The IUCN Red List of Ecosystems
Scope: Sub-global
Language: English

Coolibah-Black Box Woodlands, south eastern Australia, Australia

Assessment by: Keith, D

Overall risk category **EN**

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICALLY ENDANGERED	COLLAPSED
NE	DD	LC	NT	VU	EN	CR	CO

View on www.iucnrle.org

Citation:

Keith, D.A., Rodríguez, J.P., Rodríguez-Clark, K.M., Nicholson, E., Aapala, K., Alonso, A., ... Zambrano-Martínez, S 2013. Scientific Foundations for an IUCN Red List of Ecosystems.en. PLoS One 8. https://doi.org/10.1371/journal.pone.0062111

Scope of assessment: Sub-global

Coolibah-Black Box Woodlands, south eastern Australia, Australia

Overall risk category EN

Assessment Type

Citation:

Keith, D.A., Rodríguez, J.P., Rodríguez-Clark, K.M., Nicholson, E., Aapala, K., Alonso, A., ... Zambrano-Martínez, S 2013. Scientific Foundations for an IUCN Red List of Ecosystems.en. PLoS One 8. https://doi.org/10.1371/journal.pone.0062111

Link:

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0062111

Keywords:

Biodiversity loss, Conservation Biology, Ecological communities, Environmental - chance, Extincion risk, Food-web perspective, Global synthesis, Habitat loss, Relative resilience, Vegatation classification

Ecosystem Description

In its mature state, Coolibah - Black Box Woodland has an open structure with widely scattered trees, a variable cover of shrubs and grassy groundlayer. In its regeneration phase, it may include dense stands of saplings with limited understorey and ground layer development. Eucalyptus coolabah is the most frequently occurring tree species. Coolibah - Black Box Woodland occurs on level floodplains dissected by meandering river channels. The plain has deep alluvial clay and silt soils, which are periodically inundated by overbank flows and may remain waterlogged for extended periods. Four main processes threaten the persistence of this ecosystem (NSW Scientific Committee 2004; 2008): expansion and intensification of agricultural land use, extraction of water, invasive plants, and overgrazing by feral goats. Coolibah - Black Box Woodland occurs on the floodplain of the upper Darling River and its tributaries, about 400 km southwest of Brisbane in southeastern Australia.

Classification

IUCN Habitats Classification Scheme

- 2. Savanna
    - 2.1. Savanna - Dry

IUCN Global Typology

- Freshwater/Terrestrial
    - TF1. Palustrine wetlands
        - TF1.2 Subtropical/temperate forested wetlands

Distribution

Coolibah - Black Box Woodland occurs on the floodplain of the upper Darling River and its tributaries, within latitudes 28 - 31° S and 146 - 150° E, about 400 km southwest of Brisbane in southeastern Australia.

System

Freshwater/Terrestrial

Biogeographic Realm

Australasian

Countries

Australia

Geographic Region

Darling River floodplain

Characteristic Native Biota

In its mature state, Coolibah - Black Box Woodland has an open structure with widely scattered trees, a variable cover of shrubs and grassy groundlayer. In its regeneration phase, it may include dense stands of saplings with limited understorey and ground layer development. Eucalyptus coolabah is the most frequently occurring tree species, with other species including Eucalyptus largiflorens, Eucalyptus camaldulensis, Eucalyptus populnea subsp. bimbil, Acacia stenophylla, A. salicina, Casuarina cristata and Eremophila bignoniiflora. Common shrubs species include Muehlenbeckia florulenta and Rhagodia spinescens, while the ground layer comprises a diverse suite of grasses including species of Astrebla, Chloris, Dichanthium, Enteropogon, Panicum, Paspalidium and Sporobolus. The characteristic vertebrate fauna includes diverse assemblages of woodland and wetland bird species, many of which depend on tree hollows, other features of large trees or standing water for breeding and or foraging (NSW Scientific Committee, 2004; 2008). Regionally, the ecosystem is distinguished compositionally from other woodlands, which lack E. coolibah and the diverse grassy ground layer, and structurally from grasslands and shrublands, which lack trees and many of the characteristic woody species. Further west, floodplains are more limited in extent and experience less inundation, with ephemeral plants replacing many of the perennial plant species.

Taxa

Acacia salicina, *Acacia stenophylla*, *Astrebla spp.*, *Casuarina cristata*, *Chloris spp.*, *Cyperus spp.*, *Dichanthium spp.*, *Enteropogon spp.*, *Eremophila bignoniiflora*, *Eucalyptus camaldulensis*, *Eucalyptus coolabah*, *Eucalyptus largiflorens*, *Eucalyptus populnea subsp. bimbil*, *Marsilea spp.*, *Muehlenbeckia florulenta*, *Panicum spp.*, *Paspalidium spp.*, *Rhagodia spinescens*, *Sporobolis mitchellii*, *Sporobolus spp.*

Abiotic Features

Coolibah - Black Box Woodland occurs on level floodplains dissected by meandering river channels. The plain has deep alluvial clay and silt soils, which are periodically inundated by overbank flows and may remain waterlogged for extended periods. The climate is subtropical and semi-arid, with summer-dominant rainfall, declining from an average of about 600 mm per annum in the east to less than 350 mm per annum in the western part of the distribution.

Biotic Processes

Water regimes are a key driver of ecosystem dynamics in Coolibah - Black Box Woodland. Major floods may trigger periodic tree recruitment from which dense stands of saplings may develop and selfthin over time, eventually resulting in a sparser cover of large trees (Roberts 1993; Good et al. 2011). Extended dry periods are associated with episodes of tree mortality, which accelerate the thinning process. Different plant species have different recruitment responses to floods of varying magnitude and duration and also different tolerances to droughts of varying severity and duration (Roberts and Marston 2000; Capon 2003; Capon et al. 2009). The composition and structure of overstorey and understorey therefore varies spatially and temporally, depending on soil moisture and local flood regimes (Reid et al. 2011). The water regime also profoundly influences the dynamics of fauna assemblages, with breeding cycles of waterbirds, amphibians and many invertebrates cued to major floods associated with high resource levels (Lee and Mercer 1967; Boulton and Lloyd 1992; Kingsford and Auld 2005). Floods also mediate the movement of nutrients, organic matter, water and biota by periodically connecting rivers, wetlands and floodplains, which are otherwise isolated under dry conditions (Humphries et al. 1999; Thoms 2003). The composition of ground layer vegetation depends on past and present grazing pressure as well as the water regime (Capon 2003, 2005; Reid et al. 2011). Feral herbivores and domestic livestock are the most abundant herbivores in the system, and their effects probably overshadow those of native macropods whose abundance depends on inter-annual rainfall variation.

Threatening Processes

Four main processes threaten the persistence of this ecosystem (NSW Scientific Committee 2004; 2008). First, expansion and intensification of agricultural land use has replaced large areas of woodland with crops and pastures in recent decades (Keith et al. 2009). Second, extraction of water from rivers for irrigation has altered flood regimes and their spatial extent (Thoms and Sheldon 2000; Thoms 2003), reducing opportunities for reproduction and dispersal of characteristic flora and fauna (Kingsford and Thomas 1995; Kingsford and Johnson 1998; Sims 2004; Kingsford and Auld 2005). Future climate change may also affect the spatial and temporal availability of water in the system (Hennessy et al. 2004). Third, invasive plants have spread with agricultural intensification and are reducing the diversity and abundance of native biota. Invasion of the mat-forming forb, Phyla canescens, reduces the diversity of native ground layer plants (Taylor and Ganf 2005; Price et al. 2010; 2011). This species has spread rapidly, in response to altered water regimes and persistent heavy livestock grazing (McCosker 1999; Earl 2003). Finally, overgrazing by feral goats and rabbits and domestic livestock has altered the composition and structure of the woodland vegetation, through selective consumption of palatable native ground layer plants and seedlings of trees and shrubs, with effects most marked beneath trees where livestock concentrate their grazing activities (Robertson and Rowling 2000; Reid et al. 2011).

Collapse

Coolibah-Black Box Woodlands is assumed to have collapsed when its mapped distribution has declined to zero as a consequence of clearing for agriculture. Because water regimes are a key driver of ecosystem dynamics and water diversion for irrigation is a major threat in Coolibah-Black Box Woodland, median daily river flow was identified as a suitable variable for assessing environmental degradation. Conservatively, it was assumed that the ecosystem would collapse if median flow declined to 0-10% of unregulated levels.

Ecosystem Risk Assessment

Assessment Protocol	IUCN Red List of Ecosystems Category and Criteria	Last Assessed
IUCN RLE v2.0	Endangered C1	2013

Justification

For the Coolibah-Black Box Woodlands, Thoms and Sheldon (2000) used a hydrological model to simulate current stream discharge (with water extraction) and 'natural' discharge (without extraction). The model was evaluated by comparing modelled current flows with observed flows at the Bourke stream gauge and close correspondence was confirmed. Black et al. (1997) present a full description and evaluation of the model. It can be assumed that the ratio of current to natural flow represents change in flow over the past 50 years. This is a reasonable assumption because the first major river regulation infrastructure in the catchment was constructed in 1961 (Keepit Dam) and water extraction is likely to have been negligible prior to that year. The flow volume at which the ecosystem would collapse is uncertain, but collapse is likely to occur before median daily flow declines to zero at Bourke. Conservatively, it was assumed that the ecosystem would collapse if median flow declined to 0 - 10% of 'natural' (unregulated) levels. Thoms and Sheldon (2000) estimated that median flow at Bourke declined from 2,917 ML/day (natural) to 1,342 ML/day (current). Applying range standardisation gives a relative severity between 54% and 60%. As the flow gauge at the bottom of the catchment is indicative of range wide change in water regime, the extent of the decline is taken as 100%. Thus, the ecosystem is classified as Endangered under subcriterion C1.

Criterion A VU

Summary

Coolibah-Black Box Woodlands geographic distribution was estimated to have declined by 33% to 58%. A bounded estimate of decline in distribution for the past 50 years is therefore 47% (plausible bounds 33-58%). Using maps from historic distribution of Coolibah-Black Box Woodland in New South Wales an estimated historic decline of 65% (50-70%) was obtained; thus, the ecosystem is classified as Vulnerable (plausible range Vulnerable-Endangered) under subcriteria A1 and A3.

Risk Category VU

Subcriterion	Category	Justification
A1	VU	Keith et al. (2009) estimated that the area of the Coolibah-Black Box Woodlands declined on average by 0.79% per year between 1984 and 2004. Rates of clearing have not been assessed for the periods before c. 1984 and after 2004. There is evidence that clearing activity commenced after 1900, and accelerated between 1940 and 1969 due to increasing deployment of heavy farm machinery and development of river regulation infrastructure, which made more water available for irrigation (Bedward et al. 2007). Cropping data suggest that rates of clearing continued at similar rates after

2004, at least up until 2007 (Keith et al. 2009), although may have slowed subsequently due to prolonged drought and compliance actions under clearing legislation. It was assumed that the rate of decline in distribution during 50 years (1960-2010) was at least 0.8% and at most 1.7% per year, with an intermediate scenario of 0.8% per year for the past 25 years and 1.7% per year for the preceding 25 years. Under these scenarios, the distribution of the ecosystem was estimated to have declined by 33%, 47%, and 58%, respectively. A bounded estimate of decline in distribution for the past 50 years is 47% (plausible bounds 33-58%); thus, the ecosystem is classified as Vulnerable (plausible bounds Vulnerable-Endangered) under subcriterion A1.

Key Indicators in detail

Evidence of Continuing Decline: Decreasing
Evidence of Threatening Processes: Yes

Indicator Variable: Change in distribution

Extent (%): 33-58

Mapped distribution
Year: 1960
Year: 2010

A2a DD

Projections of future declines in distribution can be made by assuming similar rates of land conversion continue into the future (Keith et al. 2009). There is little impediment to continued clearing imposed by protected area land tenure (the ecosystem occurs mostly on freehold or leasehold land used for agriculture) and declaration of dominant trees under 'invasive native scrub' regulations promotes clearing of the ecosystem when in the juvenile thicket phase (Fensham 2008). However, clearing of native vegetation and availability of water for irrigation are regulated by permits under legislation. These opposing influences, together with uncertainties in future trends of water extraction and impacts of climate change on the water regime, create complex future scenarios that are yet to be modelled. The status of the ecosystem under subcriterion A2a is therefore Data Deficient.

Key Indicators in detail

Evidence of Continuing Decline: Stable or Increasing
Evidence of Threatening Processes: No

A2b NE

This subcriterion was not assessed.

Key Indicators in detail

Evidence of Continuing Decline: Stable or Increasing
Evidence of Threatening Processes: No

A3 VU

Using habitat suitability models and field reconnaissance, the historic distribution of Coolibah - Black Box Woodland in NSW was estimated to have declined by 61% (plausible bounds 50-67%) (Keith et al. 2009). Similar mapping in Queensland produced an estimated historic decline of 82% (Queensland Herbarium 2009). The combined data suggest an overall historic decline of 65% (TSSC 2011), with a plausible lower bound above 50% and upper bound likely to be marginally above 70%. The status of the ecosystem is therefore Vulnerable (plausibly bounds Vulnerable to Endangered) under subcriterion A3.

Key Indicators in detail

Evidence of Continuing Decline: Decreasing
Evidence of Threatening Processes: Yes

Indicator Variable: Change in distribution

Extent (%): 65

Mapped distribution
Year: 1750
Year: 2009

Criterion B

LC

Summary

Coolibah - Black Box Woodland encompasses an area of 266,400 km2. This ecosystem is estimated to occupy 910 10 × 10 km grid cells, exceeding the threshold for Vulnerable by a substantial margin. The most serious plausible threats to Coolibah - Black Box Woodland are land clearing and changes to water regimes. A broad interpretation of 'threat defined locations' under subcriterion B3 would be three jurisdictional zones with different regulatory controls on land clearing. A more narrow interpretation of threat defined locations based on neighbourhoods of contagion would produce an estimate of more than five. Based on current rates of depletion due to land clearing and current rates of environmental degradation due to changes in water regime, the ecosystem is unlikely to collapse or become Critically Endangered within the near future (c. 20 years). Therefore, is classified as Least Concern under criterion B.

Risk Category LC

Subcriterion **Category** **Justification**

B1 LC

A minimum convex polygon enclosing all mapped occurrences of Coolibah - Black Box Woodland has an area of 266,400 (130,200 - 437,300) km2. Although there is evidence of continuing decline in distribution and continuing environmental degradation, the status of the ecosystem under subcriterion B1 is Least Concern because the estimated extent of occurrence exceeds the thresholds for all threatened categories.

Key Indicators in detail

Number of Threat-defined Locations: more than 5
Evidence of Continuing Decline: Stable or Increasing
Evidence of Threatening Processes: Yes

Indicator Variable: EOO

Mapped distribution
Year: 2010
Mapped distribution (km2): 266,400

B2 LC

The Coolibah - Black Box Woodland ecosystem is present within 1,193 grid cells (752 within New South Wales). Of these, 283 grid cells (92 in NSW) contain less than 1 km2 of the ecosystem. Excluding these small occurrences, the swamps are therefore estimated to occupy 910 10 × 10 km grid cells, exceeding the threshold for Vulnerable by a substantial margin; thus, the ecosystem is classified as Least Concern under subcriterion B2.

Key Indicators in detail

Number of Threat-defined Locations: more than 5
Evidence of Continuing Decline: Stable or Increasing
Evidence of Threatening Processes: Yes

Indicator Variable: AOO

Mapped distribution
Year: 2009
Mapped distribution (10x10-km grid cells): 910

B3 LC

The most serious plausible threats to Coolibah - Black Box Woodland are land clearing and changes to water regimes. Spatial patterns of land clearing show a high degree of contagion, with the best predictor of future clearing being the proximity of a patch to land parcels already cleared of native vegetation (Bedward et al. 2007). A broad interpretation of 'threat-defined locations' under sub-criterion B3 would be three jurisdictional zones with different regulatory controls on land clearing: the leasehold western Division of NSW; the freehold Central Division of New South Wales; and Queensland. A more narrow interpretation of locations based on neighbourhoods of contagion would produce an estimate of more than five. Small protected areas are excluded from these locations, as they are not threatened by land clearing. These areas were assessed by considering the next most serious plausible threat, changes to water regimes. As protected areas are located in at least two different subcatchments with different water management infrastructure, there are at least two further locations. Hence the most precautionary interpretation produces an estimate of five locations, although it is likely that there are more. Based on current rates of depletion due to land clearing and current rates of environmental degradation due to changes in water regime, the ecosystem is unlikely to collapse or become Critically Endangered within the near future (c. 20 years); thus, the ecosystem is classified as Least Concern under subcriterion B3.

Key Indicators in detail

Number of Threat-defined Locations: 5
Evidence of Continuing Decline: Stable or Increasing
Evidence of Threatening Processes: Yes

Criterion C EN

Summary

For the Coolibah-Black Box Woodlands, Thoms and Sheldon (2000) used a hydrological model to simulate current stream discharge (with water extraction) and 'natural' discharge (without extraction). It can be assumed that the ratio of current to natural flow represents change in flow over the past 50 years. This is a reasonable assumption because the first major river regulation infrastructure in the catchment was constructed in 1961 (Keepit Dam) and water extraction is likely to have been negligible prior to that year. The flow volume at which the ecosystem would collapse is uncertain, but it is likely to occur before median daily flow declines to zero at Bourke. Conservatively, it was assumed that the ecosystem would collapse if median flow declined to 0 - 10% of 'natural' (unregulated) levels. Thoms and Sheldon (2000) estimated that median flow at Bourke declined from 2,917 ML/day (natural) to 1,342 ML/day (current). Applying range standardisation gives a relative severity between 54% and 60%. As the flow gauge at the bottom of the catchment is indicative of range wide change in water regime, the extent of the decline is taken as 100%. Thus, the ecosystem is classified as Endangered under subcriterion C1.

Risk Category EN

Subcriterion	**Category**	**Justification**
C1	EN	For the Coolibah-Black Box Woodlands, Thoms and Sheldon (2000) used a hydrological model to simulate current stream discharge (with water extraction) and 'natural' discharge (without extraction). The model was evaluated by comparing modelled current flows with observed flows at the Bourke stream gauge and close correspondence was confirmed. Black et al. (1997) present a full description and evaluation of the model. It can be assumed that the ratio of current to natural flow represents change in flow over the past 50 years. This is a reasonable assumption because the first major river regulation infrastructure in the catchment was constructed in 1961 (Keepit Dam) and water extraction is likely to have been negligible prior to that year. The flow volume at which the ecosystem would collapse is uncertain, but it is likely to occur before median daily flow declines to zero at Bourke (i.e. zero flow on 50% of days). Conservatively, it was assumed that the ecosystem would collapse if median flow declined to 0 - 10% of 'natural' (unregulated) levels. Thoms and Sheldon (2000) estimated that median flow at Bourke declined from 2,917 ML/day (natural) to 1,342 ML/day (current). Applying range standardisation gives a relative severity between 54% and 60%. As the flow gauge at the bottom of the catchment is indicative of range wide change in water regime, the extent of the decline is taken as 100%. Thus, the ecosystem is classified as Endangered under subcriterion C1. **Key Indicators in detail** Evidence of Threatening Processes: Yes **Indicator Variable:** Change in flow Extent (%): 100 Relative Severity (%): 54-60 estimated Year: 1950 Mapped distribution (ML/day): 2,917 Year: 2000 Mapped distribution (ML/day): 1,342
C2a	DD	Future projections for flooding in the upper Darling catchment would need to take into account plausible scenarios of irrigation, environmental flows and climate change. No such projections are currently available; thus, it is classified as Data Deficient under subcriterion C2a. **Key Indicators in detail**

Evidence of Threatening Processes: Yes

C2b

NE

This subcriterion was not assessed.

Key Indicators in detail

Evidence of Threatening Processes: No

C3

VU

As water extraction was assumed to be negligible prior to 1961, historic declines in the water regime are the same as current declines; with relative severity of 54 - 60 % over 100% extent. The status of the ecosystem is therefore Vulnerable under subcriterion C3.

Key Indicators in detail

Evidence of Threatening Processes: No

Indicator Variable: Change in flow

Extent (%): 100
Relative Severity (%): 54-60

estimated
Year: 1750
Mapped distribution (ML/day): 2,917
Year: 2000
Mapped distribution (ML/day): 1,342

Criterion D

DD

Summary

For the Coolibah-Black Box Woodlands suitable variables for assessing declines in biotic interactions include vegetation responses to grazing, changes in structure due to tree thinning and ringbarking and the abundance of transformer invasive plants, particularly Phyla canescens. No reliable information is available to assess the disruption of biotic processes or interactions in the ecosystem; thus, it is classified as Data Deficient under criterion D.

Risk Category

DD

Subcriterion **Category** **Justification**

D1

DD

No reliable information is available to assess the disruption of biotic processes or interactions in the ecosystem in the past 50 years; thus, it is classified as Data Deficient under subcriterion D1.

Key Indicators in detail

Evidence of Threatening Processes: No

D2a

DD

No reliable information is available to assess the disruption of biotic processes or interactions in the ecosystem in the next 50 years; thus, it is classified as Data Deficient under subcriterion D2a.

Key Indicators in detail

Evidence of Threatening Processes: No

D2b

NE

This subcriterion was not assessed.

Key Indicators in detail

Evidence of Threatening Processes: No

D3 DD

No reliable information is available to assess the disruption of biotic processes or interactions in the ecosystem historically; thus, it is classified as Data Deficient under subcriterion D3.

Key Indicators in detail

Evidence of Threatening Processes: No

Criterion E DD

Summary

No quantitative analysis has been carried out to assess the risk of ecosystem collapse for Coolibah - Black Box Woodland; thus, is classified as Data Deficient for criterion E.

Risk Category DD

Cited References

Akcakaya HR, 2000, CONSERV BIOL, V14, P1001, DOI 10.1046/j.1523-1739.2000.99125.x.
Allen CR, 2005, ECOSYSTEMS, V8, P958, DOI 10.1007/s10021-005-0147-x.
Alvarez-Filip L, 2009, P R SOC B, V276, P3019, DOI 10.1098/rspb.2009.0339.
Andren H, 1996, OIKOS, V76, P235, DOI 10.2307/3546195.
Araoz E, 2010, ECOSYSTEMS, V13, P992, DOI 10.1007/s10021-010-9369-7.
Arias-Gonzalez JE, 2012, BIODIVERS CONSERV, V21, P115, DOI 10.1007/s10531-011-0169-y.
Ayensu E, 1999, SCIENCE, V286, P685, DOI 10.1126/science.286.5440.685.
Baillie J., 2004, IUCN RED LIST THREAT.
Barbone E, 2010, REND LINCEI-SCI FIS, V21, P301, DOI 10.1007/s12210-010-0090-4.
Benson J. S., 2006, Cunninghamia, V9, P331.
Blab J, 1995, LANDSCAPE ECOL, V10, P41, DOI 10.1007/BF00158552.
Blodgett N, 2010, INT J WILDLAND FIRE, V19, P415, DOI 10.1071/WF08162.
Briske DD, 2005, RANGELAND ECOL MANAG, V58, P1, DOI 10.2111/1551-5028(2005)58(1:SMTARH)2.0.CO;2.
Burgman M, 2005, RISKS DECISIONS CONS.
Burgman M.A., 1993, RISK ASSESSMENT CONS.
Burgman MA, 1999, RISK ANAL, V19, P585, DOI 10.1111/j.1539-6924.1999.tb00430.x.
Burgman MA, 2003, ANIM CONSERV, V6, P19, DOI 10.1017/S1367943003003044.
Butchart SHM, 2004, PLOS BIOL, V2, P2294, DOI 10.1371/journal.pbio.0020383.
Butchart SHM, 2010, SCIENCE, V328, P1164, DOI 10.1126/science.1187512.
Byrne M, 2008, BIOL J LINN SOC, V93, P177, DOI 10.1111/j.1095-8312.2007.00946.x.
Cabezas A, 2009, HYDROL EARTH SYST SC, V13, P1.
Calcagno V, 2011, AM NAT, V177, pE1, DOI 10.1086/657436.
Cardinale BJ, 2007, P NATL ACAD SCI USA, V104, P18123, DOI 10.1073/pnas.0709069104.
Cardinale BJ, 2011, AM J BOT, V98, P572, DOI 10.3732/ajb.1000364.
Cardinale BJ, 2012, NATURE, V486, P59, DOI 10.1038/nature11148.
Carpenter S, 2001, ECOSYSTEMS, V4, P765, DOI 10.1007/s10021-001-0045-9.
Carpenter S. R., 2003, EXCELLENCE ECOLOGY S.
Caughley G, 1994, J ANIM ECOL, V63, P215, DOI 10.2307/5542.
Chytry M, 2002, J VEG SCI, V13, P79, DOI 10.1658/1100-9233(2002)013{[}0079:DODSWS]2.0.CO;2.
Clarke PJ, 2005, J VEG SCI, V16, P237, DOI 10.1658/1100-9233(2005)016{[}0237:LCISVI]2.0.CO;2.
Comin Francisco, 2010, ECOLOGICAL RESTORATI.
Connell JH, 1977, AM NAT, V111, P1119, DOI 10.1086/283241.
Costello MJ, 2009, MAR ECOL PROG SER, V397, P253, DOI 10.3354/meps08317.
Costello MJ, 2010, ENVIRON SCI TECHNOL, V44, P8821, DOI 10.1021/es1012752.
Cowling RM, 2008, P NATL ACAD SCI USA, V105, P9483, DOI 10.1073/pnas.0706559105.

Curran LM, 2006, P NATL ACAD SCI USA, V103, P12663, DOI 10.1073/pnas.0605449103.
Czembor CA, 2009, FOREST ECOL MANAG, V259, P165, DOI 10.1016/j.foreco.2009.10.002.
Danovaro R, 2008, CURR BIOL, V18, P1, DOI 10.1016/j.cub.2007.11.056.
Del Moral R, 2007, J VEG SCI, V18, P479, DOI 10.1658/1100-9233(2007)18{[}479:LTCOVD]2.0.CO;2.
Diamond JM, 1989, PHILOS T ROY SOC B, V325, P469, DOI 10.1098/rstb.1989.0100.
Dirzo R, 2003, ANNU REV ENV RESOUR, V28, P137, DOI 10.1146/annurev.energy.28.050302.105532.
Duffy JE, 2007, ECOL LETT, V10, P522, DOI 10.1111/j.1461-0248.2007.01037.x.
Eisenhauer N, 2011, PLOS ONE, V6, DOI 10.1371/journal.pone.0016055.
Elith J, 2006, ECOGRAPHY, V29, P129, DOI 10.1111/j.2006.0906-7590.04596.x.
Essl F, 2012, BIODIVERS CONSERV, V21, P655, DOI 10.1007/s10531-011-0206-x.
Estes JA, 2009, PHILOS T R SOC B, V364, P1647, DOI 10.1098/rstb.2008.0231.
Faber-Langendoen D., 2009, B ECOL SOC AM, V90, P87.
Fischer J, 2007, ECOSYSTEMS, V10, P964, DOI 10.1007/s10021-007-9064-5.
Folke C, 2004, ANNU REV ECOL EVOL S, V35, P557, DOI 10.1146/annurev.ecolsys.35.021103.105711.
Fontaine C, 2006, PLOS BIOL, V4, P129, DOI 10.1371/journal.pbio.0040001.
Fritz H, 2011, ECOGRAPHY, V34, P196, DOI 10.1111/j.1600-0587.2010.06537.x.
Fukami T, 2005, P ROY SOC B-BIOL SCI, V272, P2105, DOI 10.1098/rspb.2005.3277.
Fulton EA, 2011, FISH FISH, V12, P171, DOI 10.1111/j.1467-2979.2011.00412.x.
Gaston K. J., 1993, RARITY.
Gaston KJ, 2008, TRENDS ECOL EVOL, V23, P14, DOI 10.1016/j.tree.2007.11.001.
Goudard A, 2008, AM NAT, V171, P91, DOI 10.1086/523945.
Green PT, 2011, ECOLOGY, V92, P1758, DOI 10.1890/11-0050.1.
Hahs AK, 2009, ECOL LETT, V12, P1165, DOI 10.1111/j.1461-0248.2009.01372.x.
Hallenbeck W.H., 1986, QUANTITATIVE RISK AS.
Hannah J, 2012, J GEOPHYS RES-OCEANS, V117, DOI 10.1029/2011JC007591.
Hanski I, 1998, NATURE, V396, P41, DOI 10.1038/23876.
Harpole WS, 2007, NATURE, V446, P791, DOI 10.1038/nature05684.
Hartley S, 2003, CONSERV BIOL, V17, P1559, DOI 10.1111/j.1523-1739.2003.00015.x.
Hector A, 2007, NATURE, V448, P188, DOI 10.1038/nature05947.
Heemsbergen DA, 2004, SCIENCE, V306, P1019, DOI 10.1126/science.1101865.
He FL, 2011, NATURE, V473, P368, DOI 10.1038/nature09985.
Hobbs RJ, 2006, GLOBAL ECOL BIOGEOGR, V15, P1, DOI 10.1111/j.1466-822x.2006.00212.x.
Hobbs R.J., 2009, NEW MODELS ECOSYSTEM.
Hoekstra JM, 2005, ECOL LETT, V8, P23, DOI 10.1111/j.1461-0248.2004.00686.x.
Holling C.S., 1973, Annual Rev Ecol Syst, V4, P1, DOI 10.1146/annurev.es.04.110173.000245.
Holling CS, 2001, ECOSYSTEMS, V4, P390, DOI 10.1007/s10021-001-0101-5.
Hong S, 2010, J CLIMATE, V23, P4669, DOI 10.1175/2010JCLI3697.1.
Hooper DU, 2005, ECOL MONOGR, V75, P3, DOI 10.1890/04-0922.
Hooper DU, 2012, NATURE, V486, P105, DOI 10.1038/nature11118.
Huth N, 2011, J APPL ECOL, V48, P293, DOI 10.1111/j.1365-2664.2010.01936.x.
Isbell F, 2011, NATURE, V477, P199, DOI 10.1038/nature10282.
IUCN, 2001, RED LIST CAT CRIT.
IUCN, 2011, GUID APPL IUCN RED L.
Jacquez GM, 2008, ENVIRON ECOL STAT, V15, P403, DOI 10.1007/s10651-007-0066-4.
Jax K, 1998, OIKOS, V82, P253, DOI 10.2307/3546965.
Jennings MD, 2009, ECOL MONOGR, V79, P173, DOI 10.1890/07-1804.1.
Keith DA, 1998, CONSERV BIOL, V12, P1076, DOI 10.1046/j.1523-1739.1998.97202.x.
Keith DA, 2004, BIOL CONSERV, V117, P41, DOI 10.1016/S0006-3207(03)00261-1.
Keith DA, 2007, J ECOL, V95, P1324, DOI 10.1111/j.1365-2745.2007.01302.x.
Keith DA, 2009, BIOL CONSERV, V142, P1469, DOI 10.1016/j.biocon.2009.02.015.
Keith David A., 2009, Ecological Management and Restoration, V10, pS3, DOI 10.1111/j.1442-8903.2009.00453.x.
King KJ, 2006, INT J WILDLAND FIRE, V15, P527, DOI 10.1071/WF05076.
Klemas V, 2010, J COASTAL RES, V26, P789, DOI 10.2112/10A-00012.1.
Kontula T, 2009, BIODIVERS CONSERV, V18, P3861, DOI 10.1007/s10531-009-9684-5.
Lapointe NWR, 2010, J FISH BIOL, V76, P446, DOI 10.1111/j.1095-8649.2009.02470.x.
Larsen TH, 2005, ECOL LETT, V8, P538, DOI 10.1111/j.1461-0248.2005.00749.x.
Lee JK, 1992, PHOTOGRAMM ENG REM S, V58, P1579.
Lester RE, 2011, ECOL MODEL, V222, P2690, DOI 10.1016/j.ecolmodel.2011.05.009.
Likens G. E., 1992, ECOSYSTEM APPROACH I.
Lindenmayer DB, 2006, HABITAT FRAGMENTATIO.
Lindenmayer DB, 2011, ECOSYSTEMS, V14, P47, DOI 10.1007/s10021-010-9394-6.
Lindenmayer DB, 2012, AUSTRAL ECOL, V37, P745, DOI 10.1111/j.1442-9993.2011.02351.x.
Loreau M, 2000, OIKOS, V91, P3, DOI 10.1034/j.1600-0706.2000.910101.x.

Loreau M, 2003, P NATL ACAD SCI USA, V100, P12765, DOI 10.1073/pnas.2235465100.
Loreau M, 2010, PHILOS T R SOC B, V365, P49, DOI 10.1098/rstb.2009.0155.
Ludwig JA, 2007, ECOL INDIC, V7, P442, DOI 10.1016/j.ecolind.2006.05.001.
Lundberg J, 2003, ECOSYSTEMS, V6, P87, DOI 10.1007/s10021-002-0150-4.
Mac Arthur Robert H., 1967.
Mace GM, 2008, CONSERV BIOL, V22, P1424, DOI 10.1111/j.1523-1739.2008.01044.x.
Mac Nally R., 2011, WATER RESOURCES RES, V47.
McCarthy MA, 2008, J APPL ECOL, V45, P1428, DOI 10.1111/j.1365-2664.2008.01521.x.
McKnight MW, 2007, PLOS BIOL, V5, P2424, DOI 10.1371/journal.pbio.0050272.
Mearns AJ, 2010, WATER ENVIRON RES, V82, P2001, DOI 10.2175/106143010X12756668802175.
Metternicht GI, 2003, REMOTE SENS ENVIRON, V85, P1, DOI 10.1016/S0034-4257(02)00188-8.
Micklin P, 2006, EURASIAN GEOGR ECON, V47, P546, DOI 10.2747/1538-7216.47.5.546.
Midgley GF, 2010, ECOGRAPHY, V33, P612, DOI 10.1111/j.1600-0587.2009.06000.x.
Miller G, 2010, RANGELAND J, V32, P353, DOI 10.1071/RJ09076.
Miller RM, 2007, CONSERV BIOL, V21, P684, DOI 10.1111/j.1523-1739.2007.00656.x.
Moberg F, 1999, ECOL ECON, V29, P215, DOI 10.1016/S0921-8009(99)00009-9.
Molnar JL, 2008, FRONT ECOL ENVIRON, V6, P485, DOI 10.1890/070064.
Mucina L, 2006, VEGETATION S AFRICA.
Nicholson E, 2009, CONSERV BIOL, V23, P259, DOI 10.1111/j.1523-1739.2008.01158.x.
Noss RF, 1996, TRENDS ECOL EVOL, V11, P351, DOI 10.1016/0169-5347(96)20058-8.
Olson DM, 2001, BIOSCIENCE, V51, P933, DOI 10.1641/0006-3568(2001)051{[}0933:TEOTWA]2.0.CO;2.
Patrick WS, 2010, FISH B-NOAA, V108, P305.
Peterson CH, 2003, SCIENCE, V302, P2082, DOI 10.1126/science.1084282.
Peterson G, 1998, ECOSYSTEMS, V1, P6, DOI 10.1007/s100219900002.
Pickett S T A, 1989, P110.
Pickett STA, 2001, APPL VEG SCI, V4, P41, DOI 10.1111/j.1654-109X.2001.tb00233.x.
Pickett STA, 2002, ECOSYSTEMS, V5, P1, DOI 10.1007/s10021-001-0051-y.
Possingham HP, 2002, TRENDS ECOL EVOL, V17, P503, DOI 10.1016/S0169-5347(02)02614-9.
Pounds JA, 1999, NATURE, V398, P611, DOI 10.1038/19297.
Rackham Oliver, 1986, HIST COUNTRYSIDE.
Radford JQ, 2005, BIOL CONSERV, V124, P317, DOI 10.1016/j.biocon.2005.01.039.
Ramirez-Llodra E, 2010, BIOGEOSCIENCES, V7, P2851, DOI 10.5194/bg-7-2851-2010.
Regan HM, 2002, ECOL APPL, V12, P618, DOI 10.1890/1051-0761(2002)012{[}0618:ATATOU]2.0.CO;2.
Rhymer JM, 1996, ANNU REV ECOL SYST, V27, P83, DOI 10.1146/annurev.ecolsys.27.1.83.
Riecken U, 2002, NATUR LANDSCHAFT, V77, P397.
Ripple WJ, 2004, BIOSCIENCE, V54, P755, DOI 10.1641/0006-3568(2004)054{[}0755:WATEOF]2.0.CO;2.
Rodrigues ASL, 2006, TRENDS ECOL EVOL, V21, P71, DOI 10.1016/j.tree.2005.10.010.
Rodriguez JP, 2007, BIODIVERS CONSERV, V16, P183, DOI 10.1007/s10531-006-9102-1.
Rodriguez JP, 2011, CONSERV BIOL, V25, P21, DOI 10.1111/j.1523-1739.2010.01598.x.
Rodriguez JP, 2012, SAPIENS, V5, P6.
Rogers CS, 1990, MAR ECOL PROG SER, V62, P185, DOI 10.3354/meps062185.
Rosensweing ML, 1995, SPECIES DIVERSITY SP.
Rumpff L, 2011, BIOL CONSERV, V144, P1224, DOI 10.1016/j.biocon.2010.10.026.
Sang A, 2010, BIOL CONSERV, V143, P1405, DOI 10.1016/j.biocon.2010.03.015.
Scheffer M, 2001, NATURE, V413, P591, DOI 10.1038/35098000.
Schmitz OJ, 2000, AM NAT, V155, P141, DOI 10.1086/303311.
Scholze M, 2006, P NATL ACAD SCI USA, V103, P13116, DOI 10.1073/pnas.0601816103.
Shi JM, 2010, BIODIVERS CONSERV, V19, P1279, DOI 10.1007/s10531-009-9757-5.
Solow AR, 2005, MATH BIOSCI, V195, P47, DOI 10.1016/j.mbs.2005.02.001.
Spalding MD, 2007, BIOSCIENCE, V57, P573, DOI 10.1641/B570707.
Springer AM, 2003, P NATL ACAD SCI USA, V100, P12223, DOI 10.1073/pnas.1635156100.
Srivastava DS, 2005, ANNU REV ECOL EVOL S, V36, P267, DOI 10.1146/annurev.ecolsys.36.102003.152636.
Staver AC, 2009, ECOL APPL, V19, P1909, DOI 10.1890/08-1907.1.
Stoddard JL, 2008, J N AM BENTHOL SOC, V27, P878, DOI 10.1899/08-053.1.
Tansley AG, 1935, ECOLOGY, V16, P284, DOI 10.2307/1930070.
Thebault E, 2005, AM NAT, V166, pE95, DOI 10.1086/444403.
Thebault E, 2007, OIKOS, V116, P163, DOI 10.1111/j.2006.0030-1299.15007.x.
Thompson JN, 1997, ECOLOGICAL BASIS CON.
Tierney GL, 2009, FRONT ECOL ENVIRON, V7, P308, DOI 10.1890/070176.
Tilman D, 1994, NATURE, V371, P65, DOI 10.1038/371065a0.
Tilman D, 2001, SCIENCE, V294, P843, DOI 10.1126/science.1060391.
Todd BJ, 2006, BENTHIC HABITAT SUN.
Underwood AJ, 1989, TRENDS ECOL EVOL, V4, P16, DOI 10.1016/0169-5347(89)90008-6.

Vazquez DP, 2003, ECOL LETT, V6, P1077, DOI 10.1046/j.1461-0248.2003.00534.x.
Visconti P, 2010, BIOL CONSERV, V143, P756, DOI 10.1016/j.biocon.2009.12.018.
Vitousek PM, 1997, SCIENCE, V277, P494, DOI 10.1126/science.277.5325.494.
Vrijenhoek RC, 2010, MOL ECOL, V19, P4391, DOI 10.1111/j.1365-294X.2010.04789.x.
Walker B, 1999, ECOSYSTEMS, V2, P95, DOI 10.1007/s100219900062.
Walters C, 2001, CAN J FISH AQUAT SCI, V58, P39, DOI 10.1139/cjfas-58-1-39.
Watling L, 1998, CONSERV BIOL, V12, P1180, DOI 10.1046/j.1523-1739.1998.0120061180.x.
Westoby M, 1989, J RANGE MANAGE, V42, P266, DOI 10.2307/3899492.
Whittaker R H, 1972, Taxon, V21, P213, DOI 10.2307/1218190.
Wiens JA, 1989, FUNCT ECOL, V3, P385, DOI 10.2307/2389612.
Willis AJ, 1997, FUNCT ECOL, V11, P268, DOI 10.1111/j.1365-2435.1997.00081.x.
Yachi S, 1999, P NATL ACAD SCI USA, V96, P1463, DOI 10.1073/pnas.96.4.1463.
Yamano H, 2004, REMOTE SENS ENVIRON, V90, P86, DOI 10.1016/j.rse.2003.12.005.
Zhao HL, 2005, J ARID ENVIRON, V62, P309, DOI 10.1016/j.jaridenv.2004.11.009.