doi:10.1038/nature10947

Crop *Host species*	**2009/2010 harvest (million tonnes)**	**Calories per 100g flour (un-cooked)**	**Disease/Pathogen and variation in % losses**	**Loss of food* for *x* million over 1 year, given diet of 2,000 calories per day**
Rice *Oryza sativa*	701 harvest but 476* milled for food	325	Rice Blast *Magnaporthe oryzae* 10-35%	212 to 742
Wheat *Triticum aestivum*	679 harvest but 432* for food	341	Stem Rust *Puccinia graminis* 10-70%	202 to 1,413
Maize *Zea mays*	820 harvest but 271* for food	355	Corn Smut *Ustilago maydis* 2-20%	26 to 262
Potato *Solanum tuberosum*	333* harvest but for food	357	Late Blight *Phytophthora infestans* 5-78%	81 to 1,270
Soybean *Glycine max*	232 harvest but 148* for food	372	Soybean Rust *Phakospora pachyrhizi* 10-80%	75 to 600
				TOTAL: Could feed 596 – 4,287 million mouths *per annum***

Table S1: Food security and crop losses due to fungal/oomycete diseases: Five major crops that feed the world's population are challenged by the fungal/oomycete diseases shown. All global harvests are from 2009/2010 (www.fao.org or FAOSTAT1). *Figures are estimates and are based on 100% of milled rice and 100% of potato harvest being used for human consumption. However, 34% of the global wheat harvest is produced in developing countries, of which 100% is assumed to be used for human food, but only 45% of the total wheat harvest produced from developed countries is used for human food (the rest is used as animal feed and biofuel). Of the global maize harvest, 32% is produced in developing countries and 100% is assumed to be used for food and in the US 2.5% of their total harvest of 333m tonnes of maize (41% of global harvest) is used directly as food. Of the global soybean harvest, 36% is from US and Canada (10% of this is used as food, the rest goes into processed food and animal feed) and 64% is produced in developing nations, where 100% is assumed to be used as food. These figures do not take into account post-harvest storage losses.

**This is 8.5% - 61.2% of the world's population, based on the 2011 population estimate of 7 billion people.

Database	Year	Animal fungal alerts	Plant fungal alerts	Total fungal alerts	Total EID alerts
HealthMap	2007	9	9	18	9369
HealthMap	2008	13	20	33	5659
HealthMap	2009	8	15	23	11284
HealthMap	2010	23	29	52	8672
HealthMap	2011	28	18	46	8674
Total		**81**	**91**	**172**	**43658**
ProMED	1995	6	5	11	1153
ProMED	1996	10	11	21	1923
ProMED	1997	9	20	29	2384
ProMED	1998	20	12	32	2357
ProMED	1999	14	22	36	2079
ProMED	2000	7	37	44	2002
ProMED	2001	21	46	67	1930
ProMED	2002	14	41	55	1894
ProMED	2003	6	47	53	2092
ProMED	2004	2	64	66	2382
ProMED	2005	10	108	118	2582
ProMED	2006	18	62	80	2374
ProMED	2007	21	111	132	2829
ProMED	2008	19	123	142	2251
ProMED	2009	24	144	167	2399
ProMED	2010	37	142	179	2586
ProMED	2011	40	66	106	2307
Total		**278**	**1061**	**1338**	**37524**

Table S2. Summary of HealthMap (2006-2011) and ProMed (1994-2011) alerts for mycoses with the first year of data collection excluded. For our analyses we downloaded the complete ProMED and HealthMap databases from the start of data collection through to the last year of complete data collection (2010). We then used Boolean searches of the database using generic fungal search terms (fung*, mycosis) and refined this with the following specific search terms (rust, blast, blight, wilt, sigatoka, bunt, smut, light leaf spot, jarrah, oak death, blue stain, aspergillosis, blastomycosis, cryptococcosis, foot fungus, histoplasmosis, mucormycosis, paracoccidioidomycosis, sporotrichosis, thrush, valley fever, white nose syndrome, fusarium keratitis, dermatophytosis, zygomycosis, basidiobolomycosis, chromoblastomycosis, lobomycosis, mycetoma). Records were subsequently curated to remove false positives.

Table S3

Published infectious disease-driven extinction and regional extirpation events across animal and plant taxa. Data was acquired from the following review sources [1-9] and from *Web of Science* literature searches.

Host species[§]	**Pathogen species**	**Kingdom (Phylum)**	**Factors driving emergence**	**Year of occurrence**	**Reference**
Tropical central American amphibian spp. (30 species and 4 families) EXTINCTION/EXTIRPATION	*Batrachochytrium dendrobatidis*	Fungi (Chytridiomycota)	Pathogen invasion/endemic host populations	late 1980's - present	[7, 10]
Australian amphibian spp. (*n* ~ 4; 2 families) EXTINCTION	*B. dendrobatidis*	Fungi (Chytridiomycota)	Pathogen invasion/endemic host population	early 1980's	[11, 12]
Alytes obstetricans (Common midwife toad) EXTIRPATION	*B. dendrobatidis*	Fungi (Chytridiomycota)	Pathogen invasion/endemic host population	1997	[13]
Nextophrynoides asperginis (Kihansi spray toad) EXTINCTION	*B. dendrobatidis*	Fungi (Chytridiomycota)	Pathogen / habitat modification	2003	[14]
Leptodactylus fallax (Dominica and Montserrat Mountain Chicken Frog) EXTIRPATION	*B. dendrobatidis*	Fungi (Chytridiomycota)	Pathogen invasion/endemic host population	2000 (Dominica) 2009 (Montserrat)	[15, 16]
Myotis lucifugus (little brown bat) EXTIRPATION*	*Geomyces destructans*	Fungi (Ascomycota)	Pathogen invasion?	~2006	[17, 18]
Partula turgida (Hawaiian tree snail) EXTINCTION	*Steinhausia* sp.	Fungi (Microsporidia)	Pathogen invasion/endemic host population	1996	[19]
Native European Crayfish (eg. white clawed crayfish *Austropotamobius pallipes*) EXTIRPATION*	*Aphanomyces astaci*	Protoctista (Oomycota)	Pathogen invasion/spill-over	~1970's	[20, 21]
Lottia alveus (Eelgrass limpet) EXTINCTION	*Labyrinthula zosterae*	Protoctista (Slime molds; Heterokontophyta)	Knock-on effect of pathogen-driven food loss	~1930	[22]

Hawaiian native Land Birds ~ 9 (Table 7, van Riper *et al.* 1986) EXTINCTION	Avian malaria?	Protoctista (*Apicomplexa* – *Plasmodium* sp.)	Pathogen invasion and habitat loss	~1830 - 2002	[23]
Sarcophilus harrisii (Tasmanian Devil) EXTIRPATION*	Tasmanian devil facial tumour disease	Mammalian infectious cancer	Frequency-dependent contact; low host genetic diversity(?)	1996	[24]
Mustela nigripes (Black footed ferret) EXTIRPATION	Canine distemper virus (CDV)	ssRNA Virus (genus Morbillivirus	Pathogen spill-over from unknown vector	1985	[25]
Lycaon pictus (African Wild Dog) EXTIRPATION	Canine distemper virus (CDV)	ssRNA Virus (genus Morbillivirus	Pathogen spill-over from domesticated dogs	~1960 - present	[26, 27]
Rattus macleari (Christmas Island rat) EXTINCTION(?)	*Trypanosoma lewisii* ?	Protoctista (Euglenozoa)	Pathogen spill-over following introduction of *R. rattus* ?	~1905	[28]
Castanea dentata (Chestnut trees) EXTIRPATION	*Cryphonectria parasitica*	Fungi (Ascomycota)	Pathogen invasion	~1900 - ~1930	[29]
Ulnus spp. (Elm trees) EXTIRPATION	*Ophiostoma ulmi*	Fungi (Ascomycota)	Pathogen invasion, recombination	~1910	[30]
Jarrah dieback (multiple species of *Eucalyptus* and Proteaceae) EXTIRPATION/ EXTINCTION(?)	*Phytophthora cinnamomi*	Protoctista (Oomycota)	Pathogen invasion	1935	[31]
Pinus radiata (Monterey pine) EXTIRPATION(?)	*Fusarium circinatum*	Fungi (Ascomycota)	Pathogen invasion	1946	[32]
Sudden oak death syndrome (multiple species) EXTIRPATION(?)	*Phytophthora ramorum*	Protoctista (Oomycota)	Pathogen invasion	~1995	[33]

Torreya taxifolia (Florida torreya) EXTINCTION* (~99% decline)	*Pestalotiopsis microspora* ?	Fungi (Ascomycota)	Unknown.	~1950	[34]
Zostera marina and *Zostera caulescens* (Eelgrass) EXTIRPATION	*Labyrinthula zosterae*	Protoctista (Slime mold; Heterokontophyta)	Unknown	~1930	[35]

Note: We only include species where there is published evidence of extinction/extirpation, or published evidence of declines with a high likelihood of future loss. Many EIDs did not meet these strict criteria despite causing high levels of population decline (e. g. bird West Nile Virus, Red squirrel parapox virus, Prairie dog plague). * indicates species where extirpation or extinction is predicted based on projections of future population viability. (?) indicates that data is persuasive but deficient

Table S4.1

Data for Fig. 1. Summary of major taxonomic groups of pathogens that cause animal species extinctions/extirpations from Table S1

Taxonomic groups of pathogens	Disease-driven extinction/ extirpation events (% of total)	Corrected for community-level extinctions (% of total)
Fungi	39 (72.0)	11 (64.7)
Protist	12 (22.0)	3 (17.6)
Viruses	2 (3.7)	2 (11.7)
Bacteria	0 (0)	0 (0)
Helminths	0 (0)	0 (0)
others*	1 (1.9)	1 (5.88)

*Note: 'Others' includes mammalian carcinogenic cell lines and prions

Table S4.2

Data for Fig. 1. Summary of major taxanomic groups of pathogens that cause plant species extinctions/extirpations from Table S1

Taxonomic groups of pathogens	Disease-driven extinction/ extirpation events	Corrected for community-level extinctions
Fungi	4 (57.1)	4 (57.1)
Protist	3 (42.8)	3 (42.8)
Viruses	0 (0)	0 (0)
Bacteria	0 (0)	0 (0)
Helminths	0 (0)	0 (0)
others*	n/a	n/a

Disease	Pathogen	Host range	Regional losses[1]	Regional losses of absorbed CO_2 (megatonnes)[2,3]
Dutch Elm	*Ophiostoma ulmi*	Elm	25 million elms (UK, 1990's) 77 million elms (USA, by 2001)	0.395[2] to 1[3]
Chestnut blight	*Cryphonectria parasitica*	Chestnut	3.5 billion US chestnuts (USA, by 1940's)	13.8 to 35
Sudden oak death / ramorum blight	*Phytophthora ramorum*	Oak, larch *etc.*	1.4 million oaks in California Pre-emptive cull of 4 million larches (UK 2011)	0.012 to 0.05
'Jarrah' dieback	*Phytophthora cinnamomi*	2,000 of 9,000 native *spp.* in Western Australia	1 million hectares of western Australia (by 2009)	9 to 23
Pine beetle / blue stain	*Grossmania clavigera*	Lodge pole pine	16.3 million hectares of western Canada (by 2011)	207 - 520
				TOTAL: ~ 230 to 580 megatonnes

Table S5. Tree carbon sequestration losses caused by fungal/oomycete diseases

Regional losses[1] are given as trees felled/succumb to disease and resulting losses in CO_2 absorption for 5 different fungal/oomycete pathogens. Such regional losses determined for total number of lost trees estimated over period stated, with minimum[2] and maximum[3] estimates based on either [2] carbon sequestration data-base at Office of Sustainability, Tufts University US (with 25 -120 year old trees is 2.52 lbs to 5.58 lbs CO_2 per year per tree: 25 – 120 year old pines is 15 – 11.7 lbs CO_2 per year: crude mean of values is 3.95 Kg CO_2 per tree per year) or on the assumption[3] that one broad-leaved tree will absorb around 0.01 tonne of CO_2 per annum [36]. Estimates for losses due to *Phytophthora cinnamomi* are based on a eucalyptus planting density of 2300 trees per hectare [37]. Pine beetle/blue stain losses are based on a pine planting density of 1400 trees per hectare. We note that we have not evaluated losses owing to timber decay as a result of tree death. Atmospheric CO_2 levels (December 2011, http://co2now.org/) were recorded at 391.80 ppm or 834.5 Gigatonnes; maximum regional losses recorded herein equate with 0.069% global CO_2

References

1. Anderson, P.K., et al., *Emerging infectious diseases of plants: pathogen pollution, climate change and agrotechnology drivers.* Trends in Ecology & Evolution, 2004. **19**(10): p. 535-544.
2. Daszak, P. and C.A. A., *Extinction by infection.* Trends in Ecology and Evolution, 1999. **14**(7): p. 279.
3. Daszak, P., et al., *Emerging infectious diseases and amphibian population declines.* Emerging Infectious Diseases, 1999. **5**: p. 735-748.
4. Daszak, P., A.A. Cunningham, and A.D. Hyatt, *Emerging infectious diseases of wildlife - Threats to biodiversity and human health.* Science, 2000. **287**: p. 443-449.
5. Jones, K.E., et al., *Global trends in emerging infectious diseases.* Nature, 2008. **451**(7181): p. 990-3.
6. Harvell, C.D., et al., *Ecology - Climate warming and disease risks for terrestrial and marine biota.* Science, 2002. **296**(5576): p. 2158-2162.
7. Wake, D.B. and V.T. Vredenburg, *Are we in the midst of the sixth mass extinction? A view from the world of amphibians.* Proceedings of the National Academy of Sciences of the United States of America, 2008. **105**: p. 11466-11473.
8. Stuart, S.N., et al., *Status and trends of amphibian declines and extinctions worldwide.* Science, 2004. **306**(5702): p. 1783-6.
9. Smith, K.F., D.F. Sax, and K.D. Lafferty, *Evidence for the role of infectious disease in species extinction and endangerment.* Conservation Biology, 2006. **20**(5): p. 1349-1357.
10. Crawford, A.J., K.R. Lips, and E. Bermingham, *Epidemic disease decimates amphibian abundance, species diversity, and evolutionary history in the highlands of central Panama.* Proceedings of the National Academy of Sciences of the United States of America, 2010. **107**(31): p. 13777-13782.
11. Campbell, A., *Declines and disappearances of Australian frogs.* 1999, Canberra: Environment Australia. 234 p.
12. Schloegel, L.A., et al., *The decline of the sharp-snouted day frog (Taudactylus acutirostris): The first documented case of extinction by infection in a free-ranging wildlife species? (vol 3, pg 35, 2006).* Ecohealth, 2006. **3**(2): p. 122-122.
13. Bosch, J., I. Martínez-Solano, and M. García-París, *Evidence of a chytrid fungus infection involved in the decline of the common midwife toad (Alytes obstetricans) in protected areas of central Spain.* Biological Conservation, 2001. **97**: p. 331-337.
14. Channing, A., et al., *The biology and recent history of the critically endangered Kihansi spray toad Nectrophrynoides asperginis in Tanzania.* Journal of East African Natural History., 2006. **95**(2): p. 117-138.
15. McIntyre, S., *The current status of the mountain chicken Leptodactylus fallax on Dominica, eastern Caribbean: an amphibian in decline.* MSc thesis, University of East Anglia, Norwich, UK., 2003.
16. Black, R., *Fungus devastates 'chicken' frog.* http://news.bbc.co.uk/1/hi/sci/tech/7948124.stm, 2009 (accessed 2011).
17. Blehert, D.S., et al., *Bat White-Nose Syndrome: An Emerging Fungal Pathogen?* Science, 2009. **323**(5911): p. 227-227.
18. Frick, W.F., et al., *An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species.* Science, 2010. **329** (5992): p. 679-682.
19. Cunningham, A.A. and P. Daszak, *Extinction of a Species of Land Snail Due to Infection with a Microsporidian Parasite".* Conservation Biology, 1998. **12**(5): p. 1139-1141.

20. Alderman, D.J., *Geographical spread of bacterial and fungal diseases of crustaceans.* Revue Scientifique Et Technique De L Office International Des Epizooties, 1996. **15**(2): p. 603-632.
21. Alderman, D.J., D. Holdich, and I. Reeve, *Signal Crayfish as Vectors in Crayfish Plague in Britain.* Aquaculture, 1990. **86**(1): p. 3-6.
22. Carlton, J.T., et al., *The 1st Historical Extinction of a Marine Invertebrate in an Ocean-Basin - the Demise of the Eelgrass Limpet Lottia-Alveus.* Biological Bulletin, 1991. **180**(1): p. 72-80.
23. Van Riper III, C. and S.G. Van Riper, *The epizootiology and ecological significance of malaria in Hawaiian land birds.* Ecological Monographs, 1986. **56**(4): p. 327-344.
24. McCallum, H., et al., *Transmission dynamics of Tasmanian devil facial tumor disease may lead to disease-induced extinction.* Ecology, 2009. **90**(12): p. 3379-3392.
25. Williams, E.S., et al., *Canine-Distemper in Black-Footed Ferrets (Mustela-Nigripes) from Wyoming.* Journal of Wildlife Diseases, 1988. **24**(3): p. 385-398.
26. Macdonald, D.W., *Cause of Wild Dog Deaths.* Nature, 1992. **360**(6405): p. 633-634.
27. Haydon, D.T., et al., *Development of vaccination strategies for the management of rabies in African wild dogs.* Biological Conservation, 2006. **131**(2): p. 180-192.
28. Wyatt, K.B., et al., *Historical Mammal Extinction on Christmas Island (Indian Ocean) Correlates with Introduced Infectious Disease.* Plos One, 2008. **3**(11).
29. Milgroom, M.G., et al., *Intercontinental population structure of the chestnut blight fungus, Cryphonectria parasitica.* Mycologia, 1996. **88**(2): p. 179-190.
30. Brasier, C.M., *Rapid evolution of introduced plant pathogens via interspecific hybridization.* Bioscience, 2001. **51**(2): p. 123-133.
31. Wills, R.T., *The Ecological Impact of Phytophthora cinnamomi in the Stirling Range National Park, Western Australia.* Australian Journal of Ecology, 1993. **18**(2): p. 145-159.
32. Gordon, T.R., A.J. Storer, and D.L. Wood, *The pitch canker epidemic in California.* Plant Disease, 2001. **85**(11): p. 1128-1139.
33. McPherson, B.A., et al., *Sudden oak death in California: Disease progression in oaks and tanoaks.* Forest Ecology and Management, 2005. **213**(1-3): p. 71-89.
34. Schwartz, M.W., S.M. Hermann, and P.J. van Mantgem, *Estimating the magnitude of decline of the Florida torreya (Torreya taxifolia Arn.).* Biological Conservation, 2000. **95**(1): p. 77-84.
35. Muehlstein, L.K., D. Porter, and F.T. Short, *Labyrinthula-Zosterae Sp-Nov, the Causative Agent of Wasting Disease of Eelgrass, Zostera-Marina.* Mycologia, 1991. **83**(2): p. 180-191.
36. Nowak, D.J. and D.E. Crane, *Carbon storage and sequestration by urban trees in the USA.* Environmental Pollution, 2002. **116**(3): p. 381-389.
37. Koch, J.M. and S.C. Ward, *Growth of jarrah on rehabilitation of bauxite mines in SW Australia in 13 years.* Australian Forests, 2005. **68**: p. 176-185.