://www.scielo.sa.cr/pdf/rbt/v60n3/a33v60n3.pdf
Potential distribution of American black bears in northwest Mexico and implications for their conservation.	*Ursus*	Delfín-Alfonso, C.A., López-González, C.A. & Equihua, M.	Mexico	http://www.bioone.org/doi/abs/10.2192/URSUS-D-11-00007.1
Thinking spatially: The importance of geospatial techniques for carnivore conservation.	*Ecological Informatics*	García-Rangel, S. & Pettorelli, N.	UK	http://linkinghub.elsevier.com/retrieve/pii/S157495411200115X
Situación del Zorro Vinagre (*Speothos Venaticus*) en el extremo sur de su distribución (Argentina).	Interciencia	Gil, G.E. & Lobo, J.M.	Argentina, Spain	http://xa.yimg.com/kq/groups/28662970/1468922882/name/GilyLobo2012.pdf
Distribution of *Lunaria telekiana* (Brassicaceae), a poorly known species of European concern.	*Botanica Serbica*	Lakušić, D. *et al.*	Serbia	http://botanicaserbica.bio.bg.ac.rs/arhiva/pdf/2012_36_2_569_full.pdf
Rhododendron species in the Indian Eastern Himalayas : new approaches to understanding rare plant species.	*Journal American Rhododendron Society*	Menon, S. *et al.*	India, USA	http://www.nerist.ac.in/department/forestry/faculty/khan/PDFs/Journals/Rhod_nicheModelling.pdf
A biogeographical assessment of anthropogenic threats to areas where different frog breeding groups occur in South Africa: implications for anuran conservation.	*Diversity and Distributions*	Mokhatla, M.M. *et al.*	South Africa	http://doi.wiley.com/10.1111/j.1472-4642.2011.00870.x
The Alpine cushion plant *Silene acaulis* as foundation species: a bug's-eye view to facilitation and microclimate.	*PLoS ONE*	Molenda, O., Reid, A. & Lortie, C.J.	Canada	http://dx.plos.org/10.1371/journal.pone.0037223
High connectivity among habitats precludes the relationship between dispersal and range size in tropical reef fishes.	*Ecography*	Mora, C. *et al.*	Australia, Canada, UK, USA	http://doi.wiley.com/10.1111/j.1600-0587.2011.06874.x
The importance of defining the geographic distribution of species for conservation: the case of the Bearded Wood-Partridge.	*Journal for Nature Conservation*	Mota-Vargas, C. & Rojas-Soto, O.R.	Mexico	http://linkinghub.elsevier.com/retrieve/pii/S1617138111000422
Geographic and ecological analysis of the Bearded Wood Partridge *Dendrortyx barbatus*: some insights on its conservation status.	*Bird Conservation International*	Mota-Vargas, C. *et al.*	Mexico	http://www.journals.cambridge.org/abstract_S0959270912000329
Mining the Himalayan uplands plant database for a conservation baseline using the public GMBA webportal.	*Protection of the Three Poles*	Nemitz, D. *et al.*	Germany, Switzerland, USA	http://www.springerlink.com/index/10.1007/978-4-431-54006-9
Protected areas in the Spanish Pyrenees: A meaningful way to preserve biodiversity?	*Environmental Engineering and Management Journal*	Otegui, J., Villarroya, A. & Ariño, A.H.	Spain	http://omicron.ch.tuiasi.ro/EEMJ/issues/vol11/vol11no6.htm

Title	Journal	Authors	Author countries	URL
Applied landscape ecology, future socioeconomics and policy-making in the neotropics.	*Perspectives on Nature Conservation – Patterns, Pressures and Prospects*	Restrepo-Aristizábal, A., Heggestad, V. & Acuña-Rodríguez, I.S.	Chile	http://cdn.intechopen.com/pdfs/29849/InTech-Applied_landscape_ecology_future_socioeconomics_and_policy_making_in_the_neotropics.pdf
In search of critically endangered species: the current situation of two tiny salamander species in the neotropical mountains of Mexico.	*PLoS ONE*	Sandoval-Comte, A., Pineda, E. & Aguilar-López, J.L.	Mexico	http://www.ncbi.nlm.nih.gov/pubmed/22485155
Modeling the distribution of rare or cryptic bird species of Taiwan.	*Taiwania*	Wu, T. *et al.*	Chinese Taipei (Taiwan)	http://tai2.ntu.edu.tw/taiwania/pdf/ tai.2012.57.4.342.pdf
Range shifts under climate change and the role of protected areas for armadillos and anteaters.	*Biological Conservation*	Zimbres, B.Q.C. *et al.*	Brazil	http://linkinghub.elsevier.com/retrieve/pii/S0006320712001929

Impacts of development

Data mobilized through the GBIF network are being used increasingly to inform strategic planning and economic development, helping to ensure that decisions aimed at promoting growth or reducing poverty can be made with minimum negative impacts on biodiversity and the essential services that ecosystems provide.

Some examples

A TOOL FOR SENSITIVE SITING OF INDUSTRIAL DEVELOPMENTS

Willis, K.J. *et al.*, 2012. Determining the ecological value of landscapes beyond protected areas. *Biological Conservation*, online, pp.1–10. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0006320711003995

This paper described the methodology of the Local Ecological Footprinting Tool (LEFT), devised by the Oxford Biodiversity Institute to help companies avoid the most ecologically important areas when siting developments such as industrial, mining and oil installations within a concession area. The tool aims to provide fine-scale calculations of relative ecological value within a given region. It uses globally-available databases and models to provide a score for every 300 metre parcel, based on five key ecological features (biodiversity, vulnerability, fragmentation, connectivity and resilience).

The study demonstrated the potential of the tool in three regions in Algeria, the Russian Federation and Canada. To obtain biodiversity values, LEFT extracts all appropriate species occurrence records from the GBIF data index for the same ecological region as the study area, and uses ecological niche modelling to predict their distribution at very fine scales. The methodology offers reports on any land area in the world.

Author countries: **UK, Norway**

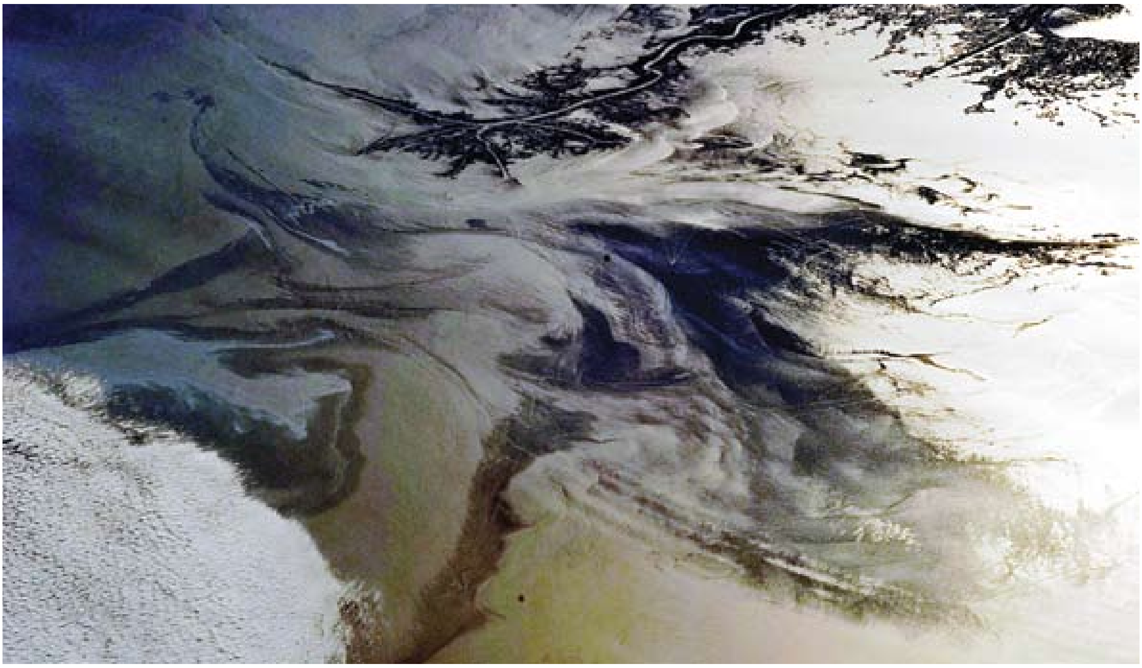
KRISHNA RIVER GORGE, SRISAILAM, ANDHRA PRADESH, INDIA.

ASSESSING THE IMPACTS OF MAJOR WATER TRANSFER PROJECTS

Example: Grant, E.H.C. *et al.*, 2012. Interbasin Water Transfer, Riverine Connectivity, and Spatial Controls on Fish Biodiversity B. Gratwicke, ed. *PLoS ONE*, 7(3), p.e34170. Available at: http://dx.plos.org/10.1371/journal.pone.0034170

A team from the United States and India researched the impacts on the biodiversity of freshwater fish from major engineering projects linking up separate river basins to transfer water from wetter to drier regions. It took the example of India’s Interlinking of Rivers Programme, which includes plans to move water across eight river basins in peninsular India via a network of more than 2000km of canals. The study used data on more than 450 species of freshwater fish occurring in Indian rivers, obtained partly from three collections accessed through GBIF. It concluded that the water transfer project would reduce biodiversity across the whole system, alter patterns of local species richness, expand distributions of widespread species and make the different basins more uniform. The research further concluded that the negative ecological impacts could be reduced if the project changed the order in which canals were added.

Author countries: **India, USA**



GULF OF MEXICO OIL SPILL OBSERVED FROM THE INTERNATIONAL SPACE STATION © NASA

MONITORING THE LONG-TERM EFFECTS OF A MAJOR OIL SPILL

Chakrabarty, P. *et al.*, 2012. SpeciesMap: a web-based application for visualizing the overlap of distributions and pollution events, with a list of fishes put at risk by the 2010 Gulf of Mexico oil spill. *Biodiversity & Conservation*, online. Available at: http://www.springerlink.com/index/10.1007/s10531-012-0284-4

This paper presented an application called SpeciesMap (http://speciesmap.org), which aims to help assess the impact of the Deepwater Horizon oil spill in 2010 on marine species in the Gulf of Mexico. The application uses occurrence records derived through GBIF on 124 fish species, including all 77 species endemic to the Gulf, to establish the area of overlap with the extent of the spill observed from satellite records. Maps are created to assess which species were potentially in the region of the spill and to what extent their range was exposed to pollution, so that species can be targeted for monitoring the long-term impact of the spill.

Author countries: USA

Biodiversity and human health

The links between biodiversity and human health are increasingly recognized, and this is reflected in the body of research making use of GBIF-mediated data in 2012. Among the major emerging areas is the use of ecological niche models to project the likely spread of disease-carrying organisms, and thus help to target areas for monitoring and prevention of the associated illnesses.

Some examples

ANOPHELES ALBIMANUS, A CARRIER OF MALARIA © JAMES GATHANY

MODELLING DISTRIBUTIONS OF DISEASE-CARRYING ORGANISMS

Fuller, D.O. *et al.*, 2012. Near-present and future distribution of *Anopheles albimanus* in Mesoamerica and the Caribbean Basin modeled with climate and topographic data. *International Journal of Health Geographics*, 11, p.13. Available at: http://dx.doi.org/10.1186/1476-072X-11-13

Foley, D.H. *et al.*, 2012. SandflyMap: leveraging spatial data on sand fly vector distribution for disease risk assessments. *Geospatial Health*, 6(3), pp.S25–30. Available at: http://www.ncbi.nlm.nih.gov/pubmed/23032280

The first of these studies by a team from the United States and Colombia looked at the projected spread of a major malaria-carrying mosquito in Mesoamerica and the Caribbean Basin. It used more than 300 records showing locations where the mosquito was present, obtained through GBIF itself and a GBIF-funded project, Mosquito Map (www.mosquitomap.org), as well as published data from mosquito surveys in Colombia. These points were combined with climate and topographical data to generate a model showing probability of the presence of the mosquito, under 'near present' (1950-2000) and future climate conditions, across the whole region. The major conclusion was that while the mosquito was unlikely to spread much further to the north or south, it is likely to invade high-altitude regions above 2,000 metres, putting many more people at risk of malaria in Mesoamerica and the Caribbean Basin by 2080.

The second study introduced SandflyMap, a new service arising from the GBIF-funded Mosquito Map project. It aims to map distributions of sand flies, associated with the spread of leishmaniasis disease. The purpose is to provide information for medical entomologists, disease control workers, public health officials and health planners. The authors encourage researchers to submit data on the occurrence of sand flies, which will also be published through GBIF.

Author countries: **USA, Colombia**

ADAPTING TRADITIONAL REMEDIES TO AN ALIEN ECOSYSTEM

van Andel, T. *et al.*, 2012. In search of the perfect aphrodisiac: Parallel use of bitter tonics in West Africa and the Caribbean. *Journal of Ethnopharmacology*, pp.1–11. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0378874112005338

This study looked at how African slave communities went about adapting their traditional knowledge of herbal medicine after they were transplanted into entirely new environments in the Caribbean region. Earlier work suggested that enslaved Africans would have sought out plants familiar to them or brought from their homelands, so that Caribbean remedies would mainly consist of plant taxa that occur on both sides of the Atlantic, would be rich in weeds and introduced plants, and poor in native forest species.

To test this hypothesis, the researchers analysed 'bitter tonic' mixtures used in the Caribbean and West Africa today as aphrodisiacs and/or to treat impotence, to see whether they were composed of the same or related plant species. The study identified 324 species used as ingredients in 35 African and 117 Caribbean aphrodisiac mixtures. The plants were compared using a number of factors, including information on their distribution based on records available through GBIF.

The results showed that, in fact, recipes from the Caribbean mostly contained new and unrelated plants, including many New World forest species, with taste, appearance and pharmacological properties similar to those used in Africa. The research suggests that enslaved Africans applied their Old World knowledge with great creativity and flexibility, reinventing their herbal medicine by finding native plant substitutes through trial and error, and by learning from Amerindians and Europeans.

Author Countries: Belgium, Colombia, Jamaica, the Netherlands, USA

Other research relating to biodiversity and human health, citing use of GBIF-mediated data

Title	Journal	Authors	Author countries	URL
Bauhinia forficata Link authenticity using flavonoids profile: relation with their biological properties.	*Food Chemistry*	Ferreres, F. *et al.*	Portugal, Spain	http://linkinghub.elsevier.com/retrieve/pii/S0308814612004165
Genetic characterization of three Cuban *Trichomonas vaginalis* virus. Phylogeny of Totiviridae family.	*Infection, Genetics and Evolution*	Fraga, J. *et al.*	Cuba	http://www.ncbi.nlm.nih.gov/pubmed/22075038
Species typing of Cuban *Trichomonas vaginalis* virus by RT-PCR, and association of TVV-2 with high parasite adhesion levels and high pathogenicity in patients.	*Archives of virology*	Fraga, J. *et al.*	Cuba	http://www.ncbi.nlm.nih.gov/pubmed/22653538
Constructing ecological networks: a tool to infer risk of transmission and dispersal of Leishmaniasis.	*Zoonoses and Public Health*	González-Salazar, C. & Stephens, C.R.	Mexico	http://doi.wiley.com/10.1111/j.1863-2378.2012.01479.x
Pharmacological investigation of *Asystasia calyciana* for its antibacterial and antifungal properties.	*International Journal of Chemical and Biochemical Sciences*	Hamid, A.A. & Aiyelaagbe, O.O.	Nigeria	http://www.iscientific.org/Volume_1_2012/17%20IJCBS-12-1-23.pdf
Complex patterns of host switching in New World arenaviruses.	*Molecular Ecology*	Irwin, N.R. *et al.*	Czech Republic, UK	http://www.ncbi.nlm.nih.gov/pubmed/22693963
Zanthoxylum genus as potential source of bioactive compounds.	*Bioactive Compounds in Phytomedicine. InTech.*	Patiño, L.O.J., Prieto, R.J.A. & Cuca, S.L.E.	Colombia	http://www.intechopen.com/source/pdfs/25790/InTech-Zanthoxylum_genus_as_potential_source_of_bioactive_compounds.pdf

Food, farming and biofuels

Researchers have used data accessed through GBIF in a number of ways to inform science on food security and agriculture. Models using occurrence data have projected areas likely to be suitable for growing particular crops in future – and indeed the pests and diseases that may affect them. GBIF has also been used to help prioritize conservation of the wild relatives of domesticated plants used for crops, in order to maintain genetic diversity that will be vital to develop the crops of the future.

Some examples

ADAPTING AGRICULTURE TO FUTURE CLIMATE CONDITIONS: THE DATE PALM

Shabani, F., Kumar, L. & Taylor, S., 2012. Climate Change Impacts on the Future Distribution of Date Palms: A Modeling Exercise Using CLIMEX V. Magar, ed. *PLoS ONE*, 7(10), p.e48021. Available at: http://dx.plos.org/10.1371/journal.pone.0048021

This research by a team from Australia used data accessed through GBIF to model changes in the areas likely to be suitable for cultivating date palms (*Phoenix dactylifera*), according to various future scenarios of climate change. After filtering from a total of 583 records for the species, 163 occurrence locations downloaded via GBIF were supplemented with 49 records from literature review to model the potential distribution of the date palm, based on current and projected future conditions of temperature and moisture. The results suggested that many parts of North Africa currently suited to date palm cultivation would become unsuitable by 2100. By 2070, Saudi Arabia, Iraq and western Iran are projected to become less suitable. On the other hand, some areas such as southeastern Bolivia and northern Venezuela will be more suitable for growing date palms. The authors suggest such projections can inform strategic planning by identifying new areas in which to cultivate this economically important crop in future, and areas that will need attention due to reduced suitability compared with current agricultural practices.

Author country: **Australia**

GUINEA PEPPER (*PIPER GUINEENSE*) © ROGER PEET

CONSERVING GENETIC DIVERSITY OF FOOD CROPS IN WEST AFRICA

Idohou, R. *et al.*, 2012. National inventory and prioritization of crop wild relatives: case study for Benin. *Genetic Resources and Crop Evolution*. Available at: http://www.springerlink.com/index/10.1007/s10722-012-9923-6

This study aimed to draw up a list of priority plants to conserve in Benin, based on their importance as wild relatives of the crops used by local people for food, livestock fodder, medicines and other purposes. An inventory of crop wild relatives (CWR) was compiled using a variety of sources, including records from major herbaria and gene banks worldwide, accessed online through GBIF. Using a series of criteria to rank their importance, the study identified 20 priority crop wild relatives for active conservation.

Author countries: **Benin, China, UK**

VAMPIRE BAT (*DESMODUS ROTUNDUS*) © TRISHA SHEARS

FORECASTING RISK OF CATTLE RABIES SPREAD BY VAMPIRE BATS

Lee, D.N., Papes, M. & Van Den Bussche, R. a., 2012. Present and Potential Future Distribution of Common Vampire Bats in the Americas and the Associated Risk to Cattle R. M. Brigham, ed. *PLoS ONE*, 7(8), p.e42466. Available at: http://dx.plos.org/10.1371/journal.pone.0042466

This study modelled the current and potential future distribution of the common vampire bat (*Desmodus rotundus*) to help predict the risk of cattle rabies in North, Central and South America, thus indicating areas that should be a focus for rabies prevention efforts. The common vampire bat, as a carrier of the rabies virus, has a significant effect on the cattle industry in Latin America.

To produce an ecological niche model for the bat, the research used 984 spatially-unique data points showing locations where the species occurs, based on museum records discovered and downloaded via the GBIF data portal.

The results showed that most of Mexico and Central America, as well as portions of Venezuela, Guyana, the Brazilian highlands, western Ecuador, northern Argentina, and areas east of the Andes in Peru, Bolivia, and Paraguay are currently highly suitable for the vampire bat. Climate projections predicted suitability in these areas and in French Guyana, Suriname, Venezuela and Colombia. The paper noted that areas with large numbers of cattle at risk include Mexico, Central America, Paraguay and Brazil.

Contradicting previous studies, the research suggests that the vampire bat was unlikely to spread significantly into the United States under future climate scenarios, with only southern Florida showing suitable conditions for the species.

Author country: **USA**

Other research related to food, farming and biofuels, citing use of GBIF-mediated data

Title	Journal	Authors	Author countries	URL
Genetically modified crops and aquatic ecosystems: considerations for environmental risk assessment and non-target organism testing.	*Transgenic research*	Carstens, K. *et al.*	Belgium, Germany, the Netherlands, New Zealand, Switzerland, UK, USA	http://www.ncbi.nlm.nih.gov/pubmed/22120952
An assessment of biomass for bioelectricity and biofuel, and for greenhouse gas emission reduction in Australia.	*GCB Bioenergy*	Farine, D.R. *et al.*	Australia	http://doi.wiley.com/10.1111/j.1757-1707.2011.01115.x
Diversity and distribution of genus *Jatropha* in Mexico.	*Genetic Resources and Crop Evolution*	Fresnedo-Ramírez, J. & Orozco-Ramírez, Q.	USA	http://www.springerlink.com/index/10.1007/s10722-012-9906-7
Environmental suitability of the Red Spider Mite *Tetranchus cinnabarinus* (Acari: Tetranychidae) among cassava in China.	*Advanced Materials Research*	Lu, H. *et al.*	China	http://www.scientific.net/AMR.518-523.5446
Temperate forage and pulse legume genetic gap analysis.	*Bocconea*	Maxted, N. *et al.*	Syria, UK	http://www.herbmedit.org/bocconea/24-115.pdf
Advances on molecular studies of the interaction soybean – Asian rust.	*Crop Breeding and Applied Biotechnology*	Morales, A.M.A.P. *et al.*	Brazil, USA	http://www.sbmp.org.br/cbab/siscbab/uploads/c8eb9792-86b6-2ef2.pdf
A common view of the opportunities, challenges, and research actions for *Pongamia* in Australia.	*BioEnergy Research*	Murphy, H.T. *et al.*	Australia	http://www.springerlink.com/content/506205400h170m31/
Spatial distribution and ecological variation of re-discovered German truffle habitats.	*Fungal Ecology*	Stobbe, U. *et al.*	Germany, Switzerland	http://www.sciencedirect.com/science/article/pii/S1754504812000268
Biomass properties in association with plant species and assortments. II: A synthesis based on literature data for ash elements.	*Renewable and Sustainable Energy Reviews*	Tao, G. *et al.*	China, Sweden	http://linkinghub.elsevier.com/retrieve/pii/S136403211200024X
Present spatial diversity patterns of *Theobroma cacao* L. in the neotropics reflect genetic differentiation in pleistocene refugia followed by human-influenced dispersal.	*PLoS ONE*	Thomas, E. *et al.*	Belgium, Colombia (Bioversity), Italy (Bioversity)	http://dx.plos.org/10.1371/journal.pone.0047676

Advancing biodiversity science

The research making use of GBIF-mediated data in 2012 covers a wide range of biodiversity-related scientific disciplines, some less directly connected with policy applications than the studies outlined in previous sections of this review. Nevertheless, the research enabled by GBIF contributes significantly to the Target 19 of the Aichi Biodiversity Targets, that ‘by 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.’

The papers in this section cover areas of research such as biogeography, taxonomy, species distribution modelling, evolutionary history and phylogeny.

Research advancing biodiversity science during 2012, citing use of GBIF-mediated data

Title	Journal	Authors	Author countries	URL
First records of the genus *Lepidion* (Gadiformes: Moridae) from Alaska.	*Northwestern Naturalist*	Alcorn, D. & Stone, R.	USA	http://www.bioone.org/doi/abs/10.1898/12-05.1
The effect of species geographical distribution estimation methods on richness and phylogenetic diversity estimates.	*International Journal of Geographical Information Science*	Amboni, M.P.M. & Laffan, S.W.	Australia	http://www.tandfonline.com/doi/abs/10.1080/13658816.2012.717627
Beta-diversity gradients of butterflies along productivity axes.	*Global Ecology and Biogeography*	Andrew, M.E. *et al.*	Canada	http://doi.wiley.com/10.1111/j.1466-8238.2011.00676.x
Quantitative visualization of biological data in Google Earth using R2G2, an R CRAN package.	*Molecular Ecology Resources*	Arrigo, N. *et al.*	USA	http://doi.wiley.com/10.1111/1755-0998.12012
Revision of the North American species of *Grindelia* (Asteraceae).	*Annals of the Missouri Botanical Garden*	Bartoli, A. & Tortosa, R.D.	Argentina, USA	http://www.bioone.org/doi/abs/10.3417/2008125
Post-glacial dispersal, rather than in situ glacial survival, best explains the disjunct distribution of the Lusitanian plant species *Daboecia cantabrica* (Ericaceae).	*Journal of Biogeography*	Beatty, G.E. & Provan, J.	UK	http://doi.wiley.com/10.1111/j.1365-2699.2012.02789.x
Species richness, taxonomy and peculiarities of the neotropical rust fungi: are they more diverse in the Neotropics?	*Biodiversity and Conservation*	Berndt, R.	Switzerland	http://www.springerlink.com/index/10.1007/s10531-011-0220-z
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Title	Journal	Authors	Author countries	URL
New records of four reef-associated fishes from east coast of India.	*Acta Ichthyologica Et Piscatoria*	Biswas, S. *et al.*	India	http://www.aiep.pl/volumes/2010/3_3/pdf/10_1230_F1.pdf
Leaf level emissions of volatile organic compounds (VOC) from some Amazonian and Mediterranean plants.	*Biogeosciences Discussions*	Bracho-Nunez, A. *et al.*	Brazil, France, Germany	http://www.biogeosciences-discuss.net/9/15279/2012/
Three new species allied to the '*Mirbelia viminalis* group' (Fabaceae: Mirbelieae), from Western Australia.	*Nuytsia*	Butcher, R.	Australia	http://florabase.dec.wa.gov.au/science/nuytsia/636.pdf
Sampling bias in geographic and environmental space and its effect on the predictive power of species distribution models.	*Systematics and Biodiversity*	Bystriakova, N. *et al.*	China, Netherlands, UK, Ukraine	http://www.tandfonline.com/doi/abs/10.1080/14772000.2012.705357
Latitude, elevational climatic zonation and speciation in New World vertebrates.	*Proceedings. Biological sciences / The Royal Society*	Cadena, C.D. *et al.*	Australia, Colombia, Denmark, USA	http://www.ncbi.nlm.nih.gov/pubmed/21632626
Synopsis of *Acalypha* (Euphorbiaceae) of continental Ecuador.	*PhytoKeys*	Cardiel, J.M. & Muñoz, P.	Spain	http://dx.doi.org/10.3897/phytokeys.17.3190
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Unravelling the evolutionary history of the polyploid complex *Ranunculus parnassiifolius* (Ranunculaceae).	*Biological Journal of the Linnean Society*	Cires, E. *et al.*	Belgium, Spain	http://doi.wiley.com/10.1111/j.1095-8312.2012.01968.x
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Biogeographical patterns of variation in Western European populations of the great green bush-cricket (*Tettigonia viridissima*; Orthoptera: Tettigoniidae).	*Journal of Insect Conservation*	Cooper, E.M. *et al.*	UK	http://www.springerlink.com/index/10.1007/s10841-012-9525-9

Title	Journal	Authors	Author countries	URL
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Atlas of pollen, spores and further non-pollen palynomorphs recorded in the glacial-interglacial late Quaternary sediments of Lake Suigetsu, central Japan.	*Quaternary International*	Demske, D., Tarasov, P.E. & Nakagawa, T.	Germany, UK	http://linkinghub.elsevier.com/retrieve/pii/S1040618212000675
Inverted patterns of genetic diversity in continental and island populations of the heather *Erica scoparia* s.l.	*Journal of Biogeography*	Désamoré, A. *et al.*	Belgium, Spain, UK	http://doi.wiley.com/10.1111/j.1365-2699.2011.02622.x
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A simple temperature-based model predicts the upper latitudinal limit of the temperate coral *Astrangia poculata*.	*Coral Reefs*	Dimond, J.L. *et al.*	USA	http://www.springerlink.com/index/10.1007/s00338-012-0983-z
Pyganodon (Bivalvia: Unionoida: Unionidae) phylogenetics: A male- and female-transmitted mitochondrial DNA perspective.	*Molecular Phylogenetics and Evolution*	Doucet-Beaupré, H. *et al.*	Canada, USA	http://www.ncbi.nlm.nih.gov/pubmed/22326838
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Title	Journal	Authors	Author countries	URL
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Title	Journal	Authors	Author countries	URL
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Title	Journal	Authors	Author countries	URL
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Diversity of bivalve molluscs in the St Lucia Estuary, with an annotated and illustrated checklist.	*African Invertebrates*	Nel, H.A., Perissinotto, R. & Taylor, R.H.	South Africa	http://africaninvertebrates.org/ojs/index.php/AI/article/view/4
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Morphological and chemical studies on *Platismatia erosa* (Parmeliaceae) from Tibet, Nepal and Bhutan.	*The Bryologist*	Obermayer, W. & Randlane, T.	Austria, Estonia	http://www.bioone.org/doi/abs/10.1639/0007-2745-115.1.51
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Temporal and spatial origin of *Gesneriaceae* in the New World inferred from plastid DNA sequences.	*Botanical Journal of the Linnean Society*	Perret, M. *et al.*	Brazil, Switzerland	http://doi.wiley.com/10.1111/j.1095-8339.2012.01303.x
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Ecological niche modeling meets phylogeography to unravel hidden past history of key forest genera in plant geography: *Podocarpus* and *Nothofagus*.	*Natureza & Conservação*	Premoli, A.C. *et al.*	Argentina	http://www.abeco.org.br/wordpress/wp-content/uploads/nec-vol-10-2/09_nc_v10n2_021S-2012.pdf

Title	Journal	Authors	Author countries	URL
Genetic signals of demographic expansion in downy woodpecker (*Picoides pubescens*) after the last North American glacial maximum.	*PLoS ONE*	Pulgarín-R, P.C. & Burg, T.M.	Canada	http://www.ncbi.nlm.nih.gov/pubmed/22792306
Predicting the fate of biodiversity using species' distribution models: enhancing model comparability and repeatability.	*PLoS ONE*	Rodríguez-Castañeda, G. *et al.*	Sweden, USA	http://www.ncbi.nlm.nih.gov/pubmed/22984502
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Title	Journal	Authors	Author countries	URL
Molecular phylogenetics and historical biogeography of the *Meiogyne-Fitzalania* clade (Annonaceae): Generic paraphyly and late Miocene-Pliocene diversification in Australasia and the Pacific.	*Taxon*	Thomas, D.C. *et al.*	Australia, China, India, Netherlands	http://www.ingentaconnect.com/content/iapt/tax/2012/00000061/00000003/art00006?token=003912832c7b76504c48663b256a493e6c243f386f576a333f2576a8d#expand/collapse
Hybridization and systematics of dioecious North American *Nymphoides* (*N. aquatica* and *N. cordata*; Menyanthaceae).	*Aquatic Botany*	Tippery, N.P. & Les, D.H.	USA	http://linkinghub.elsevier.com/retrieve/pii/S0304377012001325
Mitochondrial phylogeography of the Holarctic *Parnassius phoebus* complex supports a recent refugial model for alpine butterflies.	*Journal of Biogeography*	Todisco. V. *et al.*	Canada, Finland, Italy, UK	http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2699.2011.02675.x/abstract
Can species distribution modelling provide estimates of population densities? A case study with jaguars in the Neotropics.	*Diversity and Distributions*	Tôrres, N.M. *et al.*	Brazil	http://onlinelibrary.wiley.com/doi/10.1111/j.1472-4642.2012.00892.x/abstract
Relative embryo length as an adaptation to habitat and life cycle in Apiaceae.	*The New Phytologist*	Vandelook, F., Janssens, S.B. & Probert, R.J.	Belgium, Germany, UK	http://www.ncbi.nlm.nih.gov/pubmed/22621412
Species distribution modelling as a macroecological tool: a case study using New World amphibians.	*Ecography*	Vasconcelos, T.S., Rodríguez, M.Á. & Hawkins, B.A.	Spain, USA	http://doi.wiley.com/10.1111/j.1600-0587.2011.07050.x
First record of the deep-water whalefish *Cetichthys indagator* (Actinopterygii: Cetomimidae) in the North Atlantic Ocean.	*Journal of Fish Biology*	Vieira, R.P. *et al.*	Germany, Portugal	http://doi.wiley.com/10.1111/j.1095-8649.2012.03378.x
Identifying insects with incomplete DNA barcode libraries, African fruit flies (Diptera: tephritidae) as a test case.	*PLoS ONE*	Virgilio, M. *et al.*	Belgium	http://www.ncbi.nlm.nih.gov/pubmed/22359600
Late Pleistocene species distribution modelling of North Atlantic intertidal invertebrates.	*Journal of Biogeography*	Waltari, E. & Hickerson, M.J.	USA	http://doi.wiley.com/10.1111/j.1365-2699.2012.02782.x
The African wintering distribution and ecology of the Corncrake *Crex crex*.	*Bird Conservation International*	Walther, B.A. *et al.*	China, France, South Africa, UK	http://www.journals.cambridge.org/abstract_S0959270912000159
Glacial expansion and diversification of an East Asian montane bird, the green-backed tit (*Parus monticolus*).	*Journal of Biogeography*	Wang, W. *et al.*	China, France, Taiwan, USA	http://doi.wiley.com/10.1111/jbi.12055
Climatic niche divergence or conservatism? Environmental niches and range limits in ecologically similar damselflies.	*Ecology*	Wellenreuther, M., Larson, K.W. & Svensson, E. I.	Sweden	http://www.esajournals.org/doi/abs/10.1890/11-1181.1
Late Quaternary environmental and landscape dynamics revealed by a pingo sequence on the northern Seward Peninsula , Alaska.	*Quaternary Science Reviews*	Wetterich, S. *et al.*	Germany, Russia, UK, USA	http://dx.doi.org/10.1016/j.quascirev.2012.01.027
Reproduction and morphology of the Travancore Tortoise (*Indotestudo travancorica*).	*InTech*	Whitaker, N.	India	http://cdn.intechweb.org/pdfs/30106.pdf
Glucose inhibits the shoot bud formation in the moss *Bryum billarderi*.	*Central European Journal of Biology*	Zavala, A.M. *et al.*	Mexico	http://www.springerlink.com/index/10.2478/s11535-012-0056-x

Data papers published during 2012

The following articles were published as data papers using the workflow developed by GBIF and Pensoft Publishers to author manuscripts for peer review, based on enriched metadata for datasets published using the GBIF Integrated Publishing Tookit (IPT).

Landuyt, W.V., Vanhecke, L. & Brosens, D., 2012. Florabank1: a grid-based database on vascular plant distribution in the northern part of Belgium (Flanders and the Brussels Capital region). *PhytoKeys*, 12, p.59-67. Available at: http://www.pensoft.net/journals/phytokeys/article/2849/abstract/

Danis, B., Jangoux, M. & Wilmes, J., 2012. Antarctic Starfish (Echinodermata, Asteroidea) from the ANDEEP3 expedition. *ZooKeys*, 185, p.73-78. Available at: http://www.pensoft.net/journals/zookeys/article/3078/abstract/

Pierrat, B., Saucède, T., Festeau. A *et al.*, 2012. Antarctic, Sub-Antarctic and cold temperate echinoid database. *ZooKeys* 204 (2012): 47-52. Available at: http://www.pensoft.net/journals/zookeys/article/3134/abstract/antarctic-sub-antarctic-and-cold-temperate-echinoid-database

Shao, K.T., Lin, J., Wu, C.H., Yeh, H.M. & Cheng. T.Y., 2012. A dataset from bottom trawl survey around Taiwan. *ZooKeys*, 198, p.103–109. Available at: http://www.pensoft.net/journals/zookeys/article/3032/a-dataset-from-bottom-trawl-survey-around-taiwan

SEA URCHIN (*HELIOCIDARIS* SP) © RICHARD LING

ANAGALLIS TENELLA © BELGIAN BIODIVERSITY PLATFORM

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Discussion of GBIF in the scientific literature

In addition to the research citing direct use of GBIF-mediated data, many journal articles in 2012 included discussion of GBIF in the context of biodiversity information, data publication and access. A selection is included here.

Title	Journal	Authors	URL
Assessing biodiversity funding during the sixth extinction.	*BioEssays: news and reviews in molecular, cellular and developmental biology*	Amato, G., & Desalle, R.	http://www.ncbi.nlm.nih.gov/pubmed/22674583
Primary biodiversity data records in the Pyrenees.	*Environmental Engineering and Management Journal*	Ariño, A.H. *et al.*	http://omicron.ch.tuiasi.ro/EEMJ/pdfs/vol11/no6/3_776_Arino_11.pdf
OpenUp! Creating a cross-domain pipeline for natural history data.	*ZooKeys*	Berendsohn, W. & Güntsch, A	http://dx.doi.org/10.3897/zookeys.209.3179
A new era for specimen databases and biodiversity information management in South Africa.	*Biodiversity Informatics*	Coetzer, W. *et al.*	https://journals.ku.edu/index.php/jbi/article/viewFile/4263/4038
Freshwater journals unite to boost primary biodiversity data publication.	*BioScience*	De Wever, A. *et al.*	http://www.jstor.org/stable/info/10.1525/bio.2012.62.6.2
The Darwin Core extension for genebanks opens up new opportunities for sharing germplasm data sets.	*Biodiversity Informatics*	Endresen, D.T.F. & Knüpffer, H.	https://journals.ku.edu/index.php/jbi/article/view/4095/4064
Advancing global marine biogeography research with open-source GIS software and cloud computing.	*Transactions in GIS*	Fujioka, E. *et al.*	http://doi.wiley.com/10.1111/j.1467-9671.2012.01310.x
Efficient rescue of threatened biodiversity data using reBiND workflows.	*Plant Biosystems – An International Journal Dealing with all Aspects of Plant Biology*	Güntsch, A. *et al.*	http://www.tandfonline.com/doi/abs/10.1080/11263504.2012.740086
The ABCD of primary biodiversity data access.	*Plant Biosystems*	Holetschek, J. *et al.*	http://www.tandfonline.com/doi/abs/10.1080/11263504.2012.740085
Willing and unwilling to share primary biodiversity data: results and implications of an international survey.	*Conservation Letters*	Huang, X. *et al.*	http://onlinelibrary.wiley.com/doi/10.1111/j.1755-263X.2012.00259.x/abstract
Biodiversity data sharing is not just about species names: response to Santos and Branco.	*Trends in Ecology & Evolution*	Huang, X. & Qiao, G.	http://www.cell.com/trends/ecology-evolution/fulltext//S0169-5347%2811%2900301-6
Integrating biodiversity distribution knowledge: toward a global map of life.	*Trends in Ecology & Evolution*	Jetz, W., McPherson, J.M. & Guralnick, R.P.	http://www.ncbi.nlm.nih.gov/pubmed/22019413
Data discovery mechanisms for biodiversity resources in the Asia-Pacific region.	*The Biodiversity Observation Network in the Asia-Pacific Region*	Jinbo, U. & Ito, M.	http://www.springerlink.com/index/10.1007/978-4-431-54032-8
Improving access to biodiversity data for, and from, EIAs – a data publishing framework built to global standards.	*Impact Assessment and Project Appraisal*	King, N. *et al.*	http://www.tandfonline.com/doi/abs/10.1080/14615517.2012.705068
Challenges in developing medicinal plant databases for sharing ethnopharmacological knowledge.	*Journal of Ethnopharmacology*	Ningthoujam, S.S. *et al.*	http://www.ncbi.nlm.nih.gov/pubmed/22401841

Title	Journal	Authors	URL
BIDDSAT: visualizing the content of biodiversity data publishers in the GBIF network.	*Bioinformatics*	Otegui, J. & Ariño, A.H.	http://www.ncbi.nlm.nih.gov/pubmed/22730433
Evolutionary informatics: unifying knowledge about the diversity of life.	*Trends in Ecology & Evolution*	Parr, C.S. *et al.*	http://www.sciencedirect.com/science/article/pii/S0169534711003247
VoSeq: a voucher and DNA sequence web application.	*PLoS ONE*	Peña, C. & Malm, T.	http://dx.plos.org/10.1371/journal.pone.0039071
From text to structured data: converting a word-processed floristic checklist into Darwin Core Archive format.	*PhytoKeys*	Remsen, D. *et al.*	http://dx.doi.org/10.3897/phytokeys.9.2770
The quality of name-based species records in databases.	*Trends in Ecology & Evolution*	Santos, A.M. & Branco, M.	http://www.cell.com/trends/ecology-evolution/fulltext/S0169-5347%2811%2900298-9
Building a global observing system for biodiversity.	*Current Opinion in Environmental Sustainability*	Scholes, R.J. *et al.*	http://linkinghub.elsevier.com/retrieve/pii/S1877343511001394
An appraisal of megascience platforms for biodiversity information.	*MycoKeys*	Triebel, D., Hagedorn, G. & Rambold, G.	http://dx.doi.org/10.3897/mycokeys.5.4302
Darwin Core: an evolving community-developed biodiversity data standard.	*PLoS ONE*	Wieczorek, J. *et al.*	http://dx.plos.org/10.1371/journal.pone.0029715
Strategies to observe and assess changes of terrestrial biodiversity in the Asia-Pacific region.	*The Biodiversity Observation Network in the Asia-Pacific Region*	Yahara, T. *et al.*	http://www.springerlink.com/index/10.1007/978-4-431-54032-8
A high-performance web-based information system for publishing large-scale species range maps in support of biodiversity studies.	*Ecological Informatics*	Zhang, J.	http://linkinghub.elsevier.com/retrieve/pii/S1574954112000064

COVER PHOTOS, LEFT TO RIGHT

TOP ROW:
ANOPHELES ALBIMANUS, A CARRIER OF MALARIA © JAMES GATHANY
ANAGALLIS TENELLA © BELGIAN BIODIVERSITY PLATFORM
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WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) © SCOTT BAUER / USDA
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