nature REVIEWS MICROBIOLOGY

SUPPLEMENTARY INFORMATION

In format as provided by the authors

Microbial invasions in terrestrial ecosystems

Madhav P. Thakur, Wim H. van der Putten, Marleen M. P. Cobben, Mark van Kleunen and Stefan Geisen

https://doi.org/10.1038/s41579-019-0236-z

Supplementary Box 1: An overview of key invasive microorganisms of terrestrial environments

We conducted a systematic literature search in ISI Web of Science to identify the currently known alien microorganisms and their impacts on terrestrial ecosystems. We aimed at gathering information on alien microorganisms that are free-living as well as pathogenic to plants. We collected information on one or more alien microorganisms, their hosts and environments from more than 300 published studies (Supplementary methods). From these studies, we extracted a list of 85 alien microorganisms that are considered invasive in terrestrial ecosystems (Supplementary Table 1). Because of our soil and plant-centric search terms (Supplementary methods), we acknowledge that our list of invasive microorganisms is mainly limited to phytopathogens (60 species) with only few pathogens of animals (7 species) and the rest as non-pathogenic ones (18 species) (Supplementary Table 1). More importantly, given that our search terms were aimed at obtaining information on alien microorganisms from the wild, our list does not include alien microorganisms invading humans.

Among the pathogenic invasive microorganisms, 45 were fungi, 18 were protists (of which 16 were oomycetes), four were viruses and a bacterium (Supplementary Table 1). Among the non-pathogenic invasive microorganisms, 20 were fungi and one bacterium (Supplementary Table 1). Species diversity of invasive microorganism studies was highest in the oomycete genus *Phytophthora* (16 species) followed by fungal genera *Ophiostoma* (5 species) and *Hymenoscyphus* (4 species) (Supplementary Table 1). We have synthesized the details of some of the well-known invasive pathogenic microorganisms in Table 1.

Supplementary methods: Systematic literature search

We used ISI Web of Science search to obtain a list of alien and invasive microorganisms of terrestrial ecosystem using the following search terms:(“invas* microorgani*” OR “invas* microb*” OR “invas* bacteria*” OR “invas* fung*” OR “invas* protozo*” OR “invas* protist” OR “invas* virus” OR “invas* oomycet*” OR “invas* pathogen*” OR “invas* parasit*” OR “exotic microorgani*” OR “ exotic microb*” OR “exotic bacteria*” OR “exotic fung*” OR “exotic protozo*” OR “exotic protist” OR “exotic virus” OR “exotic oomycet*” OR “exotic pathogen*” OR “exotic parasit*” OR “non-native microorgani*” OR “ non-native microb*” OR “non-native bacteria*” OR “ non-native fung*” OR “non-native protozo*” OR “non-native protist” OR “non-native virus” OR “non-native oomycet*” OR “non-native pathogen*” OR “non-native parasit*” OR “alien microorgani*” OR “ alien microb*” OR “alien bacteria*” OR “ alien fung*” OR “alien protozo*” OR “alien protist” OR “alien virus” OR “alien oomycet*” OR “alien pathogen*” OR “alien parasit*”) **AND** (“soil” OR “terrestri*” OR “belowground” OR “below-ground” OR “aboveground” OR “above-ground” OR “plant associate*” OR “leaf” OR “rhizosph*” OR “rhizopla*” OR “root*” OR “flower*” OR “forest*” OR “grassland*” OR “grass*” OR “forb*” OR “tree*” OR “legum*” OR “crop*”).

The search was carried out on the 8th of May 2018. Using the above search terms, we obtained 567 papers. We excluded papers that did not contain any taxa specific information of alien or invasive microorganisms. At the end, we sorted 317 studies with information on at least one or multiple alien or invasive microorganisms.

Supplementary Table 1: List of invasive microorganisms of terrestrial ecosystem obtained from our systematic literature search. We provide details of some of them in Table 1 of the main text. The references used in this table are studies those appeared in our literature search. The protist group is divided into oomycete and other protists.

Species	Pathogen/non-pathogen	Group	Disease/ Common name	Reference
Amanita muscaria	Non-pathogenic	Fungi	Fly agaric	Dunk, CW, Lebel, T, Keane, PJ (2012) Characterisation of ectomycorrhizal formation by the exotic fungus *Amanita muscaria* with *Nothofagus cunninghamii* in Victoria, Australia. Mycorrhiza 22:135-147.
Amanita phalloides	Non-pathogenic	Fungi	Death cap	Pringle A, Vellinga EC (2006) Last chance to know? Using literature to explore the biogeography and invasion biology of the death cap mushroom Amanita phalloides (Vaill. ex Fr.:Fr.) Link. Biological Invasions 8:1131–1144.
Apicystis bombi	Pathogenic	Other protists	Infection in bees	Arbetman, MP, Meeus, I, Morales, CL, Aizen, MA, Smagghe, G (2013) Alien parasite hitchhikes to Patagonia on invasive bumblebee. Biological invasions 15: 489-494.
Armillaria mellea	Pathogenic	Fungi	Armillaria root rot	Coetzee, MPA, Musasira, NY, Roux, J, Roets, F, van der Merwe, NA, Wingfield, MJ (2018) *Armillaria* root rot spreading into a natural woody ecosystem in South Africa. Plant Pathology 67: 883-891.
Austropuccinia psidii	Pathogenic	Fungi	Myrtle rust	Pegg, G, Taylor, T, Entwistle, P, Guymer, G, Giblin, F, Carnegie, A (2017) Impact of *Austropuccinia psidii* (myrtle rust) on Myrtaceae-rich wet sclerophyll forests in south east Queensland. Plos One 12: e0188058.
Batrachochytrium dendrobatidis	Pathogenic	Fungi	Bd or Amphibian chytrid fungus	Lips, KR, Diffendorfer, J, Mendelson, JR, Sears, MW (2008) Riding the wave: Reconciling the roles of disease and climate change in amphibian declines. Plos Biology 6: e72.
Beet necrotic yellow vein virus	Pathogenic	Virus	Disease in sugar beet	Staniulis, J, Zitikaite, I, Zizyte, M, Jackeviciene, E, Urbanaviciene, L, Sneideris, D (2012) Detection and molecular identification of alien viruses of plums, sugar beets and tomatoes. Žemdirbystė (Agriculture) 99: 85-92.
Bradyrhizobium spp	Non-pathogenic	Bacteria	NA	Parker, M (1995) Plant fitness variation caused by different mutualist genotypes. Ecology 76: 1525-1535.
Calonectria morganii	Pathogenic	Fungi	Stem and root rot	Aiello, D, Cirvilleri, G, Polizzi, G, Vitale, A (2013) Effects of Fungicide Treatments for the Control of Epidemic and Exotic Calonectria Diseases in Italy. Plant disease 97: 37-43
Calonectria pauciramosa	Pathogenic	Fungi	Pathogen of Eucalyptus	Aiello, D, Cirvilleri, G, Polizzi, G, Vitale, A (2013) Effects of Fungicide Treatments for the Control of Epidemic and Exotic Calonectria Diseases in Italy. Plant disease 97: 37-44
Ceratocystis fagacearum	Pathogenic	Fungi	Oak wilt	Juzwik, J, Harrington, TC, MacDonald, WL, Appel, DN (2008) The origin of *Ceratocystis fagacearum*, the oak wilt fungus. Annual Review of Phytopathology. 2008: 13-26.
Ceratocystis fimbriata	Pathogenic	Fungi	Ceratocystis blight	Engelbrecht, CJB, Harrington, TC, Steimel, J, Capretti, P (2004) Genetic variation in eastern North American and putatively introduced populations of *Ceratocystis fimbriata f. platani.* Molecular Ecology 13: 2995-3005.
Chilli veinal mottle virus (ChiVMV)	Pathogenic	Virus	NA	Tiberini, A, Manglli, A, Ahmad, A, Cassia, U, Tomassoli, L (2017) First report and molecular identification of chilli veinal mottle virus in Italy. Jounal of Plant Pathology 99: 523-526.
Cronartium ribicola	Pathogenic	Fungi	White pine blister rust	Zambino, PJ (2010) Biology and pathology of Ribes and their implications for management of white pine blister rust. Forest Pathology 40: 264–291.

Cryphonectria parasitica	Pathogenic	Fungi	Chestnut blight	Dutech, C, Barres, B, Bridier, J, Robin, C, Milgroom, MG, Ravigne, V (2012) The chestnut blight fungus world tour: Successive introduction events from diverse origins in an invasive plant fungal pathogen. Molecular Ecology 21: 3931–3946
Diplodia pinea	Pathogenic	Fungi	Diplodia tip blight	Chhin, S, O'Brien, J (2015) Dendroclimatic analysis of red pine affected by Diplodia shoot blight in different latitudinal regions in Michigan. Canadian Journal of Forest Research 45: 1757-1767.
Discula destructiva	Pathogenic	Fungi	Dogwood anthracnose	Holzmueller, EJ, Jose, S, Jenkins, MA (2010) Ecological consequences of an exotic fungal disease in eastern US hardwood forests. Forest Ecology and Management 259: 1347-1353.
Dothistroma septosporum	Pathogenic	Fungi	Dothistroma needle blight	Piotrowska, MJ, Riddell, C, Hoebe, PN, Ennos, RA (2018) Planting exotic relatives has increased the threat posed by *Dothistroma septosporum* to the Caledonian pine populations of Scotland. Evolutionary Applications
Drechslera gigantea	Pathogenic	Fungi	Eyespot diseases	Peng, G, Boyetchko, SM (2006) Effect of variable dew temperatures on infection of green foxtail by *Pyricularia setariae, Drechslera gigantea*, and *Exserohilum rostratum*. Biological Control 39:539-546.
Erwinia amylovora	Pathogenic	Bacteria	Fireblight	Pester, D, Milcevicova, R, Schaffer, J, Wilhelm, E, Blumel, S (2012) *Erwinia amylovora* Expresses Fast and Simultaneously hrp/dsp Virulence Genes during Flower Infection on Apple Trees. Plos One 7: e32583
Erysiphe alphitoides	Pathogenic	Fungi	Powdery mildew	Marcais, B, Desprez-Loustau, ML (2014) European oak powdery mildew: impact on trees, effects of environmental factors, and potential effects of climate change. Annals of Forest Science 71: 633-642.
Erysiphe corylacearum	Pathogenic	Fungi	Powdery mildew	Turkkan, M, Erper, I, Eser, U, Baltaci, A (2018) Evaluation of Inhibitory Effect of Some Bicarbonate Salts and Fungicides Against Hazelnut Powdery Mildew. Gesunde Pflanzen 70: 39-44.
Escovopsioides nivea	Non-pathogenic	Fungi	NA	Reis, BM, Silva, A, Alvarez, MR, de Oliveira, TB, Rodrigues, A (2015) Fungal communities in gardens of the leafcutter ant *Atta cephalotes* in forest and cabruca agrosystems of southern Bahia State (Brazil). Fungal Biology 119: 1170-1178.
Escovopsis sp.	Non-pathogenic	Fungi	NA	Reis, BM, Silva, A, Alvarez, MR, de Oliveira, TB, Rodrigues, A (2015) Fungal communities in gardens of the leafcutter ant *Atta cephalotes* in forest and cabruca agrosystems of southern Bahia State (Brazil). Fungal Biology 119: 1170-1178.
Exserohilum rostratum	Pathogenic	Fungi	Crown and root rot	Peng, G, Boyetchko, SM (2006) Effect of variable dew temperatures on infection of green foxtail by *Pyricularia setariae, Drechslera gigantea, and Exserohilum rostratum*. Biological Control 39:539-546.
Favolaschia calocera	Non-pathogenic	Fungi	Orange pore fungus	Vizzini, A, Zotti, M, Mello, A (2009) Alien fungal species distribution: the study case of *Favolaschia calocera*. Biological invasions 11: 417-429.
Fusarium oxysporum f.sp.	Pathogenic	Fungi	Fusarium wilt of oil palm	Shabani, F, Kumar, L (2013) Risk Levels of Invasive *Fusarium oxysporum f. sp* in Areas Suitable for Date Palm (*Phoenix dactylifera*) Cultivation under Various Climate Change Projections. Plos One 8: e83404.
Geosmithia morbida	Pathogenic	Fungi	Thousand cankers disease	Hadziabdic, D, Vito, LM, Windham, MT, Pscheidt, JW, Trigiano, RN, Kolarik, M (2014) Genetic differentiation and spatial structure of *Geosmithia morbida*, the causal agent of thousand cankers disease in black walnut (Juglans nigra). Current Genetics 60: 75-87.

Gibberella circinata (Fusarium circinatum)	Pathogenic	Fungi	Pitch canker	Wingfield, MJ, Hammerbacher, A, Ganley, RJ, Steenkamp, ET, Gordon, TR, Wingfield, BD, Coutinho, TA (2008) Pitch canker caused by *Fusarium circinatum* - A growing threat to pine plantations and forests worldwide. Australasian Plant Pathology 37, 319–334.
Gremmeniella abietina	Pathogenic	Fungi	Scleroderris canker / Brunchorstia disease	Stenlid, J, Oliva, J (2016) Phenotypic interactions between tree hosts and invasive forest pathogens in the light of globalization and climate change. Philosophical Transactions of the Royal Society B-Biological Sciences 371: 20150455.
Heterobasidion irregulare	Pathogenic	Fungi	Annosus root rot	Giordano, L, Gonthier, P, Lione, G, Capretti, P, Garbelotto, M (2014) The saprobic and fruiting abilities of the exotic forest pathogen *Heterobasidion irregulare* may explain its invasiveness. Biological Invasions 16: 801-814.
Hydnangium carneum	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Hymenogaster albus	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Hymenoscyphus fraxineus	Pathogenic	Fungi	Ash dieback	Kowalski, T, Holdenrieder, O (2009) Pathogenicity of *Chalara fraxinea*. Forest Pathology 39:1–7.
Hymenoscyphus koreanus	Pathogenic	Fungi	Ash dieback	Gross, A, Han, JG (2015) *Hymenoscyphus fraxineus* and two new *Hymenoscyphus* species identified in Korea. Mycological Progress 14:19.
Hymenoscyphus occultus	Pathogenic	Fungi	Ash dieback	Gross, A, Han, JG (2015) *Hymenoscyphus fraxineus* and two new *Hymenoscyphus* species identified in Korea. Mycological Progress 14:19.
Hymenoscyphus pseudoalbidus	Pathogenic	Fungi	Ash dieback	Gross, A, Hosoya, T, Queloz, V (2014) Population structure of the invasive forest pathogen *Hymenoscyphus pseudoalbidus*. Molecular Ecology 23: 2943-2960.
Hysterangium inflatum	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Labyrinthomyces donkii	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Laccaria fraterna	Non-pathogenic	Fungi	Gumtree deceiver	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Leptographium procerum	Pathogenic	Fungi	White pine root decline	Taerum, SJ, Hoareau, TB, Duong, TA, De Beer, ZW, Jankowiak, R, Wingfield, MJ (2017) Putative origins of the fungus *Leptographium procerum.* Fungal Biology 121: 82-94.
Metarhizium anisopliae	Pathogenic	Fungi	Green muscardine disease	Genthner, FJ, Foss, SS, Glas, PS (1997) Virulence of *Metarhizium anisopliae* to embryos of the grass shrimp *Palaemonetes pugio*. Journal of Invertebrate Pathology 69: 157-164.
Nattrassia mangiferae	Pathogenic	Fungi	Leaf blight	Gumbo, T, Mkanganwi, N, Robertson, VJ, Masvaire, P (2002) Case report. *Nattrassia mangiferae* endophthalmitis. Mycoses 45: 3-4.
Neonectria faginata	Pathogenic	Fungi	Beech bark disease	Loo, J (2009) Ecological impacts of non-indigenous invasive fungi as forest pathogens. Biological Invasions 11:81-96.
Nosema ceranae	Pathogenic	Fungi	Nosemosis in honey bees	Furst, MA, McMahon, DP, Osborne, JL, Paxton, RJ, Brown, MJF (2014) Disease associations between honeybees and bumblebees as a threat to wild pollinators. Nature 506: 364-366.
Ophiostoma huntii	Pathogenic	Fungi	Discoloration in logs	Kim, GH, Kim, JJ, Lim, YW, Breuil, C (2005) *Ophiostomatoid* fungi isolated from *Pinus* radiata logs imported from New Zealand to Korea. Canadian Journal of Botany-Revue Canadienne De Botanique 83: 272-278.

Ophiostoma nigrocarpum	Pathogenic	Fungi	Discoloration in logs	Kim, GH, Kim, JJ, Lim, YW, Breuil, C (2005) Ophiostomatoid fungi isolated from *Pinus* radiata logs imported from New Zealand to Korea. Canadian Journal of Botany-Revue Canadienne De Botanique 83: 272-278.
Ophiostoma novo-ulmi	Pathogenic	Fungi	Dutch elm disease	Comeau, AM, Dufour, J, Bouvet, GF, Jacobi, V, Nigg, M, Henrissat, B, Laroche, J, Levesque, RC & Bernier, L (2015) Functional annotation of the *ophiostoma novo-ulmi* genome: Insights into the phytopathogenicity of the fungal agent of Dutch elm disease. Genome Biology and Evolution 7: 410–430.
Ophiostoma radiatcola	Pathogenic	Fungi	Discoloration in logs	Kim, GH, Kim, JJ, Lim, YW, Breuil, C (2005) *Ophiostomatoid* fungi isolated from *Pinus* radiata logs imported from New Zealand to Korea. Canadian Journal of Botany-Revue Canadienne De Botanique 83: 272-278.
Ophiostoma setosum	Pathogenic	Fungi	Discoloration in logs	Kim, GH, Kim, JJ, Lim, YW, Breuil, C (2005) *Ophiostomatoid* fungi isolated from *Pinus* radiata logs imported from New Zealand to Korea. Canadian Journal of Botany-Revue Canadienne De Botanique 83: 272-278.
Paranosema locustae	Pathogenic	Fungi	Grasshopper infections	Bardi, C, Mariottini, Y, Plischuk, S, Lange, CE (2012) Status of the alien pathogen *Paranosema locustae* (Microsporidia) in grasshoppers (Orthoptera: *Acridoidea*) of the Argentine Pampas. Biocontrol Science & Technology 22: 497-512.
Phakopsora pachyrhizi	Pathogenic	Fungi	Soybean rust	Sutrave, S, Scoglio, C, Isard, SA, Hutchinson, JMS, Garrett, KA (2012) Identifying highly connected counties compensates for resource limitations when evaluating national spread of an invasive pathogen. Plos One 7: e37793.
Phytophthora alni	Pathogenic	Oomycete	Phytophthora disease of alders	Thoirain, B, Husson, C, Marcais, B (2007) Risk Factors for the *Phytophthora* -Induced Decline of Alder in Northeastern France. Phytopathology 97: 99–105
Phytophthora cambivora	Pathogenic	Oomycete	Root rot	Feau, N, Taylor, G, Dale, AL, Dhillon, B, Bilodeau, GJ, Birol, I, Jones, SJM, Hamelin, RC (2016) Genome sequences of six *Phytophthora* species threatening forest ecosystems. Genomics Data 10: 85-88.
Phytophthora cinnamomi	Pathogenic	Oomycete	Root rot	Hardham, A, Blackman, L (2018) Pathogen profile: *Phytophthora cinnamomi*. Molecular Plant Pathology 19: 260–285
Phytophthora cryptogea	Pathogenic	Oomycete	Root and shoot rot	Feau, N, Taylor, G, Dale, AL, Dhillon, B, Bilodeau, GJ, Birol, I, Jones, SJM, Hamelin, RC (2016) Genome sequences of six Phytophthora species threatening forest ecosystems. Genomics Data 10: 85-88.
Phytophthora heveae	Pathogenic	Oomycete	Black stripe disease	Jung, T, Chang, TT, Bakonyi, J, Seress, D, Perez-Sierra, A, Yang, X, Hong, C, Scanu, B, Fu, CH, Hsueh, KL, Maia, C, Abad-Campos, P, Leon, M, Jung, MH (2017) Diversity of *Phytophthora* species in natural ecosystems of Taiwan and association with disease symptoms. Plant Pathology, 66: 194-211.
Phytophthora infestans	Pathogenic	Oomycete	Phytophthora blight	Wang, JN, Fernandez-Pavia, SP, Larsen, MM, Garay-Serrano, E, Gregorio-Cipriano, R, Rodriguez-Alvarado, G, Grunwald, NJ, Goss, EM (2017) High levels of diversity and population structure in the potato late blight pathogen at the Mexico centre of origin. Molecular Ecology, 26: 1091-1107.
Phytophthora kernoviae	Pathogenic	Oomycete	Stem lesions on mature *Fagus sylvatica* and foliar and stem necrosis of *Rhododendron ponticum*	Brasier, CM, Beales, PA, Kirk, SA, Denman, S, Rose, J (2005) *Phytophthora kernoviae* sp nov., an invasive pathogen causing bleeding stem lesions on forest trees and foliar necrosis of ornamentals in the UK. Mycological Research 109: 853-859.

Phytophthora lateralis	Pathogenic	Oomycete	Port-Orford-cedar root disease	Robin C, Piou, D, Feau, N, Douzon, G, Schenck, Hansen, EM (2011) Root and aerial infections of *Chamaecyparis lawsoniana* by Phytophthora lateralis: A new threat for European countries. Forest Pathology 41: 417–424.
Phytophthora megakarya	Pathogenic	Oomycete	Black pod of cocoa	Holmes, KA, Evans, HC, Wayne, S, Smith, J (2003) Irvingia, a forest host of the cocoa black-pod pathogen, *Phytophthora megakarya*, in Cameroon. Plant Pathology 52: 486-490.
Phytophthora nemorosa	Pathogenic	Oomycete	Sudden Oak Death and leaf blight and shoot dieback	Kozanitas, M, Osmundson, TW, Linzer, R, Garbelotto, M (2017) Interspecific interactions between the Sudden Oak Death pathogen *Phytophthora ramorum* and two sympatric *Phytophthora* species in varying ecological conditions. Fungal Ecology 28:86-96.
Phytophthora occultans	Pathogenic	Oomycete	Root rot	Man In't Veld, WA, Rosendahl, KCHM, van Rijswick, PCJ, Meffert, JP, Westenberg, M, van de Vossenberg, BTLH, Denton, G, van Kuik, FAJ (2015) *Phytophthora terminalis* sp nov and *Phytophthora occultans sp nov.*, two invasive pathogens of ornamental plants in Europe. Mycologia 107: 54-65.
Phytophthora pinifolia	Pathogenic	Oomycete	Needle blight disease	Feau, N, Taylor, G, Dale, AL, Dhillon, B, Bilodeau, GJ, Birol, I, Jones, SJM, Hamelin, RC (2016) Genome sequences of six Phytophthora species threatening forest ecosystems. Genomics Data 10: 85-88.
Phytophthora plurivora	Pathogenic	Oomycete	Root rot	Milanovic, S, Lazarevic, J, Karadzic, D, Milenkovic, I, Jankovsky, L, Vuleta, A, Solla, A (2015) Belowground infections of the invasive *Phytophthora plurivora* pathogen enhance the suitability of red oak leaves to the generalist herbivore *Lymantria dispar.* Ecological Entomology 40: 479-482.
Phytophthora pseudosyringae	Pathogenic	Oomycete	Root and collar rot	Kozanitas, M, Osmundson, TW, Linzer, R, Garbelotto, M (2017) Interspecific interactions between the Sudden Oak Death pathogen *Phytophthora ramorum* and two sympatric *Phytophthora* species in varying ecological conditions. Fungal Ecology 28:86-96.
Phytophthora ramorum	Pathogenic	Oomycete	Sudden oak death	Grünwald, NJ, Garbelotto, M, Goss, EM, Heungens, K, Prospero, S (2012) Emergence of the sudden oak death pathogen *Phytophthora ramorum*. Trends in Microbiology 20**:** 131–138.
Phytophthora terminalis	Pathogenic	Oomycete	Root rot	Man In't Veld, WA, Rosendahl, KCHM, van Rijswick, PCJ, Meffert, JP, Westenberg, M, van de Vossenberg, BTLH, Denton, G, van Kuik, FAJ (2015) *Phytophthora terminalis sp nov* and *Phytophthora occultans sp nov.*, two invasive pathogens of ornamental plants in Europe. Mycologia 107: 54-65.
Piriformospora indica	Non-pathogenic	Fungi	NA	Schafer, P, Khatabi, B, Kogel, KH (2007) Root cell death and systemic effects of Piriformospora indica: a study on mutualism. FEMS Microbiology Letters 275: 1-7.
Pisolithus albus	Non-pathogenic	Fungi	White dye-ball fungus	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula . Biological Invasions 7: 3-15.
Pisolithus microcarpus	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Plum pox	Pathogenic	Virus	Disease in plums	Staniulis, J, Zitikaite, I, Zizyte, M, Jackeviciene, E, Urbanaviciene, L, Sneideris, D (2012) Detection and molecular identification of alien viruses of plums, sugar beets and tomatoes. Žemdirbystė (Agriculture) 99: 85-92.
Pseudogymnoascus destructans	Pathogenic	Fungi	White nose syndrome	Marroquin, CM, Lavine, JO, Windstam, ST (2017) Effect of Humidity on Development of *Pseudogymnoascus destructans*, the Causal Agent of Bat White-nose Syndrome. Northeastern Naturalist 24: 54-64.

Pyrenopeziza plantaginis	Pathogenic	Fungi	Light leaf spot in *Plantago* spp.	Severns, PM, Stone, JK (2016) Pathogen invasion triggers an evolutionary trap for an endangered checkerspot butterfly dependent on an exotic host plant. Biological invasions 18: 3623-3633.
Quambalaria eucalypti	Pathogenic	Fungi	Disease in Eucalyptus trees	Perez, CA, de Beer, ZW, Altier, NA, Wingfield, MJ, Blanchette, RA (2008) Discovery of the eucalypt pathogen *Quambalaria eucalypti* infecting a non-Eucalyptus host in Uruguay. Australasian Plant Pathology 37: 600-604.
Raffaelea lauricola	Pathogenic	Fungi	Laurel wilt	Ploetz, RC, Perez-Martinez, JM, Smith, JA, Hughes, M, Dreaden, TJ, Iinch, SA, Fu, Y (2012) Responses of avocado to laurel wilt, caused by *Raffaelea lauricola*. Plant Pathology 61: 801–808.
Rhulandiella berolinensis	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Setchelliogaster rheophyllus	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Sirococcus clavigignenti-juglandacearum	Pathogenic	Fungi	Butternut canker	Broders, K, Boraks, A, Barbison, L, Brown, J, Boland, GJ (2015) Recent insights into the pandemic disease butternut canker caused by the invasive pathogen *Ophiognomonia clavigignenti-juglandacearum*. Forest Pathology 45, 1–8
Teratosphaeria (Mycosphaerella) nubilosa	Pathogenic	Fungi	Mycosphaerella leaf disease	Perez, G, Slippers, B, Wingfield, BD, Hunter, GC, Wingfield, MJ (2010) Micro- and macrospatial scale analyses illustrates mixed mating strategies and extensive geneflow in populations of an invasive haploid pathogen. Molecular Ecology 19: 1801-1813.
Teratosphaeria pseudoeucalypti	Pathogenic	Fungi	Leaf blight	Andjic, V, Pegg, GS, Carnegie, AJ, Callister, A, Hardy, GES, Burgess, TI (2010) *Teratosphaeria pseudoeucalypti*, new cryptic species responsible for leaf blight of Eucalyptus in subtropical and tropical Australia. Plant Pathology 59: 900-912.
Tomato Yellow Leaf Curl Virus (TYLCV)	Pathogenic	Virus	NA	Nannini, M, Foddi, F, Pintore, R, Pisci, R, Sanna, F, Testa, M, Accotto, GP (2011) A Survey of TYLCD Epidemics in Sardinia (Italy) - Assessing the Relative Abundance of TYLCSV and TYLCV on Tomato Crops and Bait Plants. Acta Hortic. 914, 189-192.
Trichoderma spirale	Non-pathogenic	Fungi	NA	Reis, BM, Silva, A, Alvarez, MR, de Oliveira, TB, Rodrigues, A (2015) Fungal communities in gardens of the leafcutter ant *Atta cephalotes* in forest and cabruca agrosystems of southern Bahia State (Brazil). Fungal Biology 119: 1170-1178.
Tricholoma eucalypticum (Lyophyllum eucalypticum)	Non-pathogenic	Fungi	NA	Diez, J (2005) Invasion biology of Australian ectomycorrhizal fungi introduced with eucalypt plantations into the Iberian Peninsula. Biological Invasions 7: 3-15.
Trypanosoma lewisi	Pathogenic	Other protists	Disease in rodents	Salzer, JS, Pinto, CM, Grippi, DC, Williams-Newkirk, AJ, Peterhans, JK, Rwego, IB, Carroll, DS, Gillespie, TR (2016) Impact of Anthropogenic Disturbance on Native and Invasive Trypanosomes of Rodents in Forested Uganda. Ecohealth 13: 698-707.