

Note: This is **Online Appendix 1** of Spear, D., Brown, K., Liddle, N., Parenzee, C.J. & Van Wilgen, N.J., 2026, 'Optimising species checklists for protected areas in the digital age', *Koedoe* 68(1), a1858.
<https://doi.org/10.4102/koedoe.v68i1.1858>

Online Appendix 1: Supporting Information for Spear et al. 2026 Koedoe

Appendix S1. Flow diagram for review of protected area checklists in the peer-reviewed literature, following the PRISMA flow diagram for systematic reviews (Page et al. 2021).

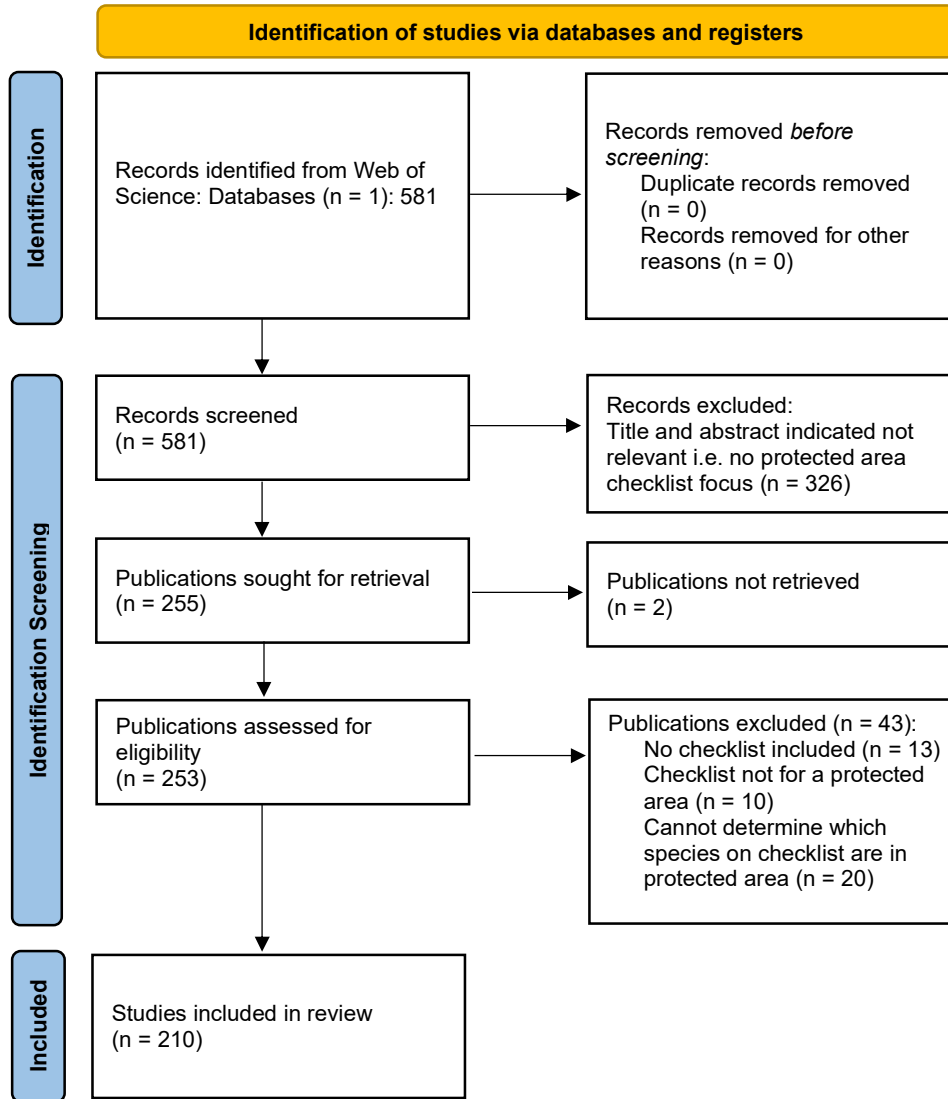
Appendix S2. List of peer-reviewed articles that were evaluated.

Appendix S3. Decision tree for allocating basis of record for 210 peer-reviewed articles.

Appendix S4. List of checklist datasets for protected areas derived from the Global Biodiversity Information Facility.

Appendix S5. Guidelines for producing species checklists for protected areas.

Appendix S1. Flow diagram for review of protected area checklists in the peer-reviewed literature, following the PRISMA flow diagram for systematic reviews (Page et al. 2021).



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Appendix S2. List of Web of Science peer-reviewed articles that were evaluated. Arranged by ascending year of publication and alphabetically by authors.

Authors	Country	Name of Protected Area	Taxonomic group/s
Stalmans et al. 1997	South Africa	Legalameetse Nature Reserve	Tracheophyta
Bermingham et al. 1998	Honduras	Reserva Biologica Cayos Cochinos	Tracheophyta, Insecta, Aves, Mammalia
Eggleton et al. 1999	Guyana	Kaieteur National Park	Isoptera
Pascarella et al. 1999	United States	Everglades National Park	Apoidea
Rubin et al. 2001	South Africa	The Karoo National Park	Tracheophyta
Whipple 2001	United States	Yellowstone National Park	Tracheophyta
Danby 2003	United States	Kluane National Park, Wrangell-St. Elias National Park and Preserve, Glacier Bay National Park and Preserve, Tatshenshini-Alsek Provincial Park and Tetlin National Wildlife Refuge	Aves, Mammalia
Wallace et al. 2003	United States	Great Smoky Mountains National Park	Membracidae
Quiroga et al. 2004	Colombia	Tayrona National Park	Polycladida
Rink 2005	United States	Canyon de Chelly National Monument	Tracheophyta
Tufan et al. 2005	Turkey	Termessos National Park	Fungi
Zomlefer and Giannasi 2005	United States	Castillo de San Marcos National Monument	Tracheophyta
Catra et al. 2006	Italy	Egadi islands	Rhodophyta, Ochrophyta, Chlorophyta

Authors	Country	Name of Protected Area	Taxonomic group/s
Dai and Penttilä 2006	China	Fenglin Nature Reserve	Basidiomycota
Johansen et al. 2007	United States	Great Smoky Mountains National Park	Cyanobacteria, Charophyta, Chlorophyta, Cyanidiophyta, Rhodophyta, Chrysophyta, Prymnesiophyta, Ochrophyta, Cryotophyta, Myzozoa, Euglenophyta
Muise et al. 2007	United States	Great Smoky Mountains National Park	Odonata
Salas-Morales et al. 2007	Mexico	Huatulco National Park	Tracheophyta
Meave et al. 2008	Mexico	Yaxchilan Natural Monument	Tracheophyta
Nobre et al. 2008	Brazil	Catimbau National Park	Rhopalocera
Rink and Cully 2008	United States	Aztec Ruins National Monument	Tracheophyta
Snyder 2008	United States	Great Smoky Mountains National Park	Diplopoda
Zomlefer et al. 2008	United States	Cumberland Island National Seashore	Tracheophyta
De Marinis and Masseti 2009	Turkey	National Park of Termessos	Mammalia
Hernandez et al. 2009	Mexico	La Paz Bay and Loreto Bay Natural Parks	Decapoda
Rink et al. 2009	United States	El Morro National Monument	Tracheophyta

Authors	Country	Name of Protected Area	Taxonomic group/s
Bora et al. 2010	Madagascar	Tsingy de Bemaraha National Park	Amphibia, Reptilia
Cobanoglu et al. 2010	Romania	Cozia National Park	Fungi
Daemane et al. 2010	South Africa	Golden Gate Highlands National Park	Tracheophyta
Favret et al. 2010	United States	Great Smoky Mountains National Park	Aphididae
Manu et al. 2010	Nigeria	Afi Mountain Wildlife Sanctuary and Cross River National Park	Aves
Muelelwa et al. 2010	South Africa	Blouberg Nature Reserve and Western Soutpansberg Conservancy	Araneae
Papp and Erzberger 2010	Montenegro	Durmitor National Park	Bryophyta
Pena-Chocarro et al. 2010	Paraguay	Mbaracayu Forest Nature Reserve	Tracheophyta
Romano et al. 2010	Italy	Cilento e Vallo di Diano National Park	Amphibia
Zomlefer et al. 2010	United States	Kennesaw Mountain National Battlefield Park	Tracheophyta
Arefin et al. 2011	Bangladesh	Satchari National Park	Angiospermae
Borges and Machado de Almeida 2011	Brazil	Jau National Park, Rio Negro State Park, Rio Unini Extractive Reserve and Amanã Sustainable Development Reserve	Aves
Gelder and Williams 2011	United States	Great Smoky Mountains National Park	Branchiobdellida
Kraaij 2011	South Africa	Bontebok National Park	Tracheophyta

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Masroor 2011	Pakistan	Margalla Hills National Park	Amphibia, Reptilia
Murai and Amr 2011	Syria	Al Thawrah Nature Reserve	Apoidea
Myers et al. 2011	United States	Adirondack Park	Insecta
Cianferoni and Mazza 2012	Italy	Foreste Casentinesi, Monte Falterona e Campigna National Park	Hemiptera
Guareschi et al. 2012	Spain	Sierra Nevada, Cabaneros, Ordesa, Picos de Europa, Aiguestortes and Monfrague National Parks	Insecta
Harris et al. 2012	Gabon	Loango National Park	Tracheophyta
Martinez-Camilo et al. 2012	Mexico	El Triunfo Biosphere Reserve	Tracheophyta
Schoeman and Foord 2012	South Africa	Marakele National Park	Formicidae
Zomlefer et al. 2012	United States	Chattahoochee River National Recreation Area	Tracheophyta
Bazairi et al. 2013	Libya	El-Kouf National Park	Tracheophyta
Bibalani and Taheri 2013	Iran	Shanjan Rangeland Protected Area	Tracheophyta
Ermilov and Anichkin 2013	Vietnam	Dong Nai Culture and Nature Reserve	Oribatida
Ermilov and Anichkin 2013	Vietnam	Dong Nai Culture and Nature Reserve	Oribatida
Ermilov and Anichkin 2013	Vietnam	Dong Nai Biosphere Reserve	Oribatida
Fourie et al. 2013	South Africa	Erfenis Dam Nature Reserve	Araneae

Authors	Country	Name of Protected Area	Taxonomic group/s
Moreno et al. 2013	Chile	Futangue Park	Tracheophyta
Rosas-Espinoza et al. 2013	Mexico	Sierra de Quila Protected Area	Amphibia
Saarela et al. 2013	Canada	Tuktut Nogait National Park	Tracheophyta
Siller et al. 2013	Hungary	Orseg National Park	Fungi
Steyn et al. 2013	South Africa	Tankwa Karoo National Park	Tracheophyta
Strazdiņa et al. 2013	Latvia	Moricšala Strict Nature Reserve	Bryophyta
Trilikauskas and Ponomareva 2013	Russia	Altai Nature Reserve	Araneae
Winfield et al. 2013	Mexico	National Park Veracruzan	Tanaidacea
Akani et al. 2014	Nigeria	Edumanon Forest Reserve	Mammalia
Arya et al. 2014	India	Madhav National Park	Aves
Baard and Kraaij 2014	South Africa	Garden Route National Park	Tracheophyta
Ciobanu et al. 2014	Chile	Ceahlău National Park	Tardigrada
Fuentes-Reinés and Suárez-Morales 2014	Colombia	Laguna Navio Quebrado	Harpacticoida
Hugo-Coetzee 2014	South Africa	Golden Gate Highlands National Park	Opipiidae
López-Pérez et al. 2014	Mexico	Parque Nacional Huatulco	Anthozoa, Asteroidea, Ophiuroidea, Actinopterygii, Chondrichthyes, Echinoidea, Holothuroidea
Cardona and Reyes 2015	Cuba	Baconao Biosphere Reserve	Tracheophyta

Authors	Country	Name of Protected Area	Taxonomic group/s
De Liberato et al. 2015	Italy	Circeo National Park	Culicidae
Ermilov and Bayartogtokh 2015	Vietnam	Bu Gia Map National Park	Oribatida
Langer et al. 2015	Germany	Kellerwald-Edersee National Park	Fungi
Machado et al. 2015	Brazil	Jericoacoara National Park	Gnathostomata
Ouvrard et al. 2015	France	Mercantour National Park	Psyllidae
Tedrow et al. 2015	Rwanda	Akagera, Nyungwe and Volcanoes National Parks and Arboretum de Ruhande	Mantodea
Tripp 2015	United States	White Rocks Open Space Nature Preserve	Fungi
Venter and Conradie 2015	South Africa	Manubi State Forest and Cape Morgan, Dwesa, Hluleka, Silaka and Mkambati Nature Reserves	Amphibia, Reptilia
Asem et al. 2016	Iran	Urmia Lake National Park	Nematoda, Insecta, Aves, Reptilia, Platyhelminthes, Apicomplexa, Branchiopoda, Mollusca, Chlorophyta, Ascomycota, Bryozoa, Cnidaria, Archaea, Bacteria
Burner et al. 2016	Malaysia	Mount Mulu National Park	Aves
Conti and Bartolucci 2016	Italy	Gran Sasso and Monti della Laga National Park	Tracheophyta

Authors	Country	Name of Protected Area	Taxonomic group/s
do Carmo and Peralta 2016	Brazil	Serra da Canastra National Park	Bryophyta
Ermilov et al. 2016	Cuba	Alejandro de Humboldt and Valle de Vioales National Parks	Oribatida
Felix and Massa 2016	Ethiopia	Kafa Biosphere Reserve and Bale Mountains National Park	Orthoptera
Foord et al. 2016	South Africa	Lekgalameetse Nature Reserve	Araneae
Gawor et al. 2016	Vietnam	Bai Tu Long National Park	Amphibia, Reptilia
Kommenov et al. 2016	Greece	Dadia-Lefkimi-Soufli Forest National Park	Araneae
McCrary et al. 2016	Honduras	Cusuco National Park	Euglossini
Rodríguez et al. 2016	Spain	Natural Park Serra da Encina da Lastra	Cyanobacteria, Rhodophyta, Ochrophyta, Myzozoa, Euglenophyta, Chlorophyta
Schejter et al. 2016	Argentina	Namuncura Marine Protected Area	Porifera, Bryozoa, Brachiopoda, Cnidaria, Mollusca, Ascidiacea, Pycnogonida, Polychaeta, Osteichthyes
Takiya et al. 2016	Brazil	Ubajara and Sete Cidades National Parks	Insecta
Yin et al. 2016	China	Nature Reserves in Jiangxi Province (See Yin et al. 2016)	Siluriformes
Aslan et al. 2017	Georgia	Lagodekhi National Park	Chrysomelidae
Ferreira et al. 2017	Brazil	Floresta Nacional de Pau-Rosa	Amphibia, Reptilia

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Larrain and Bahamonde 2017	Chile	Torres del Paine National Park	Bryophyta
Mustelin et al. 2017	United States	North-central Olympic National Park	Lepidoptera
Otero et al. 2017	Morocco	Talassemtane National Park	Coleoptera
Raimundi et al. 2017	Brazil	Serra da Mocidade National Park	Leptophlebiidae
Saarela et al. 2017	Canada	Kugluk (Bloody Falls) Territorial Park	Tracheophyta
Urbanavichus and Urbanavichene 2017	Russia	Erzi Nature Reserve	Fungi
Will et al. 2017	United States	Great Basin National Park	Carabidae
Winfield et al. 2017	Mexico	Puerto Morelos Reef National Park	Tanaidacea
Atashgahi et al. 2018	Iran	Heydari Wildlife Refuge	Tracheophyta
Awang et al. 2018	Malaysia	Taman Negara Johor Endau Rompin	Anura
Ayala-Bocos et al. 2018	Mexico	Cabo Pulmo National Park	Gnathostomata
Bego et al. 2018	Albania	Korab-Koritnik Nature Park, Lëpushë-Vermosh and Bredhi i Hotovës, Tomorri , Llogara-Karaburun, Divjakë-Karavasta and Liqeni i Shkodrës (Skadar Lake) National Parks	Rodentia
Cortés-Useche et al. 2018	Dominican Republic	Southeastern Reefs Marine Sanctuary	Gnathostomata

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Costa et al. 2018	Brazil	Sempre Vivas National Park and Serra do Cabral, Rio Preto, Biribiri and Pico do Itambé State Parks	Paepalanthus
Crespo et al. 2018	Spain	Picos de Europa, Ordesa y Monte Perdido, Aigüestortes i Estany de Sant Maurici, Monfragüe, Cabañeros and Sierra Nevada National Parks	Araneae
de Souza et al. 2018	Brazil	Anchieta Island State Park	Gnathostomata
Dippenaar-Schoeman et al. 2018	South Africa	Tswalu Kalahari Reserve	Araneae
Expósito et al. 2018	Spain	Anaga Rural Park	Tracheophyta
Haque et al. 2018	Bangladesh	Rajkandi Reserve Forest	Tracheophyta
Padiglia et al. 2018	Italy	Asinara Island and Capo Caccia-Isola Piana MPAs	Porifera
Sáez et al. 2018	Spain	Montserrat massif	Bryophyta
Sánchez-Jiménez et al. 2018	Costa Rica	Isla del Coco National Park and Las Gemelas Seamount	Gnathostomata
Sierra et al. 2018	Brazil	Jau National Park	Bryophyta
Zeng et al. 2018	China	Poyang Lake National Nature Reserve	Aves
Baptista et al. 2019	Angola	Bicuar National Park	Amphibia, Reptilia
Brito et al. 2019	Brazil	Catimbau National Park	Pentatomoidea
Burton and Lea 2019	United States	Monterey Bay National Marine Sanctuary	Gnathostomata

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Caviedes et al. 2019	Honduras	Blanca Jeannette Kawas Fernández National Park and Cuyamel-Omoa National Park	Gastropoda
Conti et al. 2019	Italy	Majella National Park	Tracheophyta
Fateryga and Fateryga 2019	Russia	Karadag State Nature Reserve	Tracheophyta
Friedlander et al. 2019	Cuba	Clipperton Atoll Marine Protected Area	Actinopterygii, Ophiuroidea, Demospongiae, Hexactinellida, Chondrichthyes, Malacostraca, Anthozoa, Crinoidea, Hydrozoa, Scyphozoa, Asteroidea, Echinoidea
Gusakov 2019	Russia	Eltonsky Nature Park	Nematoda, Diptera, Clitellata, Cyclopoida, Harpacticoida, Ostracoda, Amphipoda, Hemiptera, Coleoptera
Hornung-Leoni et al. 2019	Mexico	Reserva de la Biosfera Barranca de Metztlán	Tracheophyta
Ledesma et al. 2019	Spain	Sierra de Guadarrama National Park	Araneae
Lind and Davies 2019	South Africa	Kruger National Park	Isoptera

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Nascimento et al. 2019	Brazil	Saltinho Biological Reserve, Charles Darwin Ecological Refuge, Fernando de Noronha National Park and Wildlife Reserve of Gurjau	Chironomidae
Olmos-García et al. 2019	Mexico	Parque Nacional Sistema Arrecifal Veracruzano	Gastropoda
Paz-Ríos et al. 2019	Mexico	Alacranes Reef National Park	Amphipoda
Reyes-Chávez et al. 2019	Honduras	Rio Platano Man and Biosphere Reserve	Tracheophyta
Rodrigues et al. 2019	Brazil	Lencois Maranhenses National Park	Tracheophyta
Shi et al. 2019	China	Multiple Nature Reserves (See Shi et al. 2019)	Gnathostomata
Treitler et al. 2019	Italy	Asinara National Park	Coleoptera
Tripp and Lendemer 2019	United States	Great Smoky Mountains National Park	Fungi
Tu et al. 2019	Vietnam	Song Thanh Nature Reserve and Saola Quang Nam Nature Reserve	Mammalia
Vega-Pérez et al. 2019	Mexico	La Malinche National Park	Amphibia, Reptilia
Araújo et al. 2020	Brazil	The Sete Cidades National Park	Anuran
Bum et al. 2020	South Korea	Taebaeksan Mountain National Park	Bryophyta
Dippenaar-Schoeman et al. 2020	South Africa	Addo Elephant National Park	Araneae
Egorov et al. 2020	Russia	Mordovia State Nature Reserve	Coleoptera

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Fang et al. 2020	China	Nanling National Nature Reserve	Phytoseiidae
Hakim et al. 2020	Bangladesh	Lawachara National Park	Amphibia, Reptilia
Ijaz et al. 2020	Pakistan	Musk Deer National Park	Fungi
Iturriaga et al. 2020	Cuba	National Park Desembarco del Granma	Aves, Amphibia, Reptilia,
Kalinina et al. 2020	Russia	Polistovskiy State Nature Reserve	Basidiomycota
Kisekelwa et al. 2020	Democratic Republic of the Congo	Kahuzi-Biega National Park	Gnathostomata
Lewis 2020	Canada	Frontenac Provincial Park	Fungi
Longo et al. 2020	Italy	Ustica Island Marine Protected Area	Porifera
Marcano and Castillo 2020	Venezuela	General Juan Pablo Penaloza and Páramos Batallón y La Negra National Parks	Fungi
Taylor and Albuquerque-Lima 2020	Brazil	Catimbau National Park	Cactaceae
Tham et al. 2020	Vietnam	Cham Chu and Bac Me Nature Reserves	Mammalia
Araujo and Pinto 2021	Brazil	Mananciais da Serra Protected Area	Odonata
Araújo et al. 2021	Brazil	Caparaó National Park	Tracheophyta
Bum et al. 2021	South Korea	Gayasan Mountain National Park	Bryophyta
De Oliveira et al. 2021	Brazil	Floresta Nacional do Tapajós, APA Alter do Chão and APA Juá	Tracheophyta

Authors	Country	Name of Protected Area	Taxonomic group/s
Espinoza-Amén et al. 2021	Ecuador	Manglares Churute Ecological Reserve, Isla Santay National Recreation Area, Mache-Chindul Ecological Reserve, Islas Corazón y Fragatas Wildlife Reserve, Machalilla National Park, Manglares El Morro Wildlife Reserve, Manglares El Salado Fauna Production Area and Arenillas Ecological Reserve	Tracheophyta, Aves, Mammalia, Reptilia, Amphibia
García-Morales 2021	Mexico	Reserva de la Biosfera Pantanos de Centla	Chiroptera
Gheza et al. 2021	Italy	Majella National Park	Fungi
Hercos et al. 2021	Brazil	Mamiraud Sustainable Development Reserve	Gnathostomata
Kanga et al. 2021	Ivory Coast	Mount Nimba Integrated Nature Reserve	Anura
Meddour and Sahar 2021	Algeria	Djurdjura National Park	Tracheophyta
Polevoi 2021	Russia	Kostomuksha State Nature Reserve	Sciaroidea
Sabino et al. 2021	Brazil	Porto Ferreira State Park	Tracheophyta
Sarker et al. 2021	Bangladesh	Nijhum Dweep National Park	Gnathostomata
Silva et al. 2021	Brazil	Chapada das Mesas National Park	Bryophyta
Turghan et al. 2021	China	Arjin Mountain Nature Reserve	Aves
Zhang et al. 2021	China	Kalamaili Mountain Ungulate Nature Reserve	Sarcophagidae
Amiri et al. 2022	Iran	Zarrin-Kuh Protected Area	Tracheophyta,

Authors	Country	Name of Protected Area	Taxonomic group/s
Boudouresque et al. 2022	France	Port-Cros National Park	Rhodophyta, Tracheophyta, Charophyta, Chlorophyta
Da Silva et al. 2022	Brazil	The Chapada das Mesas National Park	Fabaceae
Dubeux et al. 2022	Brazil	Estacao Ecologica and Area de Protecao Ambiental de Murici	Reptilia
Jocque and Garrison 2022	Honduras	Cusuco National Park	Odonata
Laterza et al. 2022	Italy	Alta Murgia National Park	Pentatomoidea
Ledesma et al. 2022	Spain	Sierra de Guadarrama National Park	Cholevinae
Lobón-Rovira et al. 2022	Angola	Iona National Park	Amphibia, Reptilia
Machado et al. 2022	Brazil	Cagarras Islands Natural Monument	Gnathostomata
Marcusso et al. 2022	Brazil	Augusto Ruschi Biological Reserve	Tracheophyta
Miranda et al. 2022	Brazil	State Park of Itaúnas	Angiospermae
Monteiro et al. 2022	Angola	Quicama National Park	Tracheophyta
Queiroz et al. 2022	Brazil	Protecao Ambiental do Rio Pandeiros	Formicidae
Renner and Day 2022	United States	Lake Mead National Recreation Area	Haptophyta, Angiospermae, Amphibia, Bivaliva, Osteichthyes, Reptilia
Santos et al. 2022	Brazil	Serra dos Orgaos National Park	Trichoptera

Authors	Country	Name of Protected Area	Taxonomic group/s
Silva et al. 2022	Brazil	Sempre Vivas National Park	Lepidoptera
Singh et al. 2022	India	Great Himalayan National Park	Lepidoptera
Trovó and Echternacht 2022	Brazil	Chapada dos Veadeiros National Park	Eriocaulaceae
Varona-Álvarez 2022	Cuba	Alejandro de Humboldt National Park	Rhopalocera
Walters et al. 2022	Gabon	Parc National des Plateaux Bateke	Tracheophyta
Winfield et al. 2022	Mexico	Protected Area Tuxpan-Lobos	Amphipoda
Yaqoob et al. 2022	India	Dachigam National Park	Tracheophyta
Zhang et al. 2022	China	Nature Reserves in Qinling-Daba Mountains (see Zhang et al. 2022)	Tracheophyta
Abwe et al. 2023	Democratic Republic of the Congo	Kundelungu National Park	Gnathostomata
Arabuli et al. 2023	United States	Machakhela National Park	Oribatid mites
Bell-Doyon 2023	Canada	Mingan Archipelago National Park Reserve	Fungi
Cruz-Elizalde et al. 2023	Mexico	Sierra Gorda de Queretaro Biosphere Reserve	Amphibia, Reptilia
Ferreira et al. 2023	Brazil	Serra do Divisor National Park, Chandless State Park, Humaita Forest Reserve and Chico Mendes Environmental Park	Insecta
Friedrich 2023	Peru	ACP Panguana	Oribatid mites
Islam et al. 2023	India	Overa-Aru wildlife sanctuary	Tracheophyta

Authors	Country	Name of Protected Area	Taxonomic group/s
Karin et al. 2023	Indonesia	Gunung Dako Nature Reserve	Amphibia, Reptilia
Liu et al. 2023	China	Dabie Mountains	Basidiomycota
Manda et al. 2023	Democratic Republic of Congo	Upemba National Park	Actinopterygii
Marques et al. 2023	Brazil	Serra das Confusões National Park	Amphibia, Reptilia
Martínez-Servín et al. 2023	Mexico	Puerto Morelos Reef National Park	Actinopterygii
Rodrigues and Moreira 2023	Brazil	Aiuaba Ecological Station, Chapada Diamantina National Park, Catimbau National Park and Serra das Confusões National Park	Hemiptera
Schwarz et al. 2023	Ivory Coast	Comoé National Park	Mantodea
Sheik and Weeks 2023	United States	Shenandoah River State Park	Tracheophyta
Winfield et al. 2023	Mexico	Coral Reef Puerto Morelos National Park and Coral Reef Sian Ka'an Biosphere Reserve	Amphipoda
De León-Pesqueira et al. 2024*	Mexico	Médanos de Samalayuca Natural Protected Area	Tracheophyta

*published online in 2023. Included in 2023 data for the study.

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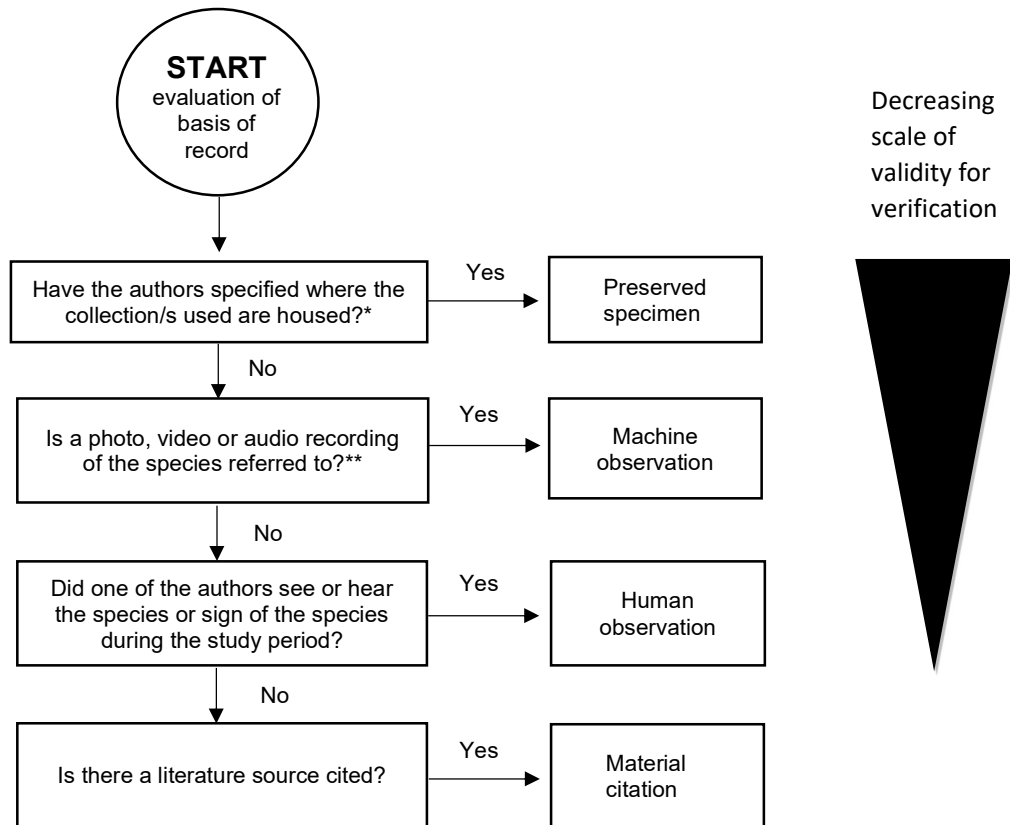
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Appendix S3. Decision tree for allocating basis of record for 210 peer-reviewed articles.



* If museum or herbarium codes and/or collection codes were provided for specimens that were previously collected then basis of record was also used.

** Audio recording was only considered to have taken place if the device for recording was mentioned, or it was very clear that audio was taped. i.e. there was no ambiguity that recording calls referred noting calls that were heard.

Appendix S4. List of Global Biodiversity Information Facility (GBIF) checklist datasets that were evaluated. Arranged alphabetically by country, then protected area, then taxonomic groups.

* The alien species lists mentioned many groups, not all of which were included on the lists.

Country	Name of Protected Area	Taxonomic Group/s
Algeria	Djurdjura National Park	Arachnida
Algeria	Théniet El Had National Park	Arachnida
Angola	Iona National Park and Namibe Regional Natural Park	Amphibia, Reptilia
Angola	Quiçama National Park	Tracheophyta
Argentina	Iguazú National Park	Insecta
Argentina	Los Cardones National Park	Mammalia
Belarus	Belovezhskaya pushcha National Park	Insecta
Belarus	Berezinsky Biosphere Reserve	Insecta
Bhutan	Toorsa Strict Nature Reserve	Tracheophyta
Brazil	Catimbau National Park	Insecta
Brazil	Chapada dos Veadeiros National Park	Tracheophyta
Brazil	Guartelá State Park	Insecta
Brazil	Iguaçu National Park	Insecta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Itacolomi State Park	Tracheophyta
Brazil	Rio Doce State Park	Insecta
Brazil	Serra do Intendente State Park	Insecta
Brazil	Ubajara (Ceará State) and Sete Cidades (Piauí State) National Parks	Insecta
Brazil and Argentina	Iguaçu and Iguazú National Parks	Tracheophyta
Brunei	Ulu Temburong National Park	Insecta

Country	Name of Protected Area	Taxonomic Group/s
Cambodia	Keo Seima Wildlife Sanctuary	Tracheophyta, Ascomycota, Basidiomycota, Actinopterygii, Amphibia, Aves, Insecta, Mammalia, Reptilia
Cambodia	Phnom Tbaeng Natural Heritage Park	Tracheophyta, Aves, Mammalia
Canada	Judith River Formation of dinosaur Provincial Park	Therapoda
Canada	Tursujuq National Park	Ochrophyta
Central African Republic	Protected Areas of Central African Republic	Insecta
Central African Republic, Cameroon and Congo-Brazzaville	Sangha Trinational Protected Area	Insecta
China	Damingshan National Natural Reserve	Arachnida
China	Gaoligongshan National Nature Reserve	Tracheophyta
China	Hailuogou Glacier Area	Insecta
China	Huanglong National Nature Reserve	Insecta
China	Jinggang Mountain National Nature Reserve	Arachnida
China	Jinggang Mountain National Nature Reserve	Arachnida
China	Jinggangshan National Nature Reserve	Arachnida
China	Nanling Priority Area for Biodiversity Conservation	Insecta
China	Wulipo National Nature Reserve	Arachnida
China	Wuyi Mountain National Nature Reserve	Insecta
China	Yintiaoling National Natural Reserve	Diplopoda
Colombia	Protected Areas in Colombia	Arachnida
Colombia	Protected Areas in Colombia	Insecta
Colombia	Seaflower Biosphere Reserve	Actinopterygii, Chondrichthyes

Country	Name of Protected Area	Taxonomic Group/s
Colombia	Seaflower Biosphere Reserve	Asteroidea, Crinoidea, Echinoidea, Holothuroidea, Ophiuroidea
Croatia	Plitvice Lakes National Park	Insecta
Ecuador	Jardín de los Sueños Reserve	Aves
Eswatini	Hawane Nature Reserve and Dam	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Eswatini	Malalotja Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Eswatini	Matenga Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Eswatini	Mlawula Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Ethiopia	Kafa Biosphere Reserve, Bale Mountains National Park and other areas of conservation interest	Insecta
Gabon	Monts Birougou National Park	Insecta
Gabon	Moukalaba National Park	Insecta
Ghana	Atewa Range Forest Reserve	Basidiomycota
Ghana	Atewa Range Forest Reserve	Insecta
Ghana	Atewa Range Forest Reserve	Tracheophyta
Ghana	Bia Conservation Area	Basidiomycota
Ghana	Bia North Tributaries Forest Reserve	Tracheophyta
Ghana	Bonsa River Forest Reserve	Tracheophyta
Ghana	Forest Reserves in Ghana	Tracheophyta
Ghana	Mole National Park	Mammalia, Reptilia
Honduras	Cusuco National Park	Insecta
India	Dumna Nature Park	Insecta
India	Kangchendzonga Biosphere Reserve	Tracheophyta
India	Kaziranga National Park	Enoplea
India	Mahananda Wildlife Sanctuary	Tracheophyta
India	Namdapha National Park and Tiger Reserve	Arachnida
India	National Wildlife Refuges in Southern Indiana	Insecta, Astacidea, Fish
India	Neora Valley National Park	Insecta
India	Neora Valley National Park	Tracheophyta
India	Senchal Wildlife Sanctuary	Tracheophyta

Country	Name of Protected Area	Taxonomic Group/s
India	Silent Valley National Park	Nematoda
India	Singhalila National Park	Tracheophyta
Indonesia	Lake Kalimpa'ai Lore Lindu National Park	Amphibia
Indonesia	Sebangau National Park	Mammalia
Italy	Alta Murgia National Park	Insecta
Italy	Foreste Casentinesi, Monte Falterona e Campigna National Park	Insecta
Italy	Marine Protected Area Isole Ciclopi	Chlorophyta, Rhodophyta
Italy	Marittime Nature Park	Mammalia
Italy	Monviso Natural Park	Insecta
Italy	Protected Area of Rome	Arachnida
Italy	Val Grande National Park	Insecta
Italy	Foreste Casentinesi National Park	Mammalia
Ivory Coast	Comoé National Park	Insecta
Kazakhstan	Ulytau State National Natural Park	Tracheophyta
Kazakhstan	State National Natural Park Buiratau	Tracheophyta
Kenya	A Rocha Dakatcha Nature Reserve	Insecta
Kenya	A Rocha Dakatcha Nature Reserve	Mammalia
Kenya	A Rocha Dakatcha Nature Reserve	Tracheophyta
Kenya	A Rocha Dakatcha Nature Reserve and its Surrounding Area	Aves
Kenya	Sibiloi National Park	Amphibia, Reptilia
Madagascar	Montagne d'Ambre National Park	Arachnida
Malaysian Borneo	Tawau Hills Park	Aves
Mexico	Barranca del Cupatitzio National Park	Insecta
Mexico	White Sands National Monument	Insecta
Mozambique	Bazaruto National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Mozambique	Bazaruto National Park	Insecta
Nepal	Api Nampa Conservation Area	Tracheophyta, Aves, Insecta
Nepal	Kangchenjunga Conservation Area	Tracheophyta
Niue	Huvalu Conservation Area	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Pakistan	Margalla Hills National Park	Actinopterygii, Amphibia, Aves, Mammalia, Reptilia
Panama	Coiba National Park	Arachnida
Panama	Panama's National Parks	Insecta
Poland	Ojców National Park	Insecta
Poland	Świętokrzyski National Park	Insecta
Russia	Kaluzhskie Zaseki Nature Reserve	Insecta
Russia	Kondinskie lakes Natural Park	Aves, Mammalia, Actinopterygii, Amphibia, Reptilia
Russia	Kondinskie lakes Natural Park	Bryophyta

Country	Name of Protected Area	Taxonomic Group/s
Russia	Kondinskie lakes Natural Park	Fungi
Russia	Kondinskie lakes Natural Park	Tracheophyta
Russia	Kurilsky Nature Reserve	Cyclostomata, Fish, Amphibians, Reptilia, Aves, Mammalia, Invertebrates
Russia	Kurilsky Nature Reserve	Tracheophyta, Bryophyta, Algae, Fungi, Lichen
Russia	Noomto Natural Park	Tracheophyta
Russia	Oleniy Nature Park	Tracheophyta
Russia	Onega Pomorie National Park	Fungi
Russia	Prioksko-Terrasny reserve	Mammalia
Russia	Prioksko-Terrasnyi Biosphere Reserve	Bryophyta
Russia	Prioksko-Terrasnyi Biosphere Reserve	Tracheophyta
Russia	Shorsky National Park	Bryophyta
Russia	Visimsky State Natural Biosphere Reserve	Tracheophyta
Russia	Voronezhsky Biosphere Reserve	Tracheophyta
Russia	Yuganskiy Nature Reserve	Amphibia, Aves, Mammalia, Reptilia
Russia	Yugyd Va National Park	Bryophyta
Saudi Arabia	Rawdhat Khorim National Park	Insecta
Seychelles	Aride Special Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Cousin Special Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Curieuse Special Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Ile-aux-Vaches Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Morne-Seychellois National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Praslin National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Recif Special Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Silhouette National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Seychelles	Vallée de Mai Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Addo-Elephant National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)

Country	Name of Protected Area	Taxonomic Group/s
South Africa	Agulhas National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Augrabies Falls National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Bontebok National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Camdeboo National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Garden Route National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Garden Route National Park	Insecta
South Africa	Golden Gate Highlands National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	iSimangaliso Wetland Park	Chaetnotida
South Africa	iSimangaliso Wetland Park	Porifera
South Africa	Kalahari Gemsbok National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Karoo National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Kruger National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Mapungupwe National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Marakele National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Mokala National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Mountain Zebra National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Namaqua National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Richtersveld National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Table Mountain National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	Tankwa-Karoo National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)

Country	Name of Protected Area	Taxonomic Group/s
South Africa	Verloren Valei Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
South Africa	West Coast National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Spain	El Cachucho Marine Protected Area	Malacostraca
Spain	Mediterranean Natural Parks	Insecta
Spain	Sierra de Guadarrama National Park	Insecta
Spain	Spanish National Parks	Arachnida
Sweden	Sweden	Tracheophyta, Aves, Insecta, Ascomycota, Mammalia, Arachnida
Switzerland	Swiss National Park	Nematoda
Switzerland	Swiss National Park	Nematoda
Taiwan	Mianhua and Huaping Islets Wildlife Refuge	Tracheophyta, Mammalia, Reptilia, Insecta, Aves, Chondrichthyes, Osteichthyes
Taiwan	Taijiang National Park	Mollusca
Tanzania	Amani Forest Nature Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Tanzania	Kimboza Forest Reserve	Insecta
Tanzania	Ngorongoro Biosphere Reserve	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Tanzania	Serengeti National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Thailand	Doi Suthep-Pui National Park	Insecta
Tonga	Protected Areas of Tonga	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Turkey	Dilek Peninsula-Büyük Menderes Delta National Park	Arachnida
Turkey	Kazdağı National Park	Insecta
Uganda	Bukaleba Forest Reserve	Mammalia
Uganda	Igwe-Luvunya Forest Reserve	Tracheophyta
Uganda	Mabira Central Forest Reserve	Mammalia
Uganda	Mpanga Forest Reserve	Mammalia
Uganda	Mpigi Forest Reserve	Mammalia
Uganda	Murchison Falls National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Uganda	Queen Elizabeth National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Uganda	West-Bugwe Forest Reserve	Mammalia
Uganda	West-Bugwe Forest Reserve	Tracheophyta
Uganda	Zika Forest Reserve	Mammalia

Country	Name of Protected Area	Taxonomic Group/s
Ukraine	Dvorichanskyi National Nature Park	Amphibia
Ukraine	Dvorichanskyi National Nature Park	Insecta
Ukraine	Kinburnska Kosa Landscape Park	Tracheophyta
Ukraine	Luhansk Nature Reserve of NASU	Tracheophyta
Ukraine	National Nature Park Kamianska Sich	Tracheophyta
Ukraine	Oleksandrivskyi Landscape Reserve	Tracheophyta
Ukraine	Pyriatynskyi National Nature Park	Actinopterygii
Ukraine	Pyriatynskyi National Nature Park	Zooplankton
Ukraine	Sahy Landscape Reserve	Tracheophyta
Ukraine	Shyroka Balka Botanical Reserve	Tracheophyta
Ukraine	Slobozhanskyi National Nature Park	Amphibia
Ukraine	Slobozhanskyi National Nature Park	Mammalia
Ukraine	Slobozhanskyi National Nature Park	Reptilia
Ukraine	Sofiivskyi Botanical Reserve	Tracheophyta
Ukraine	Stanislavskyi Landscape Reserve	Tracheophyta
Ukraine	Valley of Kurgans Park	Tracheophyta
United States	Mammoth Cave National Park	Chondrichthyes
United States	Sequoia and Kings Canyon National Parks	Diplopoda
United States of America	Carmel Pinnacles Marine Protected Area	Porifera
United States of America	Flower Garden Banks National Marine Sanctuary	Porifera
United States of America	Great Smoky Mountains National Park	Diplopoda
United States of America	Great Smoky Mountains National Park	Insecta
United States of America	Great Smoky Mountains National Park	Insecta
United States of America	Great Smoky Mountains National Park	Insecta
United States of America	Great Smoky Mountains National Park	Insecta, Arachnida
United States of America	Great Smoky Mountains National Park	Tardigrada
Uzbekistan	Chatkal State Biosphere Reserve	Tracheophyta
Vietnam	Bạch Mã National Park	Insecta
Zimbabwe	Chimanimani National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Zimbabwe	Nyanga National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)
Zimbabwe	Protected Areas of Zimbabwe	Arachnida
Zimbabwe	Protected Areas of Zimbabwe	Reptilia
Zimbabwe	Victoria Falls National Park	*Alien species (Animalia, Bacteria, Chromista, Fungi, Plantae, Protozoa, Viruses)

Appendix S5. Proposed guidelines for developing species checklists for protected areas.

During the process of researching checklists and developing checklists for South Africa's national parks, we have developed guidelines for the checklist creation process, which includes collecting occurrence data, assigning accepted names, compiling a checklist from multiple sources and adding additional information to the list. These guidelines are primarily directed at the development of species checklists for protected areas and not necessarily the publication of checklists in journal articles.

The first step is to collate occurrence data from different sources. Once this is done, the occurrence data needs to be put into the same format e.g. columns in the same order in MS Excel, which is commonly used by protected area staff. After this, accepted names should be assigned to each occurrence record. The GBIF species lookup tool can be useful for this step. However, checks need to be made that matching is accurate and at the correct taxonomic level, as the GBIF species name matching tool sometimes matches to higher taxonomic ranks. A checklist can then be created for the accepted names and their associated synonyms for which there is occurrence data and/or a record of the sources used to include each taxon. This list should be checked for inaccurate names that could be the result of misidentification e.g., in iNaturalist. A more comprehensive approach would be to validate all the occurrence records before creating the final checklist, but protected area staff don't always have capacity to do this. Including the information source for listed species is critical for users to judge the information accuracy of checklists. For example, a species merely being listed on a previous checklist without an indication of the sources used to develop that checklist does not provide confidence that the species is present, whereas verifiable specimen collections or direct observations across multiple sources provide a more reliable indication of occurrence. As such, tracking all the sources that identify a particular species in a particular area is an important step in the validation of checklists. Once the final list of names has been created, additional information can be included, such as IUCN Red List status, level of endemism and year of most recent record. Such data is useful for prioritising monitoring and decision making. A database of relevant information for species can be kept so that it is easy to associate it with names in a checklist using R or functions in MS Excel, which is commonly used by protected area staff.

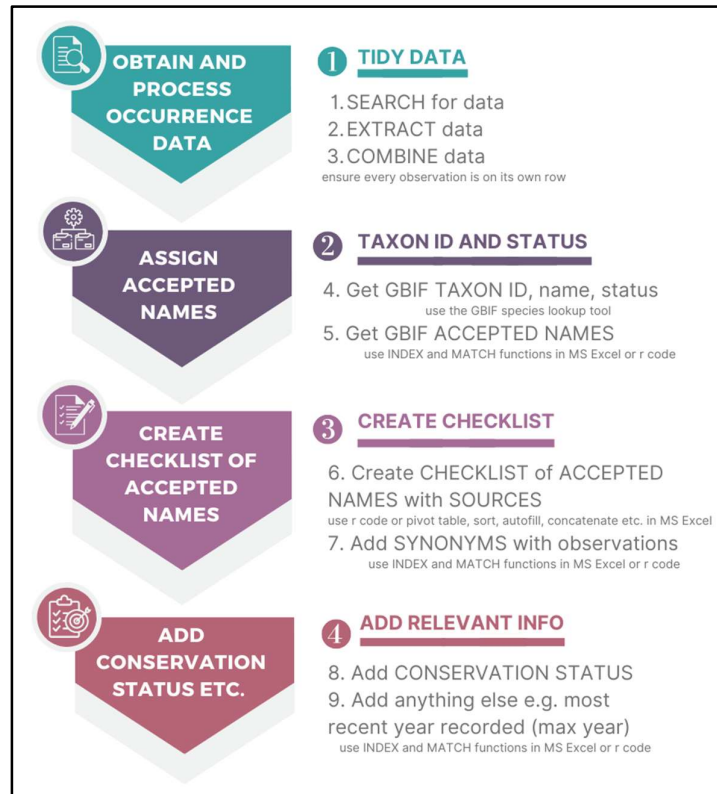
1. Creating checklists

A consistent and standardised approach should be used for the compilation of species checklists. One vital aspect is choosing and specifying the taxonomic backbone that is being used.

The proposed checklist creation process

The checklist creation process has four main steps:

1. Occurrence record data needs to be obtained from all available sources and put into the same format.
2. Accepted names need to be assigned to all occurrence records following a particular taxonomic backbone. One way of doing this is by using the accepted name from GBIF. However, other relevant taxonomic backbones can also be used.
3. A checklist needs to be made of accepted names and their associated synonyms for which there is occurrence data.
4. Additional information can be included, such as IUCN Red List status and year of most recent record.



The first step in creating a species checklist is to obtain occurrence record data from all available sources. These sources include but are not limited to the following:

- ▶ Protected area checklists from park staff and ecologists
- ▶ Research projects conducted by researchers from universities
- ▶ Scientific publications and reports
- ▶ Protected area management plans, lower-level plans, state of knowledge reports
- ▶ Protected area herbarium and museum data
- ▶ Survey data using different approaches, such as seine nets and Sherman traps
- ▶ Mammal census data, including aerial and road counts

- ▶ BRUV (Baited Remote Underwater Video) data
- ▶ Camera trap data
- ▶ Monitoring data
- ▶ Data in national databases
- ▶ Data on protected area staff computers
- ▶ Existing protected area databases
- ▶ GBIF (Global Biodiversity Information Facility)
- ▶ iNaturalist, including park lists without coordinates
- ▶ Park staff and taxon experts
- ▶ Ranger patrol data (e.g. CyberTracker, EarthRanger and Spatial Monitoring and Reporting Tool)

The second step of the checklist creation process involves assigning accepted names to all observation records while retaining the verbatim name. Accepted names from a standardised, recognised taxonomic backbone need to be used for names in your checklist. The verbatim names that are reported in sources are not necessarily the names that appear in the checklist. However, synonyms can be included with accepted names. It is important to note that some sources do not record the appropriate name. e.g. some records in iNaturalist may record the wrong name. For example, there may only be a particular subspecies that is found in a park, but some records are at the species level. The final list will just include the subspecies name with the assumption that the observation records for the taxon are the subspecies and the recorded e.g. user of iNaturalist was not aware of this.

The third step of the process is creating a list that only includes the appropriate accepted names, i.e. accepted names from a particular taxonomic backbone, such as GBIF, that have been checked to retain the appropriate names and exclude names that have been recorded in error. For example, iNaturalist users may have selected the name of a monkey or antelope that does not occur in the country or selected a species name when it is a subspecies that is known to occur in a protected area.

The final step of the process is to append relevant information, such as Red List status and CITES listing. Species occurrence status information, such as whether a species is endemic, often needs to be compiled from relevant literature.

2.1 Collating occurrence data

The first step of collating relevant occurrence data requires conducting literature searches and obtaining data from other protected area staff members.

2.1.1 Getting data from GBIF¹

GBIF data can be downloaded for Protected Areas from the GBIF website by specifying the most southerly, northerly, easterly and westerly coordinates of a bounding box that is larger than the park (also see Supplementary material of Spear et al. 2023¹). Park boundary polygons can then be used to determine which points are in a protected area using the intersection function in QGIS. Data can also be downloaded from GBIF using the R package `rgbif` (see <https://cran.rproject.org/web/packages/rgbif/index.html>) and using GBIF's API (see <https://www.gbif.org/developer/occurrence>). Also see <https://data-blog.gbif.org/post/downloading-longspecies-lists-on-gbif/> for guidelines on how to download GBIF occurrence data using R and Python. Additionally, there is a [GBIF occurrences plugin](#) for QGIS. To use the plugin, Open QGIS and click Plugins > Manage and install plugins > Type GBIF into the search bar and select and install the GBIF occurrences plugin. Click Vector > GBIF occurrences.

¹ Spear, D., van Wilgen, N.J., Rebelo, A.G., & Botha, J.M. 2023. Collating biodiversity occurrence data for conservation. *Frontiers in Ecology and Evolution*, 11, 1037282.

Collate tidy occurrence data



Find publications, protected area management plans, checklists from park staff or ecologists, monitoring, census & survey data, incl. BRUV and camera traps, birder checklists, data from partners/researchers, protected area databases, herbarium data, online databases, and GBIF.



- Extract data from different sources into MS Excel.
- Use verbatim name as per source.
- Add field with source name. Use dataset name for GBIF.
- Add protected area name.



- For each set of raw data, make a version with columns in the same order including verbatim name and source.
- Select, copy and paste each set of data into the same spreadsheet with verbatim name and source.
- Ensure Tidy Data: every observation in its own row.



- There is a QGIS plug-in and other guidelines for downloading GBIF data for parks.
- Use the table of dataset keys and names or follow guidelines to find these on GBIF.
- Use Ctrl+G and Ctrl+Shift+arrows to select data.

Data that are downloaded from GBIF include a dataset key, but they often don't include relevant detail about the dataset. The name of the dataset that each observation record originated from can be obtained using the dataset key. A table of dataset keys and dataset names has been compiled to easily allocate the dataset names using INDEX and MATCH functions in MS Excel.

What is Tidy Data?

Each row is one observation. • Each column is a variable. • Each cell is a single value.

2.1.2 Getting data from pdfs

Data copied from pdfs does not always copy to MS Excel in the format that is needed. Sometimes the data in each row will paste as one sentence and not in different columns. There are a few different tools in MS Excel that can be used to help with getting the data into the required columns. Text to columns sometimes works. Before using text to columns, copy and paste the column of text to a new

column and then use the copy for editing using different approaches. Something that can be useful to use in association with [text to columns](#) is replacing a particular recurring text string that separates different variables with a character, such as \$. This character can then be used to separate the text into different columns using [text to columns](#). A very useful tool to try is [Flash Fill](#). Flash Fill will automatically fill in data if it can pick up a pattern. You will need to check that the data has been filled correctly. You may need to change some of the data and redo the Flash Fill or make sure that you have covered enough examples for the Flash Fill to automatically fill in the relevant data in the relevant columns. You might be able to use Flash Fill for some of the data but not all of it. Also, bear in mind that you don't need to extract all the information from a table in a pdf. It might be sufficient to extract just the names or the names and one or two other columns. Information such as Red List status can be obtained later in the process using up to date data. Another tool that can sometimes be useful for extracting data from a text string is using a combination of the IF and FIND functions or other similar functions to return particular text if particular text is found in the text string. For example, if you have a column where you want to pull out the terms endemic, alien and indigenous and extralimital, then you could use a formula like:

```
B1=IFERROR(IF(FIND("alien",A1)>0,"alien"),IFERROR(IF(FIND("endemic",A1)>0,"endemic"),IFERROR(IF(FIND("indigenous",A1)>0,"indigenous"),IF(FIND("extralimital",A1)>0,"extralimital")))))
```

Pdfs of scanned papers and reports are problematic as their contents cannot be copied and pasted. There are online tools that can be used to convert pdf images to text using optical character recognition (OCR). These can be found by searching "convert pdf image to text".

2.1.3 Standardising data fields and formats

A standardised approach for collating data needs to be used. You can create MS Excel spreadsheets for the data that has been copied from pdfs including all fields in the order they were in the source. Then, you can create MS Excel spreadsheets where you have the information in a specific order. For example, your first four columns might be Source detail, Source type, National Park, Verbatim name. If you create a different spreadsheet for each source, then create a spreadsheet that has the data in the same order in different spreadsheets for different sources, as all data sources will need to be combined.

2.2 Assign accepted names

After all relevant occurrence data are collated, accepted names need to be assigned by matching verbatim names with a relevant taxonomic backbone. It is very important to keep a record of the verbatim names from the different sources. The accepted name is allocated in a separate column. First, create a list of names that can be uploaded to GBIF to match with GBIF names and return GBIF taxon keys, names, taxonomic status. A csv file is required with a column of scientific names with the heading scientificName and ideally a kingdom column with the kingdom specified. Guidelines are provided on the webpage of the [species look up](#) tool. Although GBIF may not be the final taxonomic backbone that you use for your species checklist, the GBIF species lookup tool is useful in picking up some typos. After obtaining GBIF names and taxon keys they can be used for matching with other taxonomic backbones, such as the South African National Plant Checklist. Names from the World Register of Marine Species (WoRMS) are often used for standardising the names of marine species. WoRMS is incorporated into the GBIF taxonomic backbone along with the Catalogue of Life Checklist and the World Checklist of Vascular Plants.

Two useful approaches to matching names include having a 'friendly' version of the scientific name for your verbatim names and the list of names that you are trying to match to. i.e. scientific name without authors and the second useful tool is to use INDEX and MATCH functions in MS Excel (see Supplementary Material of Spear et al. 2023²). I have also created a version of the SANPC that is matched to GBIF. i.e. matching can be done using the GBIF taxon key. However, you need to check whether matching is at the same level. i.e. whether GBIF has matched a subspecies at the species level. The best way to match to the SANPC is using name without authors. This can also be obtained using TNRS.

² Spear, D., van Wilgen, N.J., Rebelo, A.G., & Botha, J.M. 2023. Collating biodiversity occurrence data for conservation. *Frontiers in Ecology and Evolution*, 11, 1037282.

Assign accepted names



- For plants, copy list of names into the TNRS to get scientific name without authors to use for name matching.
- Alternatively, use the GBIF species lookup tool to get canonical name or create own name without authors.



- Create a csv file with names and heading scientificName.
- Upload the csv file to the GBIF Species Matching Tool to get GBIF scientific names.
- Open the matched file using Data -> From Text/CSV in an MS Excel sheet and check for matches at higher rank.



- For plants, Use INDEX-MATCH function to bring in accepted names and taxon status from taxonomic backbone using the taxon key as unique identifier across sheets OR use an R-Script
- If taxon status says SYNONYM, add that name into a synonyms column.



- Ensure correct format of CSV file for GBIF to match correctly using the GBIF Species Lookup Tool

Tips

2.3 Create a checklist with sources

Ideally, before creating a checklist, the validity of all the data records should be checked. As this often isn't possible because of time constraints, providing a record of the source of occurrence records provides an indication of the reliability and likelihood of an occurrence being accurate. A list of all of the data sources for each accepted name can be created by using the r code that has been developed or by creating a pivot table of accepted species names and sources. To create a pivot table, you can add a column of 1s to use for in the pivot table or use another third column. It is also important to have a record of the verbatim names that have been used in sources and list them as synonyms. This enables tracking of the origin of names on the list. Remember to check the final list of names for errors and correct these. If there is only a subspecies in the park, use the subspecies name only and not the species name. If an iNaturalist user used a name for something elsewhere, change to the correct name.

Create Checklist



PIVOT

Use R code or

- Create a Pivot table of accepted names and sources.
- Sort by sources and copy down source names where values.
- Concatenate using **=CONCATENATE(SOURCE1,"",S2)**
- Use TRIM and FIND and REPLACE to remove extra commas.



FILTER

- Filter taxonomic status for synonyms and create a sheet with synonyms (verbatim name) and accepted names.
- Remove duplicate synonyms (verbatim names).
- There will be some repeated Accepted names.



ADD SYN

- Match synonyms to pivoted checklist using accepted names.
- Check for multiple synonyms to be added. i.e. where accepted name repeated in list of synonyms.
- To save space in final list, you can concatenate synonyms and accepted names column with = as a separator.



Tips

- R code can be used for this step.
- Abbreviate source names to save space in the final checklist.
- Check the final list of names for errors. iNat users sometimes get names wrong.

Once the pivot table has been created, sort by each source and copy down the source name for wherever there is a value (record for the source). You can double click in the corner of the cell to copy down the source name to everywhere there is a number. Check that this has happened correctly. Then, use the CONCATENATE function to concatenate sources, e.g. `CONCATENATE(A2,"",B2,"",C2)`. Remove additional commas and spaces using TRIM, SORT, FIND and REPLACE functions. To add synonyms to your list of accepted names, you can take the names that are synonyms into a sheet and do a lookup (INDEX+MATCH) against the accepted name to pull through synonyms. To create the list of synonyms, you can sort the full list of names by the taxonomic status column. For plants, use the SANPC taxonomic status. Copy across the verbatim name (or another column of synonyms with the corrected version of verbatim name e.g. full name in SANPC or on GBIF for verbatim name) and accepted name columns for synonyms. Remove duplicate verbatim names from the list of synonyms and remember to check for multiple synonyms. You can sort by the accepted name column and use the formula `=B3=B2` to find repeated accepted names. Check that the names used as synonyms are

spelt correctly etc. CONCATENATE can be used to combine the accepted names and synonyms into the final checklist to save space. Ideally, checklist names should be checked by someone who knows what is in the park.

R code can be used to conduct this process quickly, consistently and with fewer errors.

An example of R code used to create a checklist for a protected area

```
#load your libraries
library(tidyverse)
library(readxl)
library(dplyr)
library(tidyr)
library(knitr)
library(kableExtra)

#remove NAs from synonym column without removing whole row
PA_clean <- PA %>%
  mutate(synonyms = replace_na(synonyms, ""))

# Combine species name and synonyms
PA_syn <- PA_clean %>%
  group_by(acc_name) %>% #pivots on the accepted name column
  mutate(synonyms = ifelse(any(synonyms != ""),
    paste(acc_name, "=", paste(synonyms, collapse = " ")),
    acc_name))

kable(PA_syn, "html") %>%
  kable_styling()

# Pivot to get unique sources
result <- PA_syn %>%
  distinct(acc_name, Source, .keep_all = TRUE) %>%
  group_by(acc_name) %>%
  summarise(
    synonyms = first(synonyms),
    Sources = paste(unique(Source), collapse = ", "),
    TaxonKey = first(gbif_taxon_key)
  )
)
```

2.4 Add conservation status and other relevant information

Any information that you want to include in your checklist can be added using the INDEX and MATCH functions. Recommended annotations for checklists include IUCN Red List status, CITES, occurrence status, and most recent year recorded. To save space in the final word version of the checklist, the CONCATENATE function can be used to list different conservation statuses in the same column. Remember to add full descriptions of any abbreviations used. A database has been created for plants and animals that includes IUCN Red List, CITES, sensitive species and other relevant information.

Example extract of a plant checklist for a protected area

Scientific Name	Source	Occurrence Status	Threat Status
<i>Abutilon sonneratianum</i> (Cav.) Sweet	iNat, KSAN, Palmer 1989	indig	LC
<i>Adromischus sphenophyllus</i> C.A.Sm.	iNat	indig; end	LC
<i>Adromischus triflorus</i> (L.f.) A.Berger	KSAN, Palmer 1989		LC, Sensitive
<i>Agave sisalana</i> Perrine	Masubelele et al. 2009	notindig; nat	NE
<i>Aizoon rigidum</i> L.f. = <i>Aizoon rigidum</i> L.f. var. <i>angustifolium</i> Sond.	KSAN, Palmer 1989	indig	LC
<i>Aloe ferox</i> Mill.	iNat, KSAN, Obs.org, Palmer 1989	indig	LC, CITES II

Source descriptions:

KSAN: Kimberley South African National Parks Herbarium; iNat: iNaturalist; Obs.org: Observation.org

Masubelele, M.L., Foxcroft, L.C. & Milton, S.J., 2009, 'Alien plant species list and distribution for Camdeboo National Park, Eastern Cape Province, South Africa', *Koedoe: African Protected Area Conservation and Science* 51(1), 80–89.

Palmer, A.R., 1989, 'The vegetation of the Karoo Nature Reserve, Cape Province. 1. A phytosociological reconnaissance', *South African Journal of Botany* 55(2), 215–230.

Occurrence status:

end: endemic to the province; indig: indigenous; notindig: not indigenous; nat: naturalized

Threat status descriptions:

South African Red List status: LC - Least Concern; NE – Not Evaluated

CITES Supporting Information II includes species that are not currently threatened with extinction but may become so without trade controls.