Global *Bd* Mapping Project: 2014 Update

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World scientists continue to advance knowledge of the ecology and impact of *Batrachochytrium dendrobatidis* (*Bd*) infection of amphibians. In 2007, we began mapping *Bd*'s global occurrence to aid the science and management of this infectious disease. We continue to compile global occurrence data, and we are pleased to continue working with our partners Dr. David Aanensen and Mat Fisher at Imperial College, London, UK, who lead management of the interactive website *Bd*-maps.net (Olson et al. 2013). Herein, we provide a brief update of the taxonomic and geographic patterns of our global dataset as of June 2014.

Taxonomy in this summary follows Amphibian Species of the World 6.0 (Frost 2014). Species and country counts as of June 2014 include species from published locations that may not yet be shown on the maps. Maps presented here may be downloaded for your use at: http://www.fs.fed.us/pnw/lwm/aem/people/olson.html. Our newly compiled data are not yet available at *Bd*-maps.net, and are intended to be uploaded there later this year as part of a larger website upgrade.

Taxonomic Patterns: To date, *Bd* has been detected in 695 of 1,377 (50%) amphibian species sampled (Table 1). In February 2011, our data compilation showed that *Bd* was detected in 508 of 1,055 (48%) species sampled (Table 2), hence over the last three years we have accrued knowledge of *Bd* detections in 187 of 322 (58%) additional species. Patterns of both sampling and infection are apparent by amphibian family (Table 3). More extensive sampling among the Gymnophiona has occurred since 2011, and caecilians have been observed with active, fatal chytridiomycosis (Gower et al. 2013). Among salamanders, 96 plethodontids have been sampled, with *Bd* occurrence in 48% of species. Of anuran families with over 100 species sampled, *Bd* occurrence is highest in hylids (60% of 188 species), ranids (59% of 114 species) and craugastorids (57% of 102 species), and is lower in bufonids (44% of 135 species).

We are tracking changes in amphibian taxonomy. The total numbers of species and families have changed since 2011, and consequently direct comparisons with some of our previously reported family patterns (Olson et al. 2013) may be difficult. Family taxonomy has changed not only in number but in combination—the Strabomantidae have been merged back into the Craugastoridae, the Leiuperidae back into the Leptodactylidae; the Telmatobiidae have been split off from the Ceratophryidae, the Odontophrynidae from the Cycloramphidae and the Ascaphidae from the Leiopelmatidae. In addition, several very small families have been established; many of the as-yet-unsampled families are among these, and no major taxon of Anura remains unsampled for *Bd* (Table 3). Some larger families have limited sampling. Among anurans, there is relatively limited sampling in the Microhylidae (42 of 554 species, 7.6%) and Rhacophoridae (35 of 370 species, 9.5%). Among salamanders, we are not aware of *Bd* testing in Rhyacotritonidae, and only a few Hynobiidae have been sampled; one family of caecilians remains entirely unsampled, and only a few species have been sampled in other caecilian families, such as the Ichthyophiidae, the largest family, in which 3 of 55 species have been tested for *Bd*.

Table 1. Global compilation of *Batrachochytrium dendrobatidis (Bd)* detections in amphibians as of 10 June 2014.

Order	No. Species with *Bd* Detected	No. Species Tested	Species Prevalence (%)	Total Species	No. Families with *Bd* Detected	No. Families Tested	Family Prevalence (%)	Total families
Anura	600	1194	50.2	6,386	41	49	83.7	55
Caudata	88	159	54.8	674	7	8	87.5	9
Gymnophiona	7	24	29.2	200	4	9	44.4	10
Total	695	1,377	50.4	7,260	52	66	78	74

Table 2. Global compilation of *Batrachochytrium dendrobatidis (Bd)* detections in amphibians as of 4 February 2011.

Order	No. Species with *Bd* Detected	No. Species Tested	Species Prevalence (%)	No. Families with *Bd* Detected	No. Families Tested	Family Prevalence (%)
Anura	449	935	48.0	35	40	87.5
Caudata	59	114	51.7	6	8	75
Gymnophiona	0	6	0	0	2	0
Total	508	1,055	48.2	41	50	82

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Table 3. *Batrachochytrium dendrobatidis* (*Bd*) **occurrence patterns by amphibian family.**

Anura	No. Species with *Bd* Detected	No. Species Tested	Species Prevalence (%)	Total No. Species in Family
Allophrynidae				3
Alsodidae	0	6	0.00	29
Alytidae	6	9	0.67	12
Aromobatidae	7	9	0.78	117
Arthroleptidae	7	37	0.19	145
Ascaphidae	1	2	0.50	2
Batrachylidae	2	4	0.50	14
Bombinatoridae	4	5	0.80	7
Brachycephalidae	1	1	1.00	54
Brevicepitidae	0	6	0	33
Bufonidae	60	135	0.44	577
Calyptocephalel-lidae	1	1	1.00	5
Centrolenidae	11	17	0.65	148
Ceratobatrachidae	0	3	0	86
Ceratophryidae	6	6	1.00	12
Ceuthomantidae				4
Conrauidae	0	2	0	6
Craugastoridae	58	102	0.57	728
Cycloramphidae	3	4	0.75	36
Dendrobatidae	16	23	0.70	183
Dicroglossidae	13	27	0.48	182
Eleutherodac-tylidae	26	41	0.63	206
Heleophrynidae	5	5	1.00	7
Hemiphractidae	8	10	0.80	104
Hemisotidae	0	2	0	9
Hylidae	113	188	0.60	941
Hylodidae	10	11	0.91	42
Hyperoliidae	32	72	0.44	218
Leiopelmatidae	1	3	0.33	4
Leptodactylidae	20	31	0.64	201
Limnodynastidae	14	21	0.67	43
Mantellidae	0	60	0	206
Megophryidae	4	13	0.31	183
Micrixalidae	0	1	0	26
Microhylidae	10	42	0.24	554
Myobatrachidae	21	37	0.57	89
Nasikabatrachidae				1
Nyctibatrachidae	1	1	1.00	29
Odontobatrachidae				1
Odontophrynidae	3	4	0.75	52
Pelobatidae	3	3	1.00	4
Pelodytidae	0	1	0	3
Petropedetidae	2	5	0.40	12
Phrynobatrachidae	5	19	0.26	87
Pipidae	10	16	0.62	33
Ptychadenidae	6	16	0.38	55
Pyxicephalidae	16	24	0.67	78
Ranidae	67	114	0.59	359
Ranixalidae	1	5	0.20	10

Cunningham, Claude Miaud and the RACE project have collected

Anura	No. Species with *Bd* Detected	No. Species Tested	Species Prevalence (%)	Total No. Species in Family
Rhacophoridae	18	35	0.51	370
Rhinodermatidae				3
Rhinophrynidae	0	1	0	1
Scaphiopodidae	1	6	0.17	7
Sooglossidae				4
Telmatobiidae	6	7	0.86	61
Total Anurans	600	1194	0.502	6,386

Caudata	No. Species with *Bd* Detected	No. Species Tested	Species Prevalence (%)	Total No. Species in Family
Ambystomatidae	14	19	0.74	37
Amphiumidae	2	3	0.67	3
Cryptobranchidae	3	3	1.00	4
Hynobiidae	0	9	0	61
Plethodontidae	46	96	0.48	444
Proteidae	3	3	1.00	7
Rhyacotritonidae				4
Salamandridae	17	22	0.77	110
Sirenidae	3	4	0.75	4
Total Caudata	88	159	0.553	674

Gymnophiona	No. Species with *Bd* Detected	No. Species Tested	Species Prevalence (%)	Total No. Species in Family
Caeciliidae	0	4	0	42
Chikilidae				4
Dermophiidae	2	3	0.67	14
Herpelidae	2	3	0.67	9
Ichthyophiidae	0	3	0	55
Indotyphlidae	1	1	1.00	21
Rhinatrematidae	0	2	0	11
Scolecomorphidae	2	3	0.67	6
Siphonopidae	0	4	0	25
Typhlonectidae	0	1	0	13
Total Gymnophiona	7	24	0.29	200

Of the 1,377 tested species, 322 (23.4%) are considered Threatened by the IUCN Red List of Threatened Species (falling in the Vulnerable, Endangered or Critically Endangered categories), while an additional 104 are classed as Near Threatened, and 49 as Data Deficient. *Bd* was detected in 159 of the Threatened species (49.4%), 59 of the Near Threatened species (56.7%) and 23 of the Data Deficient species (46.9%).

Geographic Patterns: *Bd* has been detected in 71 of 105 (68%) sampled countries (Figures 1, 2, and 3). In comparison to maps in Olson et al. (2013), our 2014 data set shows more comprehensive coverage of *Bd* sampling in south Asia (India, Sri Lanka, Cambodia, Laos, Vietnam, Singapore and Thailand), along with many more samples in West Africa (Côte d'Ivoire, Ghana, Cameroon, São Tomé and Príncipe, Sierra Leone and Benin). The most obvious gaps in coverage are most of Russia and central Asia, and the Amazon Basin of South America. In the U.S.A., the Great Plains are still mostly unexplored, although recent data for South Dakota have not yet been mapped (Brown and Kerby 2013). We are aware that Andrew a great deal of additional data for the UK, France and Corsica, but these have not yet been published and so cannot be shown here.

We have provided watershed-scale maps of *Bd* occurrences for the U.S.A. at two spatial resolutions: 5th and 6th hydrologic unit code (HUC; 5th- and 6th-field watersheds) (Figures 4 and 5). These maps may be useful for a variety of management or scientific purposes due to the heightened interest in *Bd* as an emerging infectious disease and aquatic invasive species. When prioritization is needed for allocation of scarce resources, *Bd* management or research might be guided by knowledge of its known occurrence at watershed scales. For example, selecting locations for water draws for fighting wildfires might take into consideration *Bd*-infected watersheds, since this aquatic fungus may be present in surface waters independent from amphibians and could be inadvertently transported in water drops. To mitigate this possibility, water draws might be taken from other watersheds, or disinfection might be a priority within known-infected areas. Similarly, field gear disinfection procedures,

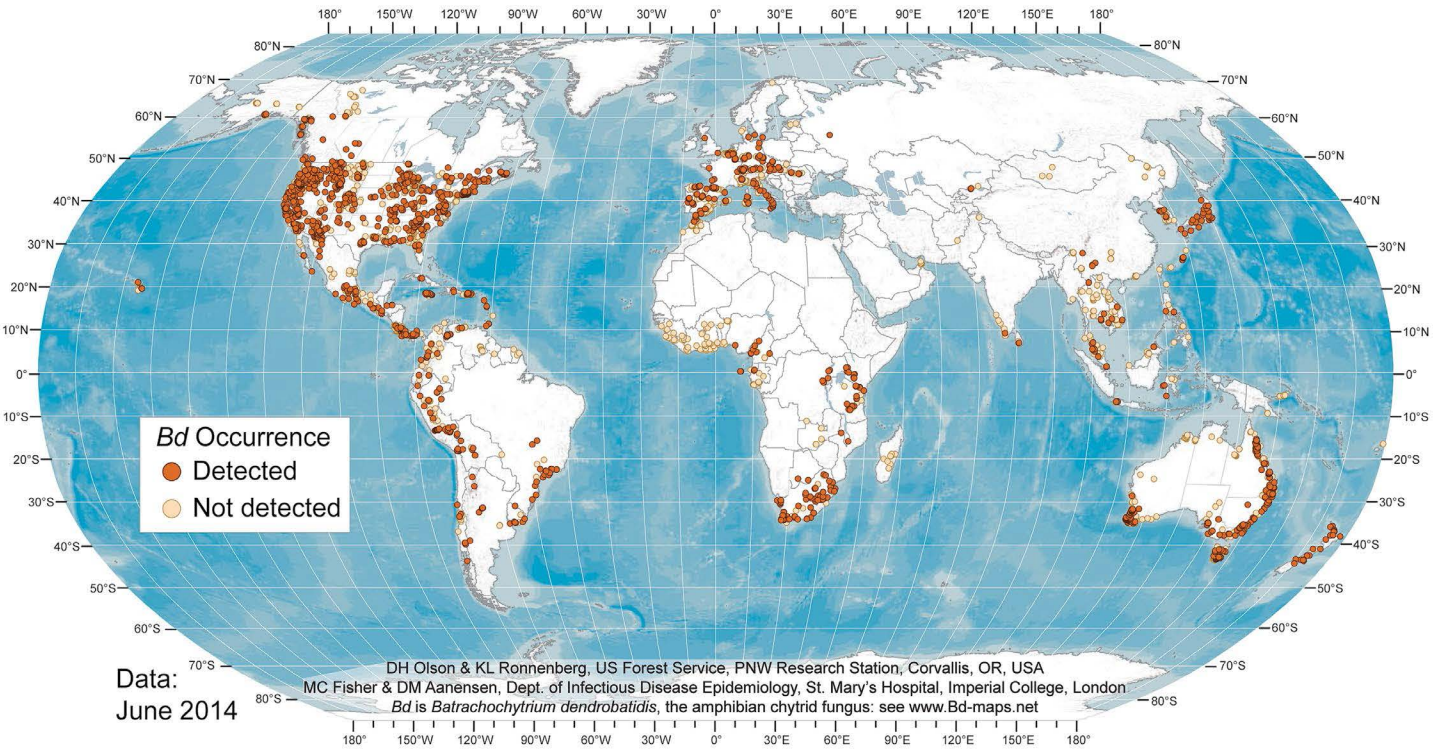

Fig. 1: Global distribution of *Batrachochytrium dendrobatidis* in June 2014. Map may be downloaded at: http://www.fs.fed.us/pnw/lwm/aem/people/olson.html .

reduced water or animal translocation and conservation education might be priority concerns within infected areas. This information could also be used to encourage sport fishers and recreational boaters in these areas to clean boats and gear, as is already done to prevent the spread of other aquatic invasive species such as New Zealand mudsnails (*Potamopyrgus antipodarum*) and Zebra mussels (*Dreissena polymorpha*).

In summary, we are grateful to the world community for their active partnership in this work. *Bd* mapping has been a tool that has aided communication and networking among researchers and natural resource managers. Rapid dissemination of wildlife disease research results has increased the pace of both science and conservation, with an acceleration of knowledge discovery, synthesis and application. We provide the current brief update in this spirit, without further analysis or attribution. In that light, if your data do not seem to be represented in our summary, we invite you to contact us.

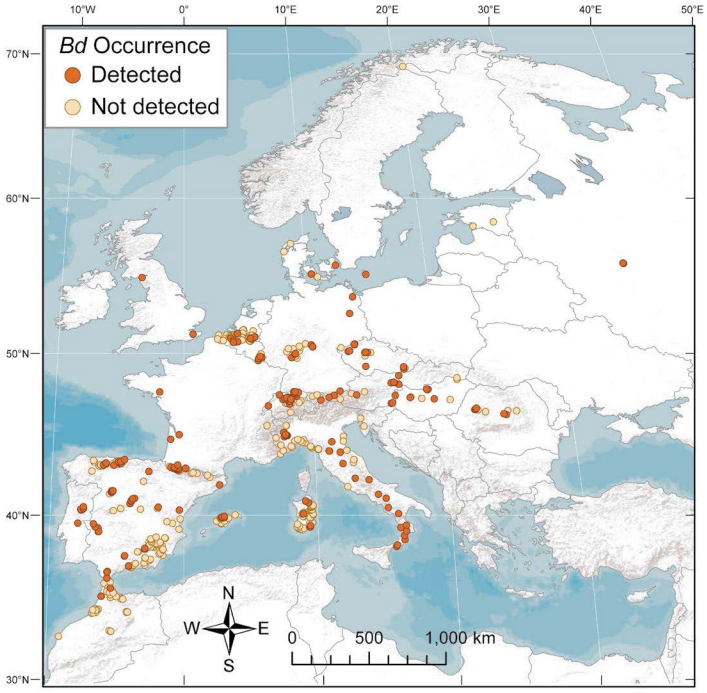

Figure 2. European distribution of *Batrachochytrium dendrobatidis* in June 2014.

References

1. Brown J., Kerby J. 2013. *Batrachochytrium dendrobatidis* in South Dakota, USA amphibians. *Herpetological Review* 44: 457-458.
2. Frost D.R. 2014. Amphibian Species of the World: an Online Reference. Version 6.0 (Date of access). Electronic Database accessible at http://research.amnh.org/herpetology/amphibia/index.html . American Museum of Natural History, New York, USA.
3. Gower D.J., T. Doherty-Bone, S.P. Loader, M. Wilkinson, M.T. Kouete, B. Tapley, F. Orton, O.Z. Daniel, F. Wynne, E. Flach, H. Müller, M. Menegon, I. Stephen, R.K. Browne, M.C. Fisher, A.A. Cunningham, T.W.J. Garner. 2013. *Batrachochytrium dendrobatidis* infection and lethal chytridiomycosis in caecilian amphibians (Gymnophiona). *EcoHealth* 10: 173-183.
4. Olson, D.H., D.M. Aanensen, K.L. Ronnenberg, C.I. Powell, S.F. Walker, J. Bielby, T.W.J. Garner, G. Weaver, the Bd Mapping Group and M.C. Fisher. 2013. Mapping the global emergence of *Batrachochytrium dendrobatidis*, the amphibian chytrid fungus. *PLOS ONE* 8(2): e56802. doi:10.1371/journal.pone.0056802

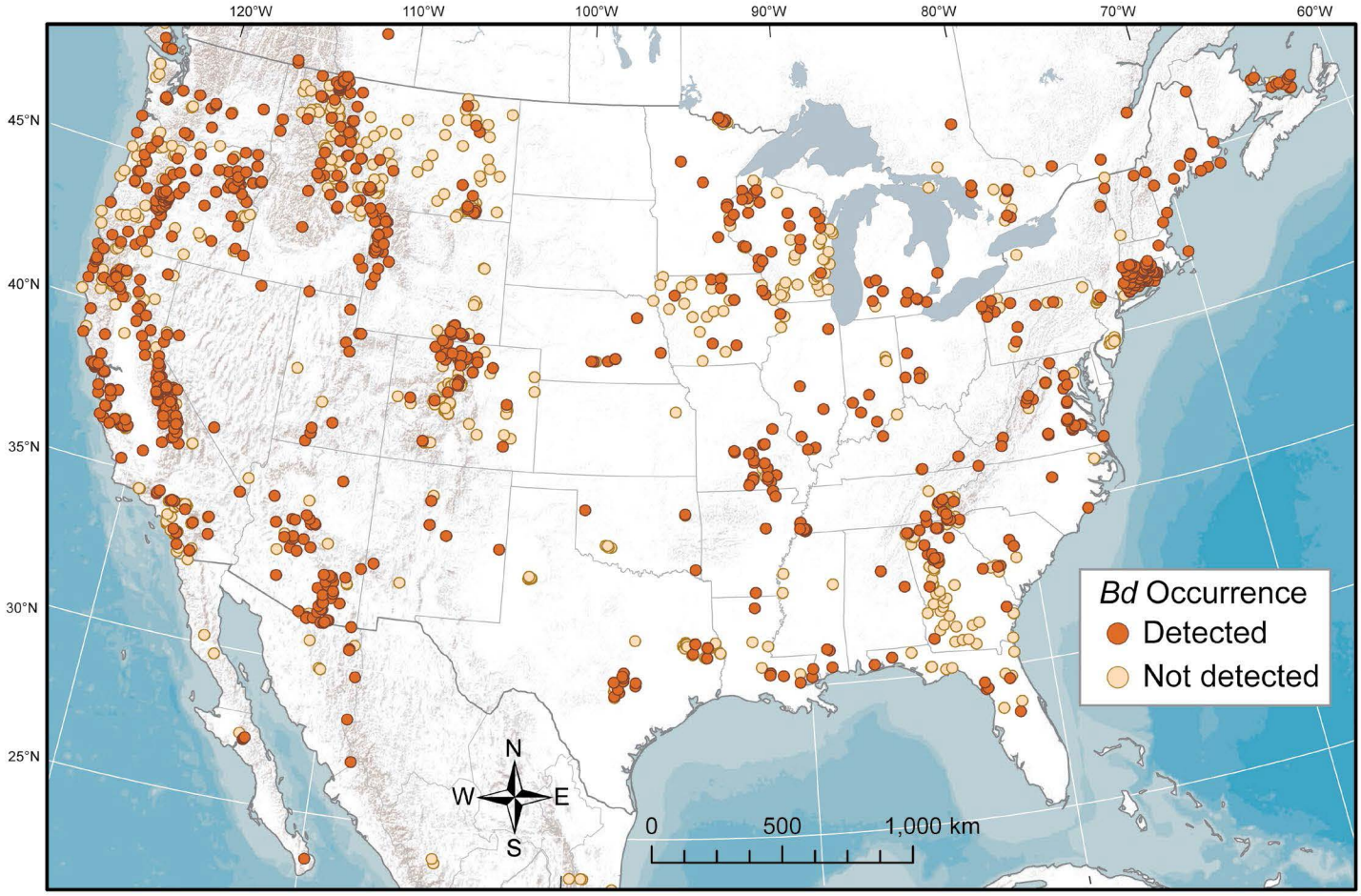

Fig. 3: United States distribution of *Batrachochytrium dendrobatidi* s in June 2014.

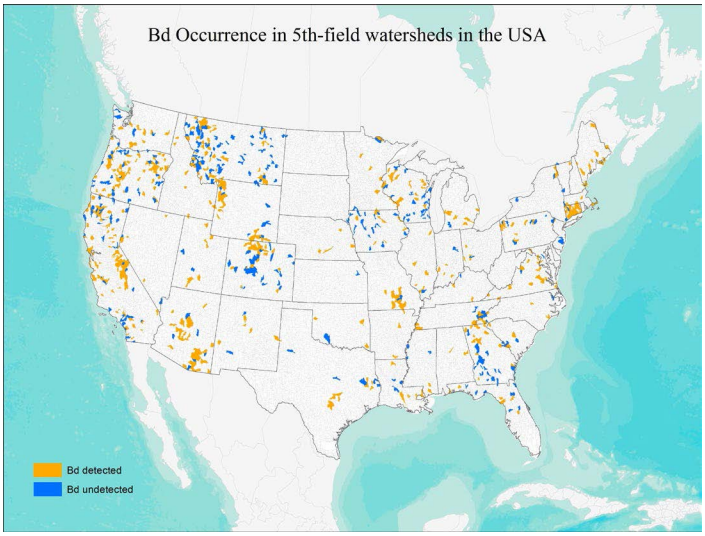

Fig. 4: Occurrence of *Batrachochytrium dendrobatidi* s in the U.S.A. by 5th field watershed in June 2014.

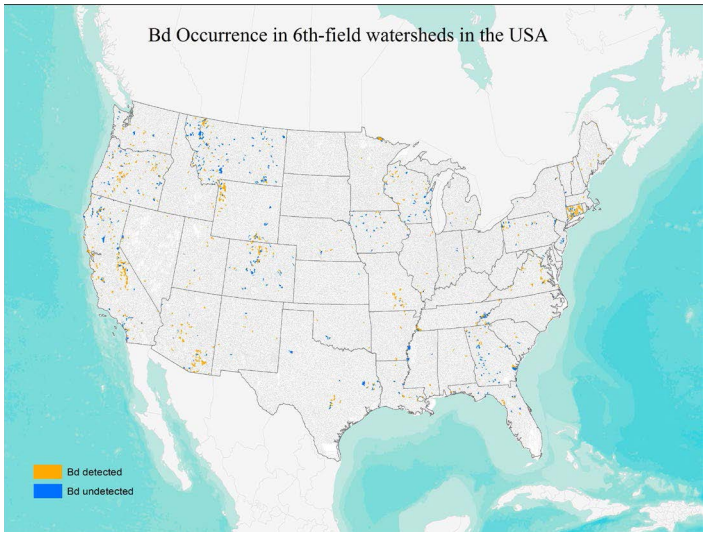

Fig. 5: *Occurrence of Batrachochytrium dendrobatidis* in the U.S.A. by 6th field watershed in June 2014.