

Supplementary material for

Overlooked and undervalued: the neglected role of fauna and a global bias in ecological restoration assessments

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Fig. S1. PRISMA 2009 flow diagram

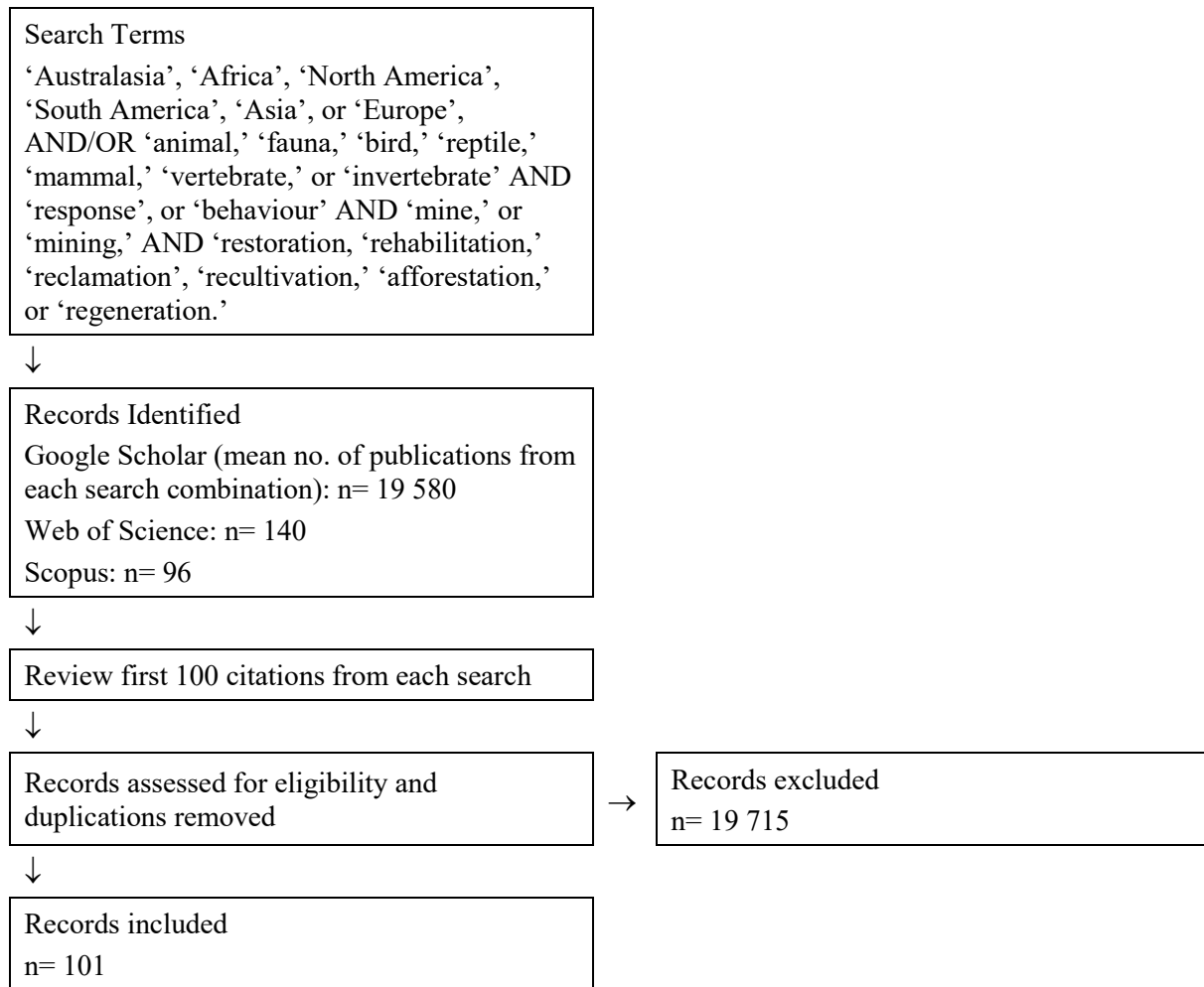
Fig. S2. Countries ranked by (a) publication output of fauna responses to mine site restoration studies, (b) mineral production output (metric tons; Reichl et al. 2014), and (c) megadiversity ranking (Médail and Quézel 1999).

Table S1. Summary of the 101 publications used in this review.

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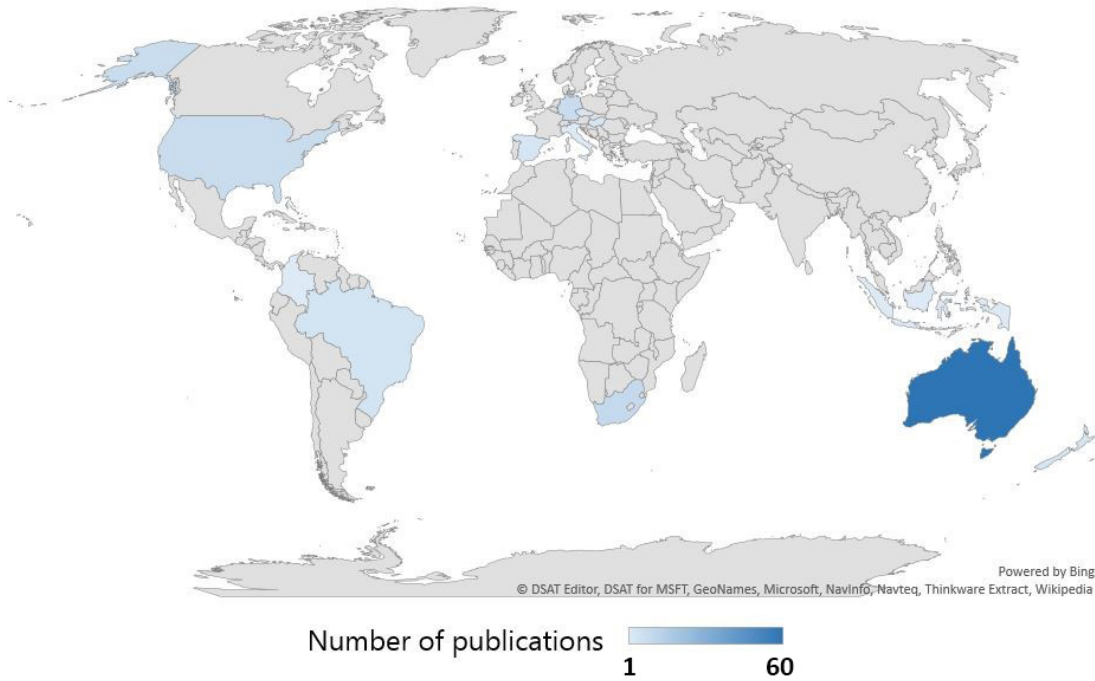
Fig. S1: PRISMA 2009 flow diagram (Moher et al. 2009).



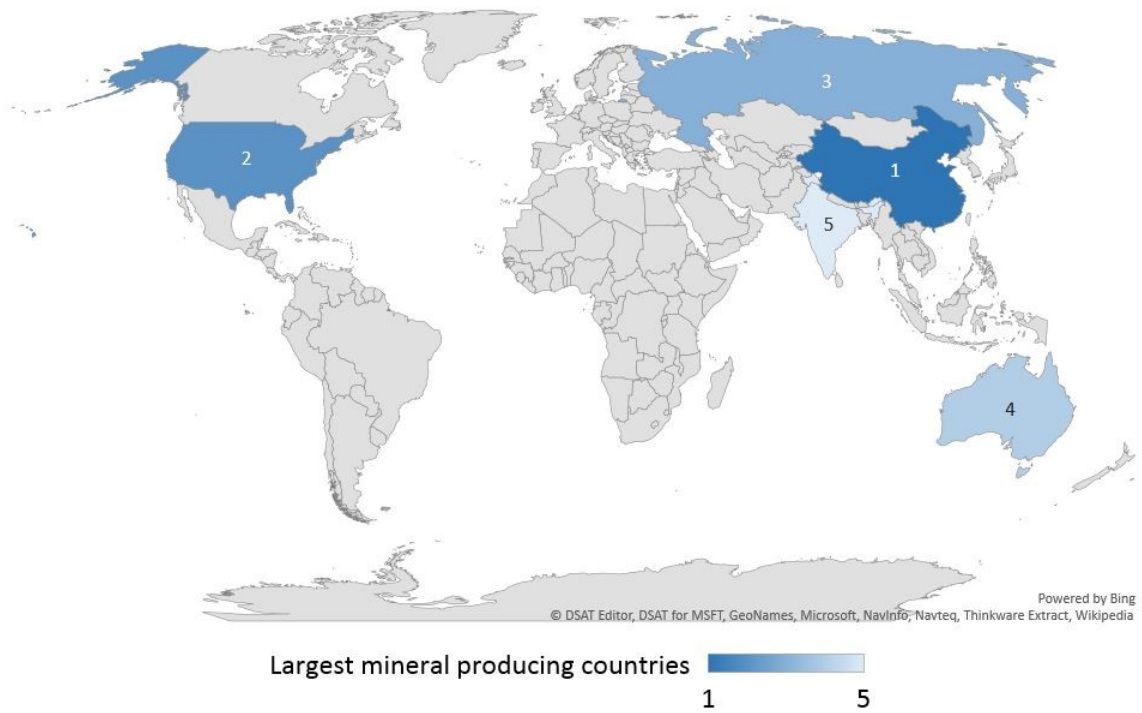
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of Internal Medicine* 151, 264-269.

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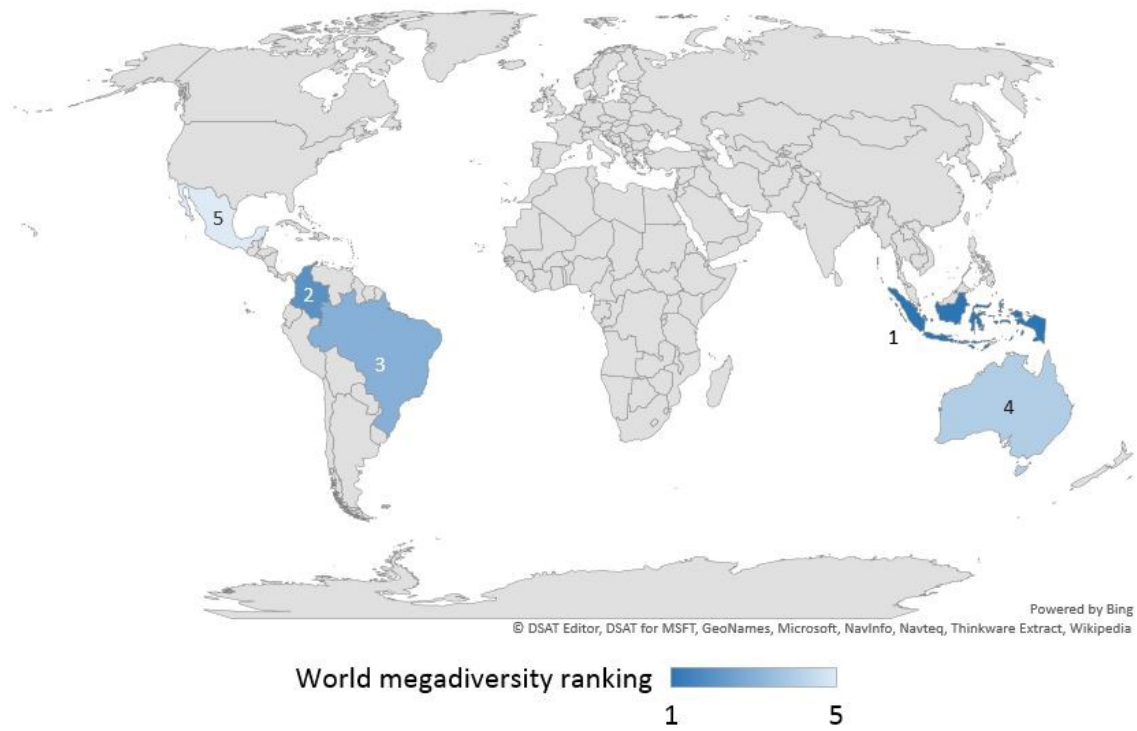
a)



b)



c)



Médail, F., and Quézel, P. (1999). Biodiversity hotspots in the Mediterranean Basin: setting global conservation priorities. *Conservation Biology* **13**, 1510-1513.

Table S1: Summary of the 101 publications used in this review.

Authors	Date	Continent	Group	Target	Mineral
Andersen	1993	Australasia	Invertebrate	Formicidae	Uranium
Andersen and Sparling	1997	Australasia	Invertebrate	Formicidae	Uranium
Andersen et al.	2003	Australasia	Invertebrate	Formicidae	Coal
Andres and Mateos	2006	Europe	Invertebrate	Multiple	Limestone
Armstrong and Nichols	2000	Australasia	Vertebrate	Multiple	Bauxite
Becker et al.	2013	America	Vertebrate	Multiple	Not stated
Bisevac and Majer	1999a	Australasia	Invertebrate	Formicidae	Sand
Bisevac and Majer	1999b	Australasia	Invertebrate	Multiple	Sand
Brady and Noske	2010	Australasia	Vertebrate	Multiple	Bauxite
Brandle et al.	2000	Europe	Invertebrate	Coleoptera	Coal
Bulluck and Buehler	2006	America	Vertebrate	Multiple	Coal
Burgar et al.	2017	Australasia	Vertebrate	<i>Chiroptera</i>	Bauxite
Comer and Wooller	2002	Australasia	Vertebrate	Multiple	Sand
Craig et al.	2007	Australasia	Vertebrate	<i>Pogona minor</i>	Bauxite
Craig et al.	2010	Australasia	Vertebrate	Multiple	Bauxite
Craig et al.	2011	Australasia	Vertebrate	<i>napoleonis</i>	Bauxite
Craig et al.	2014	Australasia	Vertebrate	Multiple	Bauxite
Craig et al.	2015	Australasia	Vertebrate	Multiple	Bauxite
Cristescu et al.	2013	Australasia	Vertebrate	<i>Phascolarctos cinereus</i>	Sand
Cuccovia	1999	Australasia	Invertebrate	Acarine	Bauxite
Curry and Nichols	1985	Australasia	Vertebrate	Multiple	Bauxite
Cusser and Goodell	2013	America	Invertebrate	Multiple	Coal
Davis et al.	2003	Africa	Invertebrate	Coleoptera	Sand
Davis et al.	2013	Africa	Invertebrate	Coleoptera	Not stated
Doherty et al.	2016	Australasia	Vertebrate	<i>Calyptrorhynchus</i> sp.	Bauxite
Dominguez-Haydar and Armbrecht	2011	America	Invertebrate	Formicidae	Coal
Dunger et al.	2001	Europe	Invertebrate	Multiple	Coal
Dunger et al.	2004	Europe	Invertebrate	Collembola	Coal
Ferreira and Van Aarde	1996	Africa	Vertebrate	Multiple	Not stated
Fox and Fox	1978	Australasia	Vertebrate	Multiple	Sand
Fox and Fox	1984	Australasia	Vertebrate	Multiple	Sand
Fox and Twigg	1991	Australasia	Vertebrate	Mice	Sand
Frick et al.	2014	Australasia	Vertebrate	Multiple	Sand
Galan	1997	Europe	Vertebrate	Multiple	Coal
Gould	2011	Australasia	Vertebrate	Multiple	Bauxite
Gould and Mackey	2015	Australasia	Vertebrate	Multiple	Bauxite
Greenslade and Majer	1980	Australasia	Invertebrate	Collembola	Bauxite
Greenslade and Majer	1993	Australasia	Invertebrate	Collembola	Bauxite
Hamilton and Vimmerstedt	1981	America	Invertebrate	Annelida	Not stated
Hendrychová et al.	2012	Europe	Invertebrate	Multiple	Coal
Hill and Phinn	1993	Australasia	Vertebrate	Swamp Wallabies	Sand
Holl	1995	America	Invertebrate	Lepidopteran	Coal

		North			
Holl	1996	America	Invertebrate	Lepidopteran	Coal
Jackson and Fox	1996	Australasia	Invertebrate	Formicidae	Sand
Kielhorn et al.	1999	Europe	Invertebrate	Coleoptera	Coal
Koch et al.	2010	Australasia	Invertebrate	Multiple	Bauxite
Kumssa et al.	2004	Africa	Invertebrate	Multiple	Multiple
		North			
Lannoo et al.	2009	America	Vertebrate	Multiple <i>Calyptrorhynchus</i>	Coal
Lee et al.	2013	Australasia	Vertebrate	sp.	Multiple
Letnic and Fox	1997a	Australasia	Vertebrate	Multiple	Sand
Letnic and Fox	1997b	Australasia	Vertebrate	Multiple	Sand
Lythe et al.	2017	Australasia	Invertebrate	Multiple	Bauxite
Madden and Fox	1997	Australasia	Invertebrate	Multiple	Sand
Majer	1981	Australasia	Invertebrate	Multiple	Bauxite
Majer	1984a	Australasia	Invertebrate	Formicidae	Bauxite
Majer	1984b	Australasia	Invertebrate	Formicidae	Bauxite
Majer	1985	Australasia	Invertebrate	Formicidae	Sand
		South			
Majer	1996	America	Invertebrate	Formicidae	Bauxite
Majer and Nichols	1998	Australasia	Invertebrate	Formicidae	Bauxite
Majer et al.	1982	Australasia	Invertebrate	Formicidae	Sand
Majer et al.	1985	Australasia	Invertebrate	Formicidae	Iron ore
Majer	1989	Australasia	Invertebrate	Multiple	Bauxite
Majer et al.	2013	Australasia	Invertebrate	Formicidae	Bauxite
Mawson	1986	Australasia	Invertebrate	Araneae	Bauxite
Moir et al.	2005	Australasia	Invertebrate	Hemiptera	Bauxite
Nichols and Bamford	1985	Australasia	Vertebrate	Multiple	Bauxite
Nichols and Burrows	1985	Australasia	Invertebrate	Multiple	Bauxite
Nichols and Nichols	2003	Australasia	Both	Multiple	Bauxite
Nichols and Watkins	1984	Australasia	Vertebrate	Multiple	Bauxite
Ottonetti et al.	2006	Europe	Invertebrate	Formicidae	Coal
Passell	2000	Asia	Vertebrate	Multiple	Tin
		North			
Petersen et al.	2016	America	Vertebrate	Sage Grouse	Coal
Pižl	2001	Europe	Invertebrate	Oligochaeta Pheasant, Nightjar,	Coal
				Yellowhammer	Coal
Purger et al.	2004a	Europe	Vertebrate	Quail	Coal
Purger et al.	2004b	Europe	Vertebrate	Multiple	Coal
Purger et al.	2007	Europe	Invertebrate	Multiple	Coal
Redi et al.	2005	Africa	Invertebrate	Diplopoda	Multiple
		South			
Ribas et al.	2012	America	Invertebrate	Formicidae	Gold
Rufaut et al.	2006	Australasia	Invertebrate	Multiple	Coal
Rufaut et al.	2015	Australasia	Invertebrate	Coleoptera	Coal
Seifert and Prosche	2017	Europe	Invertebrate	Formicidae	Not stated
		North			
Sieg et al.	1987	America	Invertebrate	Multiple	Bentonite
Simmonds et al.	1994	Australasia	Invertebrate	Araneae	Bauxite
		North			
Taillefer and Wheeler	2012	America	Invertebrate	Multiple	Peat
Tajovský	2001	Europe	Invertebrate	Multiple	Coal
Taylor and Fox	2001	Australasia	Vertebrate	Multiple	Sand
Thompson and Thompson	2003	Australasia	Vertebrate	<i>Pogona minor</i>	Not stated

Thompson and Thompson	2005	Australasia	Vertebrate	Multiple	Gold
Tizado and Núñez-Pérez	2016	Europe	Invertebrate	Multiple	Coal
Topp et al.	2001	Europe	Invertebrate	Multiple	Coal
Topp et al.	2010	Europe	Invertebrate	Coleoptera	Coal
Triska et al.	2016	Australasia	Vertebrate	Multiple	Bauxite
Twigg and Fox	1991	Australasia	Vertebrate	Multiple	Sand
van Arde et al.	1996a	Africa	Both	Multiple	Multiple
van Arde et al.	1996b	Africa	Invertebrate	Diplopoda	Multiple
Van Schagen	1986	Australasia	Invertebrate	Formicidae	Coal
Wassenaar et al.	2005	Africa	Invertebrate	Multiple	Multiple
Watts et al.	2008	Australasia	Invertebrate	Coleoptera	Peat
Wheater and Cullen	1997	Europe	Invertebrate	Multiple	Limestone
Wykes	1985	Australasia	Vertebrates	Aves	Bauxite
Zeppelini et al.	2009	America	Invertebrate	Collembola	Sand

Table S2: Summary of the accessible grey literature surrounding fauna and mine site restoration

Authors	Date	Document type	Mention to fauna	Direct reference to fauna monitoring in restoration?
Glenn <i>et al.</i>	2014	Bulletin	Only mentions current monitoring methods overlook fauna, and fauna monitoring is not common	No
Guinea	2007	Management plan	Management plan for marine turtles	No
Knuckey	2017	Monitoring plan	Monitoring plan for ghost bats	No
McLaughlin	2012	Rehabilitation strategy	Return of habitat corridors necessary for fauna populations, document references attempt of the project to minimise impacts to threatened fauna	No
Weipa	2015	Management plan	Management plan for feral pigs	No
Brennan <i>et al.</i>	2005	Guidance document	Methods for increasing fauna return to rehabilitating sites	Yes- techniques for promoting fauna return to rehabilitated sites following mining
Majer	1997	Book chapter	Invertebrates in the restoration process	Yes- An Australian perspective on the role of invertebrates in the mining restoration process

Majer	1998	Conference proceedings	Return of animals to reclaimed mine lands	Yes- Long term patterns of fauna recolonization after mine rehabilitation, and potential influencing factors
McKee	2007	Conference presentation	Establishment of burrows and nests in reclaimed mine sites to promote growth of raptors and mountain plovers	Yes- construction of burrows and nests in reclamation sites
Moloney <i>et al.</i>	1998	Conference proceedings	Mammal distribution after fire and mining	Yes- study of small mammal recolonization in revegetated mined areas
Nawrot and Klimstra	1989	Book chapter	Wetland habitats on developed mines	Yes- Reintroduction of birds in reclaimed mines
Nickel and Claremont	2015	Monitoring plan	Monitoring plan for conservation significant fauna.	Yes- monitoring to be conducted in and around rehabilitation
Tibbett	2015	Book chapter	Mentions vertebrate studies from Alcoa, and the key role fauna play in ecosystem processes	Yes- basic overview of percentage of vertebrates recolonising rehabilitated sites (from published literature)

Table S3: Breakdown of terminologies used across literature assessing fauna responses to mining.

Main Terminology	Definition	Literature
Rehabilitation	<p>“Direct or indirect actions with the aim of reinstating a level of ecosystem functionality where ecological restoration is not sought but rather renewed and ongoing provision of ecosystem goods and services”</p> <p>– McDonald et al. 2016</p>	<p>Andersen et al. 2003, Armstrong & Nichols 2000, Bisevac & Majer 1999a,b, Brady & Noske 2010, Comer & Wooller 2002, Cristescu et al. 2013, Cuccovia 1999, Curry & Nichols 1986, Davis et al. 2013, Dominguez-Haydar & Armbrrecht 2011, Ferreira & Van Aarde 1996, Gould 2011, Gould & Mackey 2015, Greenslade & Majer 1993, Hill & Phinn 1993, Jackson & Fox 1996, Koch et al. 2010, Kumssa et al. 2004, Lee et al. 2013, Letnic & Fox</p>

		1997b, Majer 1981, 1984a,b, 1985, 1996, Majer & Nichols 1998, Majer et al. 1982, 1984, 1985, Mawson 1986, Nichols & Bamford 1985, Nichols & Burrows 1985, Nichols & Nichols 2003, Nichols & Watkins 1984, Ottonetti et al. 2006, Redi et al. 2005, Ribas et al. 2012, Rufaut et al. 2006, 2015, Simmonds et al. 1994, Thompson & Thompson 2003, 2005, Van Aarde et al. 1996a,b, Van Schagen 1986, Wassenaar et al. 2005, Wykes 1985
Restoration	<p>“The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed”</p> <p>– Clewell et al. 2004; McDonald et al. 2016</p>	<p>Andersen 1993, Andersen & Sparling 1997, Andres & Mateos 2006, Becker et al. 2013, Burgar et al. 2017, Craig et al. 2007, 2011, 2014, 2015, Frick et al. 2014, Lythe et al. 2017, Majer et al. 2013, Moir et al. 2005, Passell 2000, Petersen et al. 2016, Taillefer & Wheeler 2012, Tizado & Núñez-Pérez 2016, Triska et al. 2016, Watts et al. 2008, Wheeler & Cullen 1997, Zeppelini et al. 2009</p>
Regeneration	<p>“Germination, birth, or other recruitment of biota including plants, animals, and microbiota, whether arising from colonisation or in situ process”</p> <p>– McDonald et al 2016</p>	<p>Bulluck & Buehler 2006, Davis et al. 2003, Fox & Fox 1978, 1984, Fox & Twigg 1991, Letnic & Fox 1997a, Madden & Fox 1997, Rufaut et al. 2006, Taylor & Fox 2001, Twigg & Fox 1991</p>
Reclamation	<p><i>¹No SER Definition Provided</i></p> <p>“To re-establish some sort of vegetation cover on a degraded land service”</p> <p>– Bradshaw 1983</p>	<p>Cusser & Goodell 2013, Greenslade and Majer 1980, Holl 1995,1996, Kielhorn et al. 1999, Pižl 2001, Sieg et al. 1987, Topp et al. 2010</p>
Revegetation	<p>“Establishment by any means, of plants on sites (including terrestrial, freshwater, and marine areas) that may or may not involve local or native species”</p> <p>– McDonald et al 2016</p>	<p>Craig et al. 2010, Doherty et al. 2016, Galan 1997, Lannoo et al. 2009</p>
Recultivation	<p><i>No SER Definition Provided</i></p> <p>“Replantation of an area of land with tree or shrub species”</p> <p>– adapted from Hüttl et al 1996</p>	<p>Dunger et al. 2004, Purger et al. 2004a, b, 2007, Seifert & Prosche 2017, Tajovský 2001, Topp et al. 2001</p>

Afforestation	<i>No SER Definition Provided</i>	Dunger et al. 2001, Hamilton and Vimmerstedt 1981, Hendrychová et al. 2012
	“Conversion of large areas to forests” – Nosetto et al 2005	
Unclear		Brändle et al. 2000
Multiple terminologies		Becker et al. 2013, Brandle et al. 2000, Bulluck & Buehler 2006, Craig et al. 2010, Davis et al. 2013, Dominguez-Haydar & Armbrrecht 2011, Dunger et al. 2004, Hendrychová et al. 2012, Hill & Phinn 1993, Jackson and Fox 1996, Letnic & Fox 1997a, Lythe et al. 2017, Majer & Nichols 1998, Majer et al. 2013, Nichols & Burrows 1985, Ottonetti et al. 2006, Petersen et al. 2016, Pižl 2001, Ribas et al. 2012, Rafaut et al. 2006, 2015, Seifert & Prosche 2017, Tajovský 2001, Topp et al. 2001, 2010, Wassenaar et al. 2005, Wheeler & Cullen 1997, Zeppelini et al. 2009

¹SER: Society for Ecological Restoration, International Standards for the Practice of Ecological Restoration. McDonald et al. 2016.

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