Resilience of multiple ecosystem services and biodiversity in a temperate forest (UK)

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Dynamics and Thresholds of Ecosystem Services in Wooded Landscapes

Bournemouth University

bess biodiversity & ecosystem service sustainability
www.nerc-bess.net

Dynamics of ecosystem services in forest ecosystems is a two-year (2013-2015) research project funded by the UK Natural Environment Research Council under the BESS (Biodiversity and Ecosystem Services for Sustainability) research programme.

The project aims to identify the form of the quantitative relationships between biodiversity, ecosystem functions and services at the landscape scale, and to establish whether there are critical levels of biodiversity that are required in wooded landscapes for provision of such services.

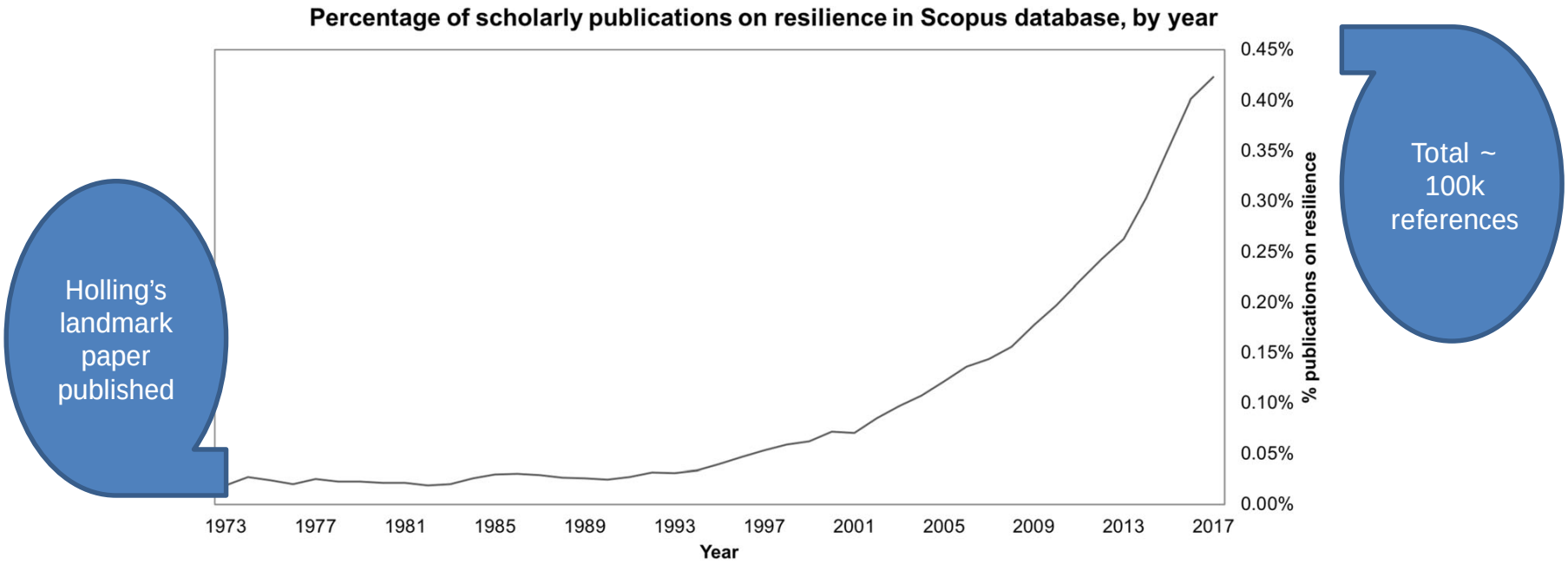
Woodlands in many parts of the world are currently at risk because of the combined effects of climate change, aerial pollution, overgrazing and the spread of pests and diseases. These factors can interact with each other, leading to the collapse of wooded ecosystems and their replacement with other plant communities. Research is needed to identify which woodland areas are at risk of such collapse occurring, so that appropriate management responses can be identified. Information is also needed on the potential impacts of such "ecosystem thresholds", both on wildlife and on humans, through changes in the provision of ecosystem services.

This project aims to provide this information, by studying woodlands in the New Forest National Park. Research will comprise a combination of field surveys along gradients of forest dieback, resurvey of long-term plots and use of spatially explicit models of ecosystem dynamics. The project will help increase understanding of how major ecological changes occur in woodlands, and their potential ecological and societal impacts.

Read the latest project updates in the News page.

Mark Ash wood, illustrating canopy collapse.

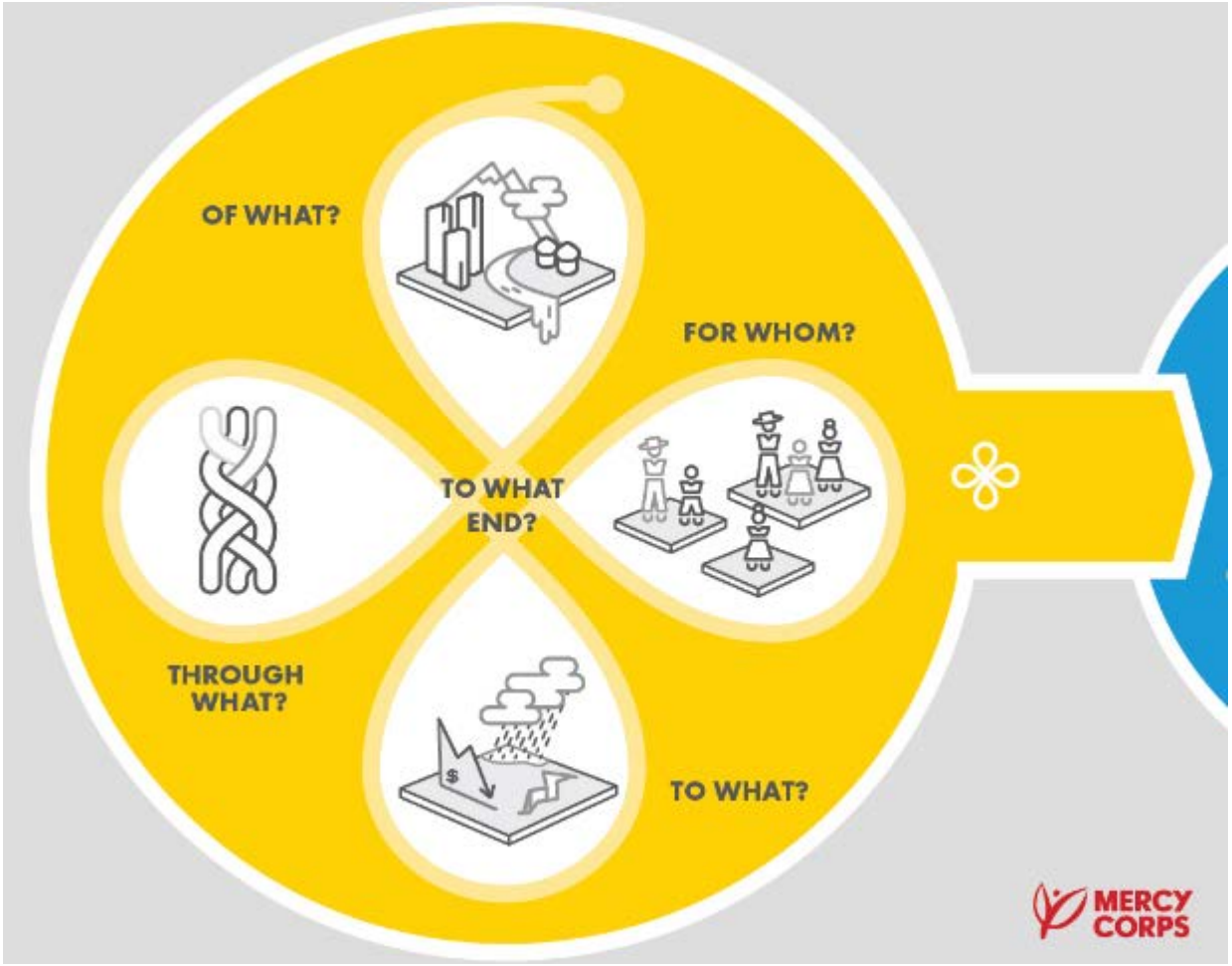
Meanings of resilience



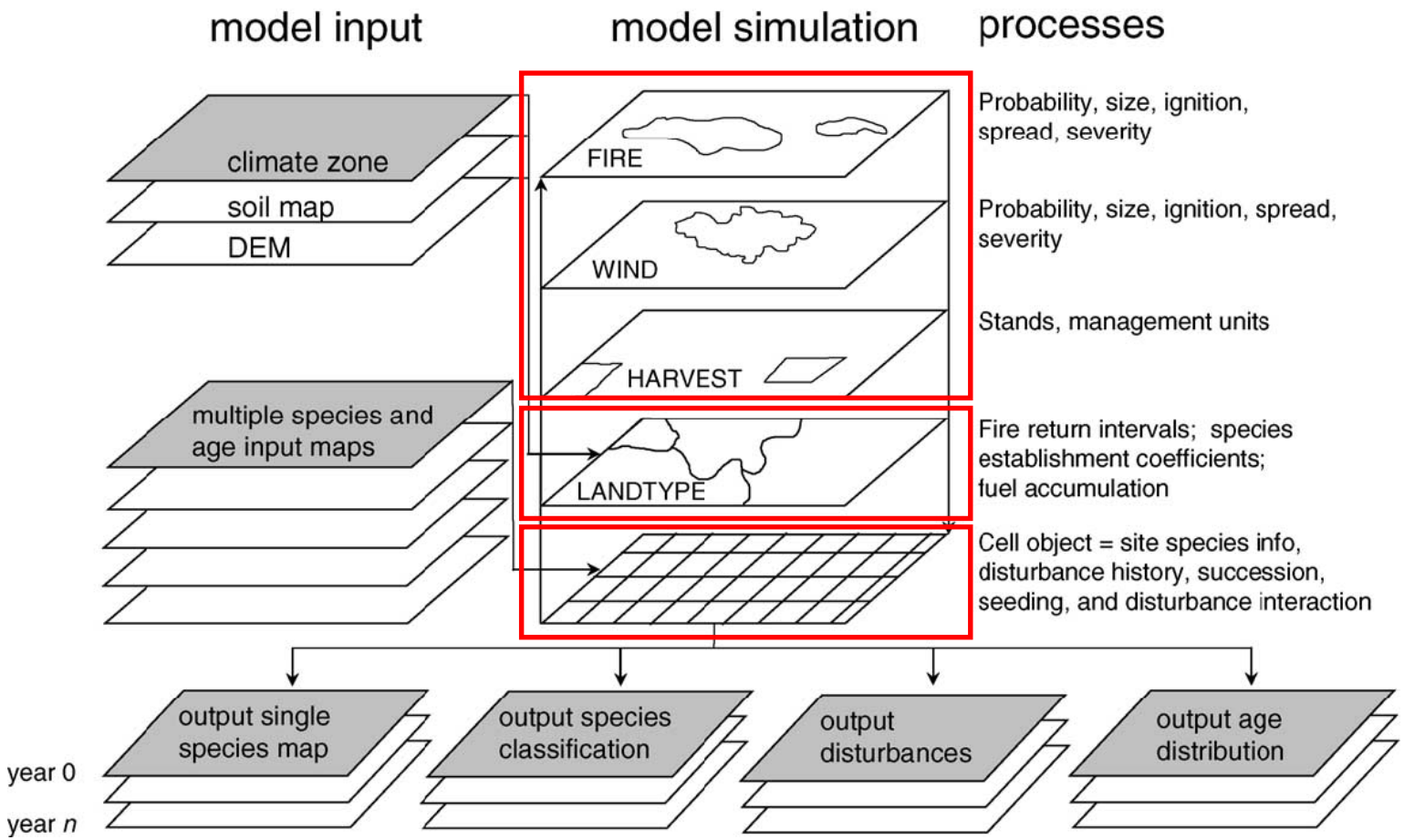
Moser, S., Meerow, S., Arnott, J. and Jack-Scott, E. 2019. The turbulent world of resilience: interpretations and themes for transdisciplinary dialogue. *Climatic Change,* 153**,** 21-40.

Growing popularity in science, policy, practice and society (200 million hits on Google in less than a second)

Getting practical



Landis-II model structure



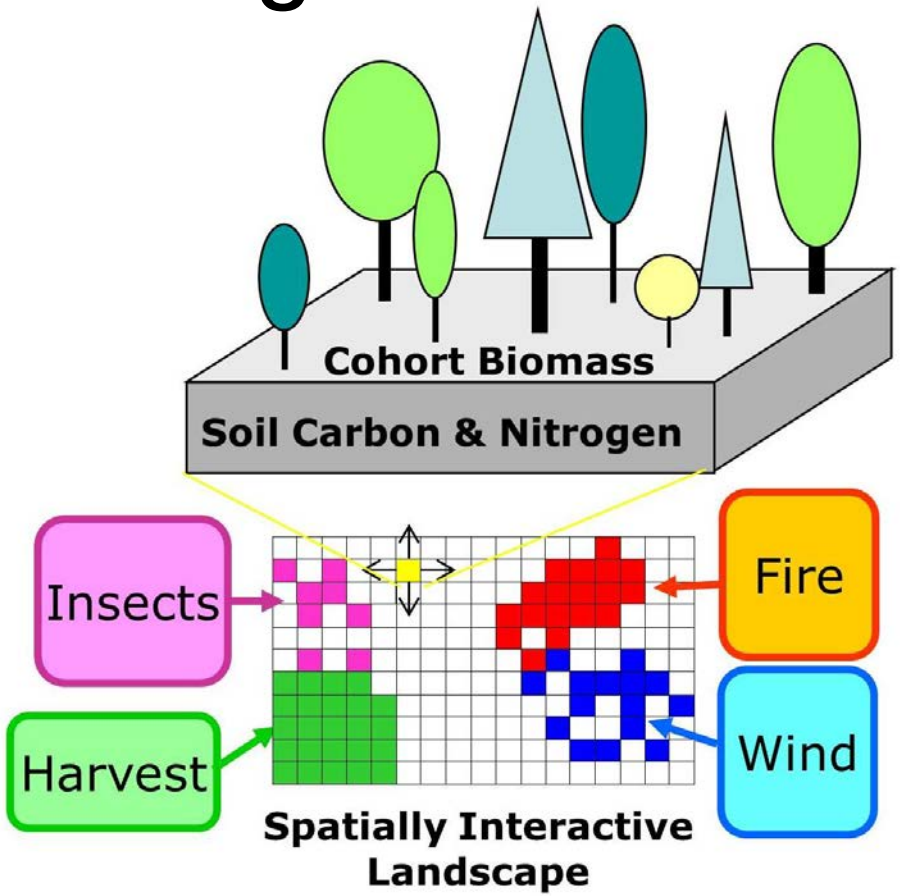
From Mladenoff D.J., 2004. Ecological Modelling: 180,7-19 (modified)

LANDIS-II

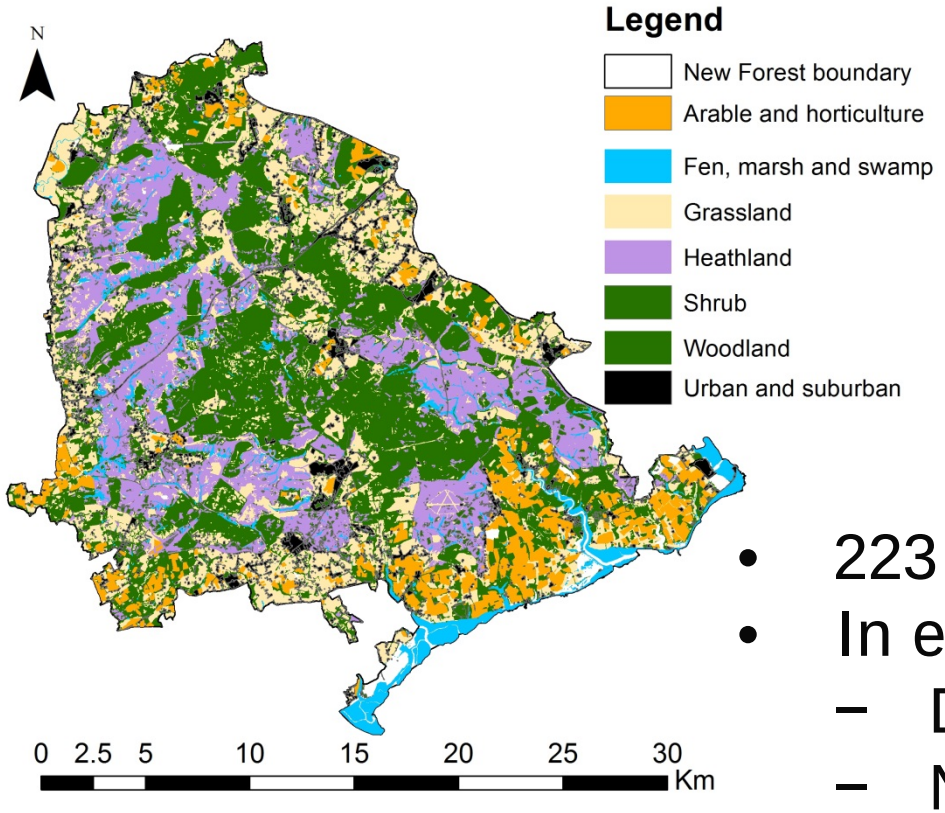
sponsored by

Portland State UNIVERSITY

Landis-II Net Ecosystem Carbon and Nitrogen Succession

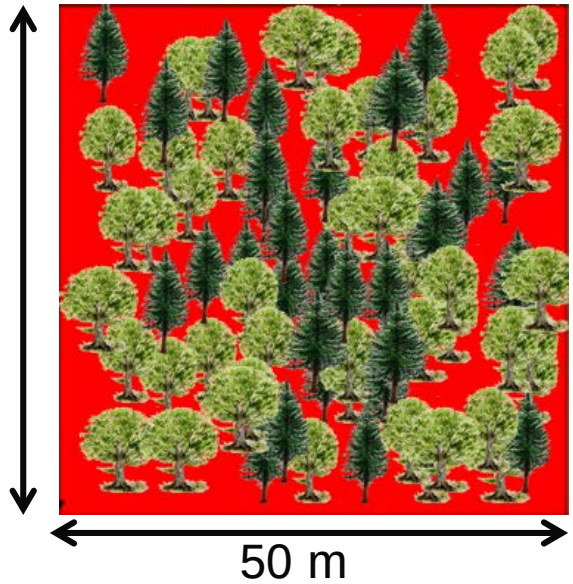


Lucash M.S., Scheller R.M., Creutzburg H. M., 2014. Century Succession. LANDIS-II Meeting. April 2014. Harvard Forest, MA.

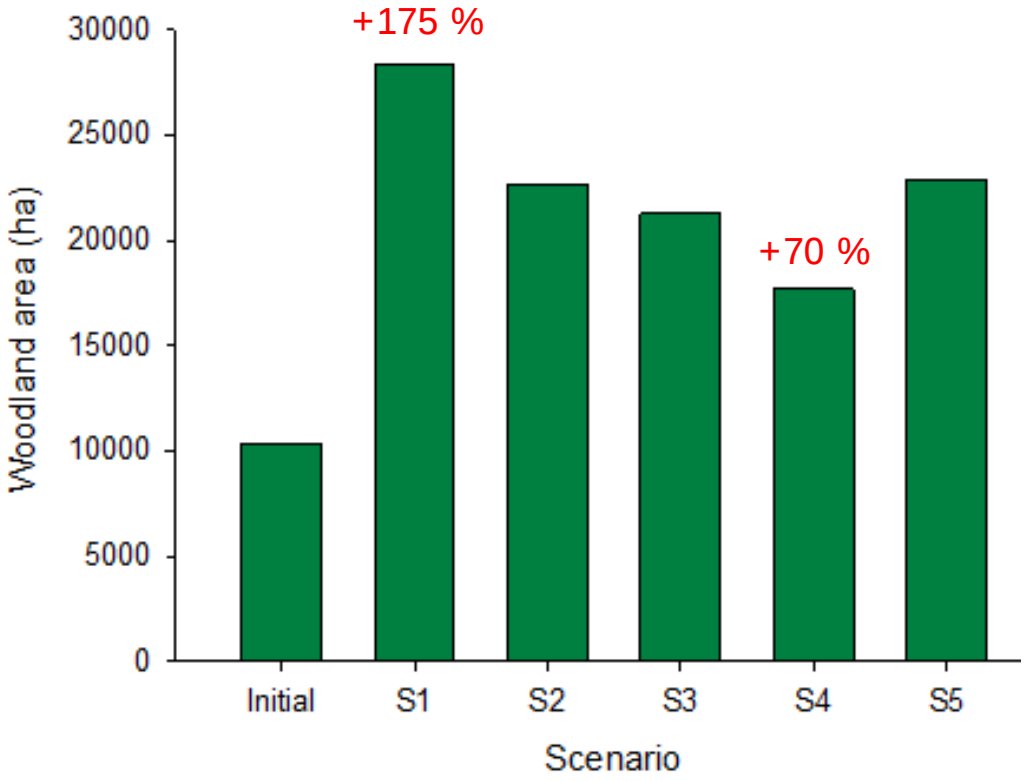


Field surveys

- 223 survey plots (0.25 ha)
- In each plot collected data on:
  - Dbh trees >10 cm
  - No of sapling
  - No of seedling
- Additional plots:
  - Soil data, ground flora, lichen, fungi, recreational and aesthetics values



New Forest resilience



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Research Article

Dynamics and Conservation Management of a Wooded Landscape under High Herbivore Pressure

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We present the use of a spatially explicit model of woodland dynamics (LANDIS-II) to examine the impacts of herbivory in the New Forest National Park, UK, in relation to its management for biodiversity conservation. The model was parameterized using spatial data and the results of two field surveys and then was tested with results from a third survey. Field survey results indicated that regeneration by tree species was found to be widespread but to occur at low density, despite heavy browsing pressure. The model was found to accurately predict the abundance and richness of tree species. Over the duration of the simulations (300 yr), woodland area increased in all scenarios, with or without herbivory. While the increase in woodland area was most pronounced under a scenario of no herbivory, values increased by more than 70% even in the presence of heavy browsing pressure. Model projections provided little evidence for the conversion of woodland areas to either grassland or heathland; changes in woodland structure and composition were consistent with traditional successional theory. These results highlight the need for multiple types of intervention when managing successional landscape mosaics and demonstrate the value of landscape-scale modelling for evaluating the role of herbivory in conservation management.

1. No-disturbances
2. Browsing
3. Heathland burning
4. Fire + browsing
5. Fire + browsing + protection from herbivores by spiny shrubs

300 years simulations

New Forest resilience

Remarkably resilient as a socio-ecological system, having withstood many mega-disturbances over the past 900 years

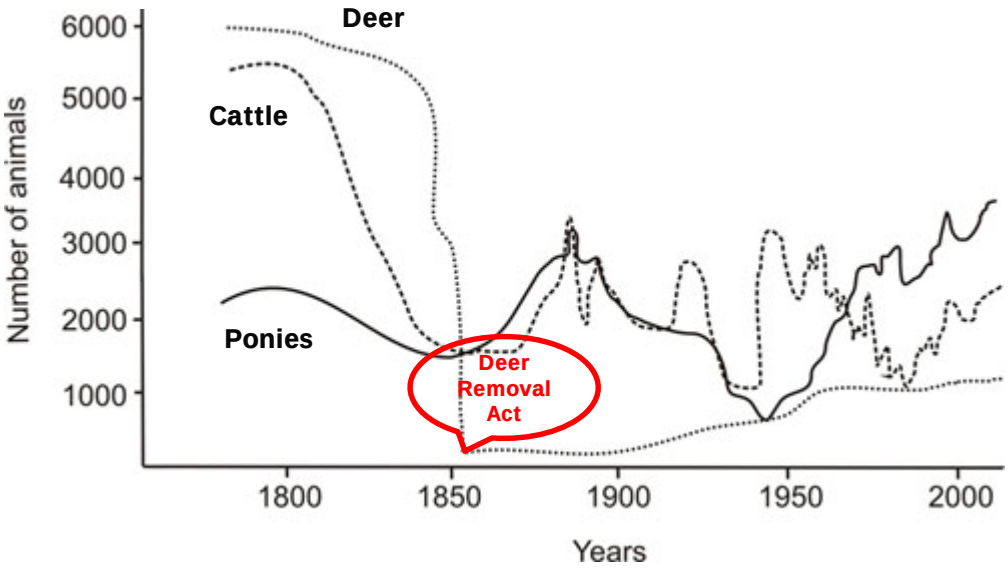
Newton, A. C. 2011. Social-ecological resilience and biodiversity conservation in a 900-year-old protected area. *Ecology and Society* **16**(4): 13.
http://dx.doi.org/10.5751/ES-04308-160413

Insight

Social-ecological Resilience and Biodiversity Conservation in a 900-year-old Protected Area

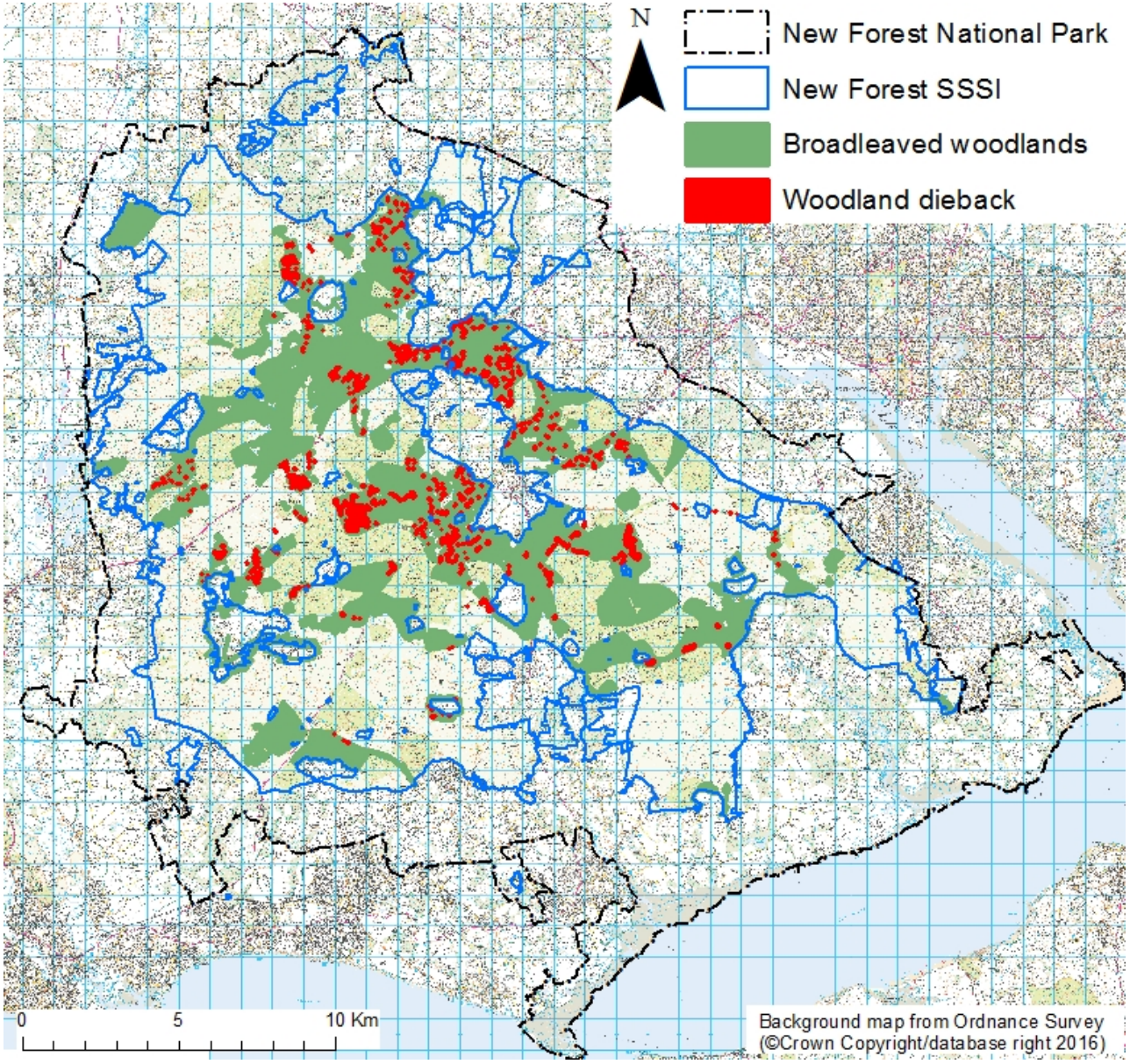
Adrian C. Newton [1]

ABSTRACT. Protected areas are increasingly being recognized as coupled social-ecological systems, whose effectiveness depends on their resilience. Here I present a historical profile of an individual case study, the New Forest (England), which was first designated as a protected area more than 900 years ago. Uniquely, a traditional pattern of land use has been maintained ever since, providing a rare opportunity to examine the resilience of an integrated social-ecological system over nine centuries. The New Forest demonstrates that over the long term, coupled social-ecological systems can be resilient to major internal and external shocks, including climate change, mass human mortality and war. Changes in governance had the greatest impact on the reserve itself, with two major crises identified in the mid-19th and 20th centuries. Resolution of these crises depended on the formation of alliances between local people and external partners, including the general public, a process that was supported by improvements in visitor access. Over a timescale of centuries, this social-ecological system has been highly dynamic in disturbance regimes but relatively stable in land use patterns. However, the factors underpinning resilience have changed over time. This case study suggests that for protected areas to be effective over the long term, social structures and institutions as well as environmental processes require adaptive capacity.

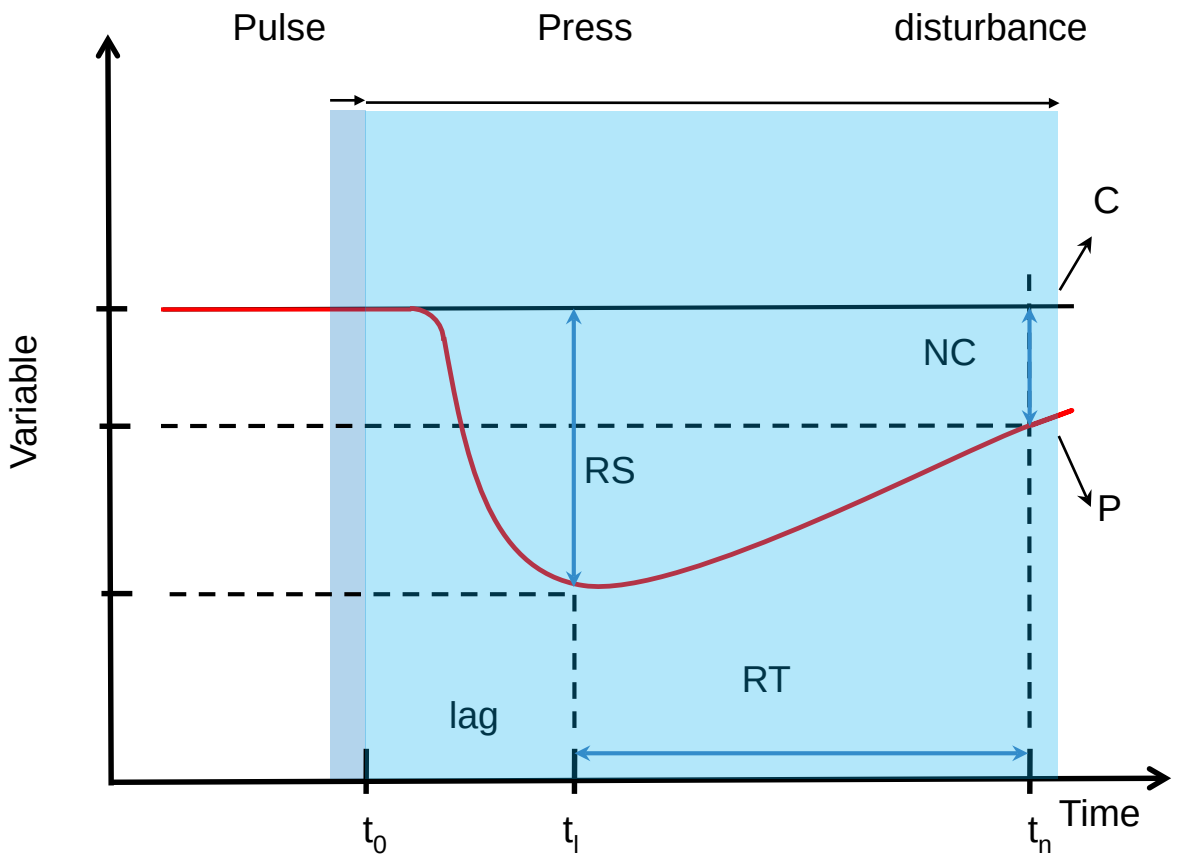


Newton A. C., 2011. Ecology and Society

New Forest stands die-back



‘Pulse’ and ‘Pulse+Press’ design



Pulse: One-off disturbance applied to 0%, 20%, 40%, 60%, 80%, and 100% of the area

Pulse+Press: One-off disturbance applied to 0%, 20%, 40%, 60%, 80%, and 100% of the area, followed by press disturbance

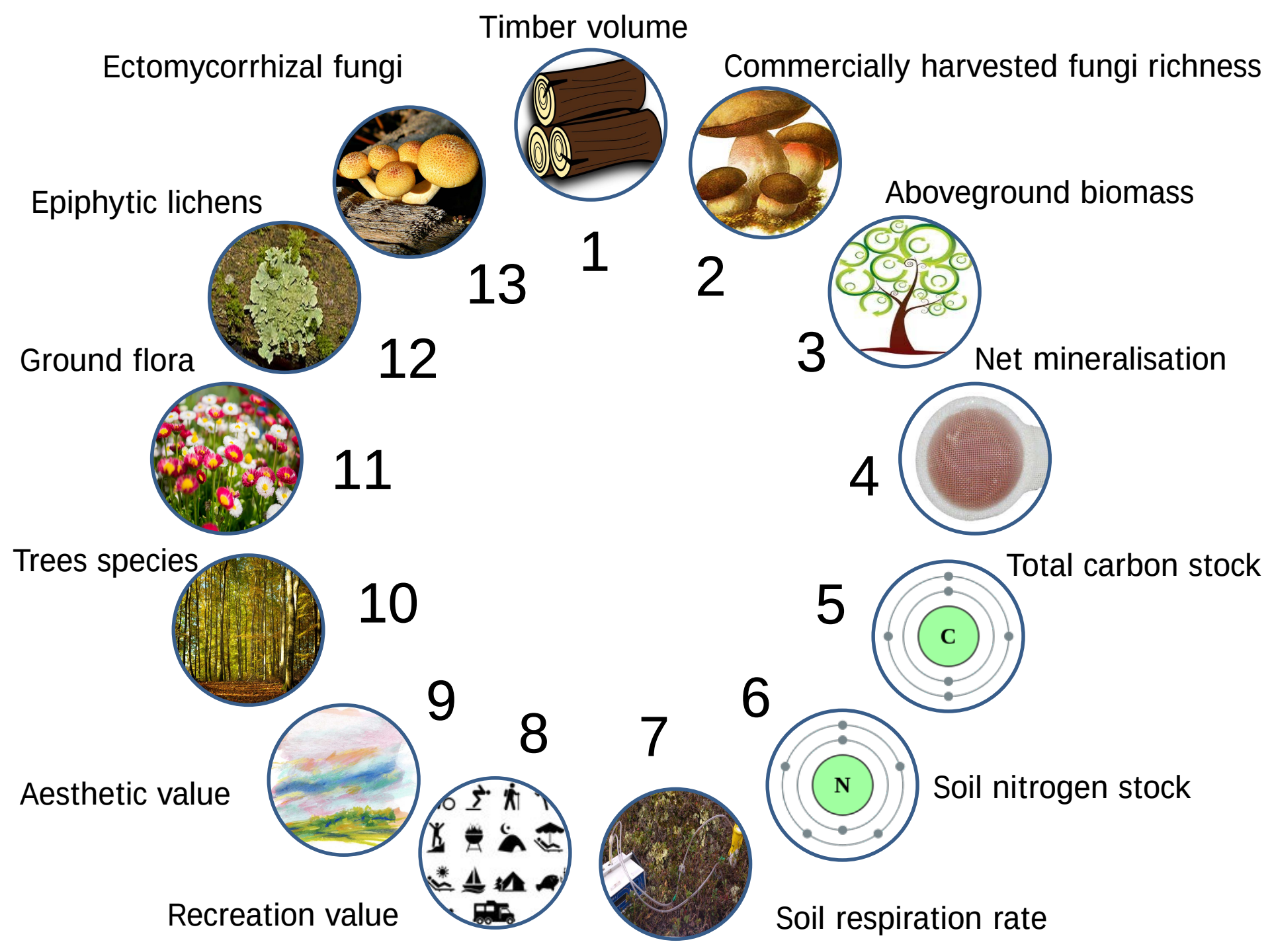
Harvesting of beech and oak>10 cm dbh. Browsing based on current levels

Resilience properties

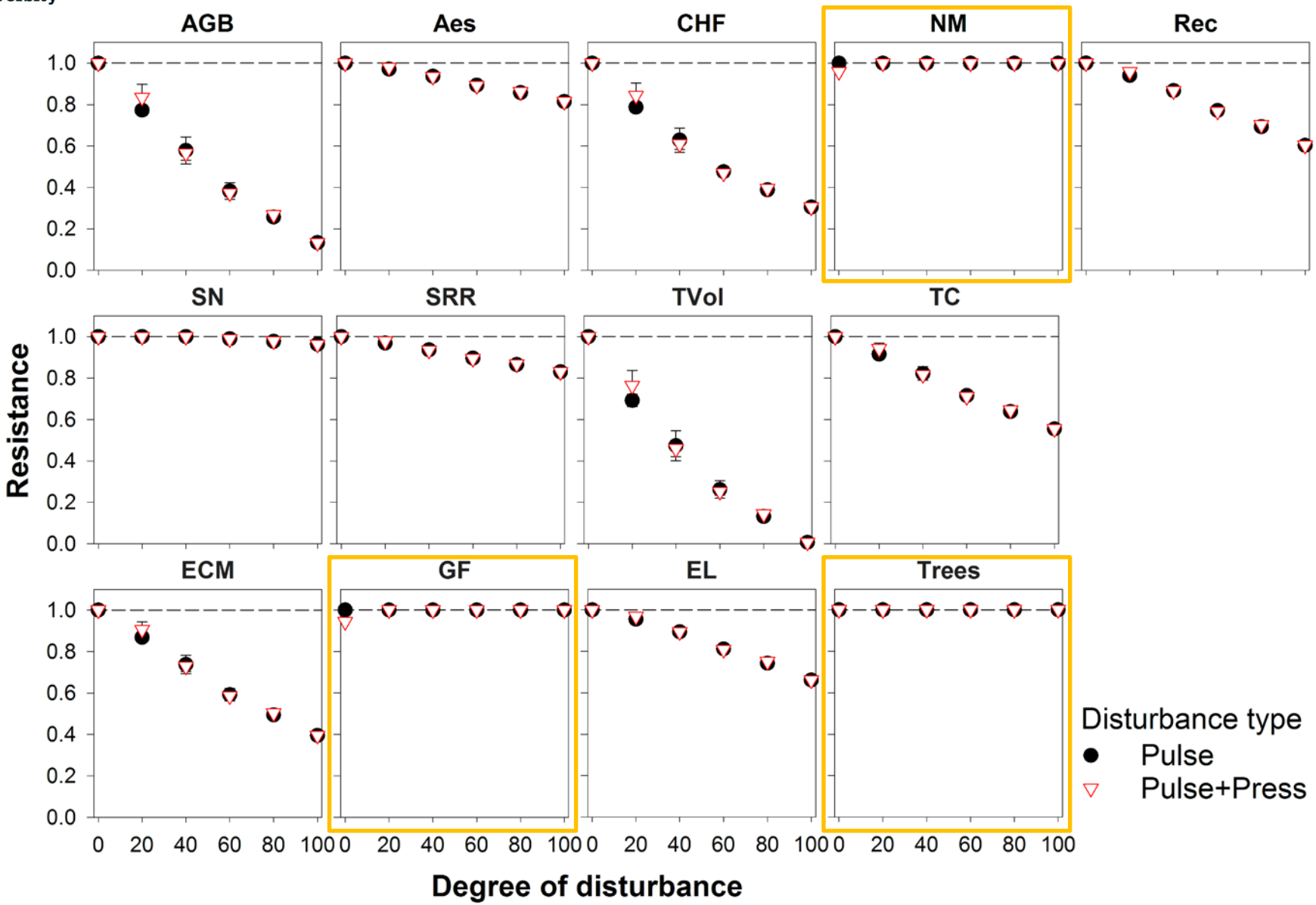
- **Resistance** - Measured as the magnitude of change of each variable (i.e. ecosystem service or biodiversity measure) caused by the disturbance.

- **Recovery time** - Measured as the time taken for each variable to return to the pre-disturbance value.

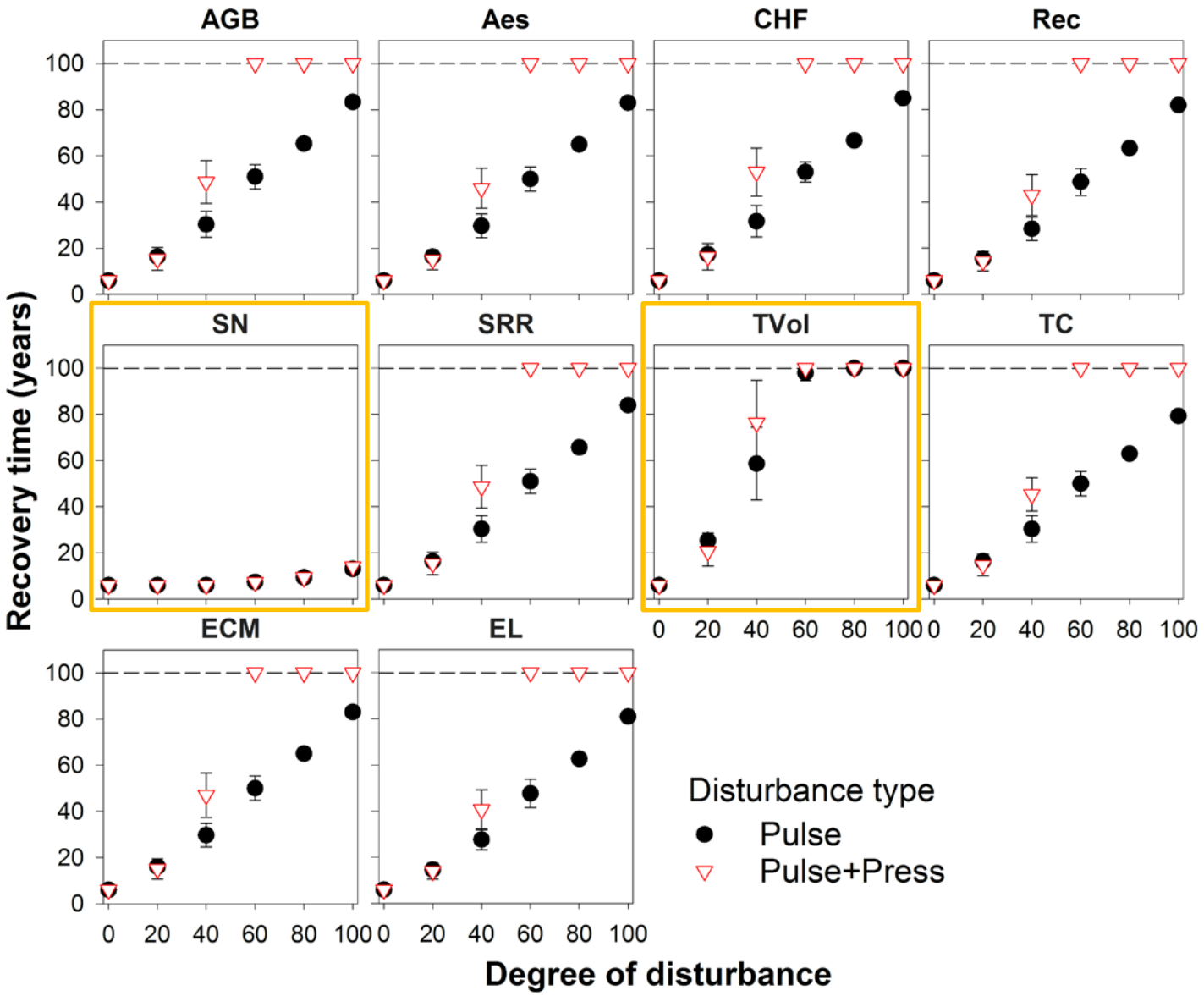
- **Net change** - Measured by comparing each variable at the end of the simulation with the pre-disturbance value.


Timber volume
1
Commercially harvested fungi richness
2
Aboveground biomass
3
Net mineralisation
4
Total carbon stock
5
C
6
N
Soil nitrogen stock
7
Soil respiration rate
8
Recreation value
9
Aesthetic value
10
Trees species
11
Ground flora
12
Epiphytic lichens
13
Ectomycorrhizal fungi

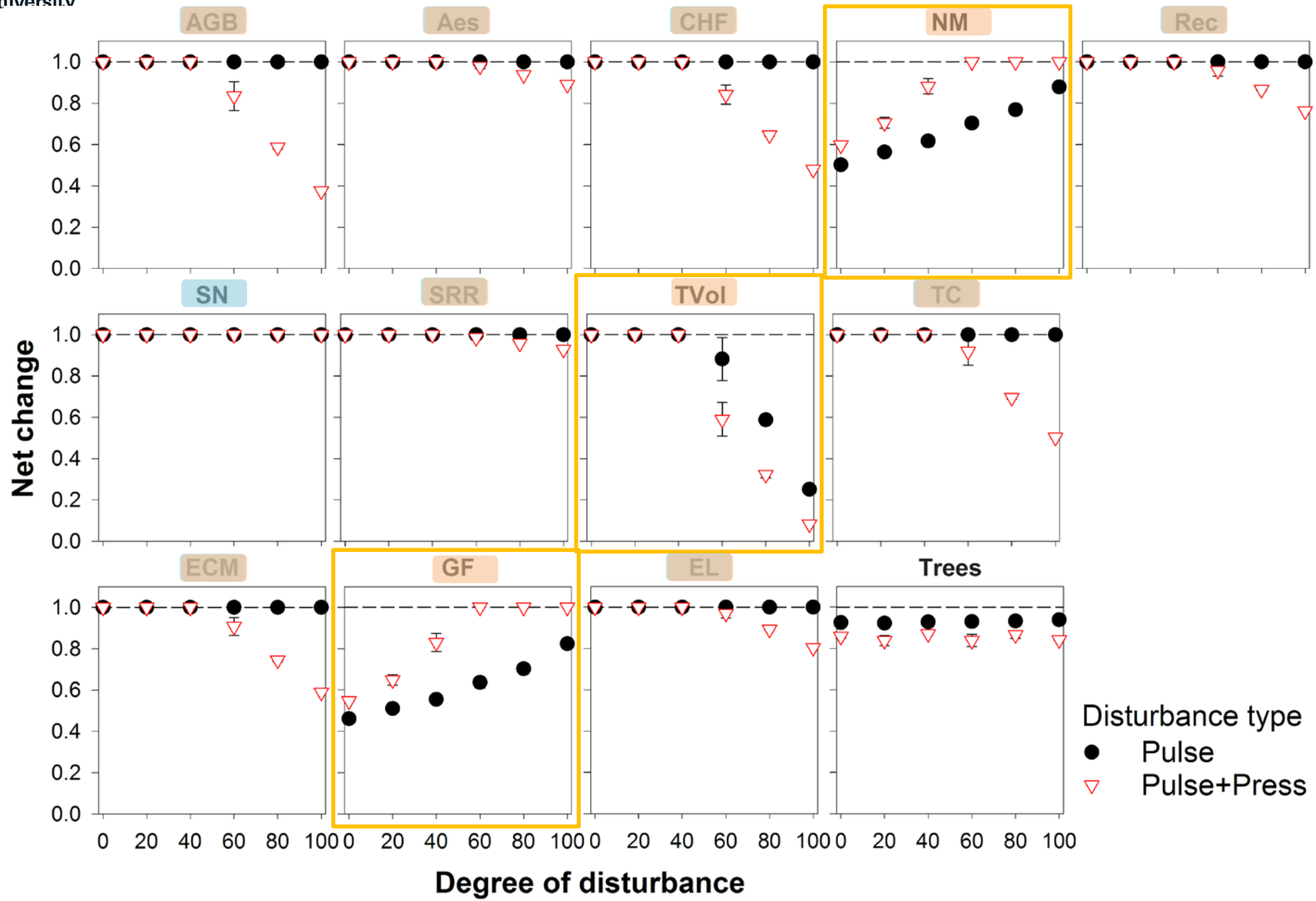
Resistance


AGB
Aes
CHF
NM
Rec
SN
SRR
TVol
TC
ECM
GF
EL
Trees
Resistance
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Degree of disturbance
Disturbance type
Pulse
Pulse+Press

Recovery


AGB
Aes
CHF
Rec
SN
SRR
TVol
TC
ECM
EL
Recovery time (years)
Degree of disturbance
0
20
40
60
80
100
Disturbance type
Pulse
Pulse+Press

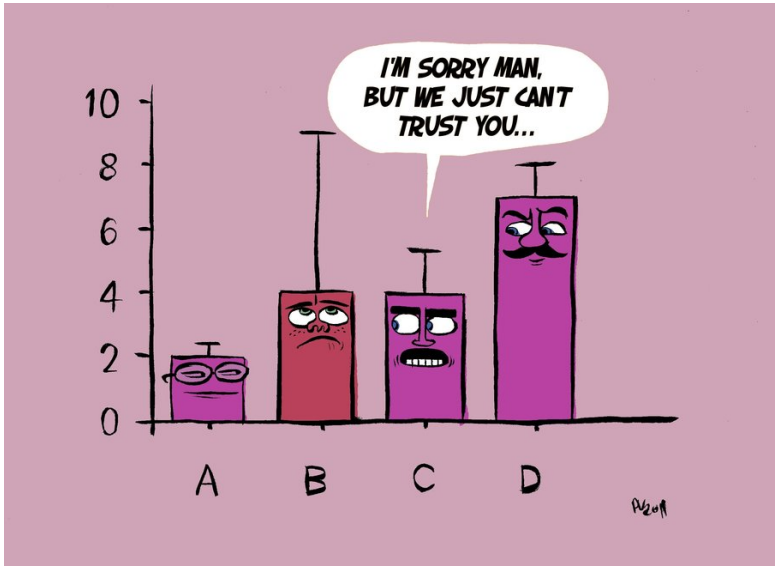
Net change


AGB
Aes
CHF
NM
Rec
SN
SRR
TVol
TC
ECM
GF
EL
Trees
Net change
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Degree of disturbance
Disturbance type
Pulse
Pulse+Press

Take home messages

1. When the New Forest as a whole is considered, **woodland area is resilient** to heathland burning and browsing combined
2. When only the woodlands are considered, the majority of **the ecosystem services and biodiversity measures are resilient to a one-off disturbance** (the black dots)
3. When only the woodlands are considered, the majority of **the ecosystem services and biodiversity measures are NOT resilient to a one-off disturbance, followed by a continuous disturbance** (the red triangles) – in other words '*When browsing is combined with a pulse disturbance that causes tree mortality, such as a windthrow event or pathogen attack, the forest displays a threshold response - resilience of the forest declines a lot more rapidly*'

Limitations



- Total carbon stock, soil nitrogen stock and tree species richness were calculated from the Century Extension of LANDIS-II, which common to all ecological models is subject to a number of limitations and assumptions.
- AGB was used as indicator for the remaining of the ecosystem services and biodiversity measures.

Implications for management

In the case study examined here, specific recommendations to enhance resilience in the short-medium term could include:

- (i) protecting tree regeneration from high herbivore pressure, which limits recruitment of trees;
- (ii) limiting the current management practice of tree cutting and heathland burning outside the woodland units, so that trees might colonise nearby grassland and heathland and adapt to the new environmental conditions.

Thank you for your attention

ORIGINAL RESEARCH

WILEY Ecology and Evolution Open Access

Quantifying resilience of multiple ecosystem services and biodiversity in a temperate forest landscape

Elena Cantarello[1] | Adrian C. Newton[1] | Philip A. Martin[1] | Paul M. Evans[1] | Arjan Gosal[1] | Melissa S. Lucash[2]

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Testing the relative sensitivity of 102 ecological variables as indicators of woodland condition in the New Forest, UK

Paul M. Evans[a,*], Adrian C. Newton[a], Elena Cantarello[a], Neil Sanderson[b], Davey L. Jones[c,f], Nadia Barsoum[d], Joan E. Cottrell[d], Stuart W. A'Hara[d], Lauren Fuller[e]

SCIENTIFIC REPORTS

OPEN

Thresholds of biodiversity and ecosystem function in a forest ecosystem undergoing dieback

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P. M. Evans[1], A. C. Newton[1], E. Cantarello[1], P. Martin[1], N. Sanderson[2], D. L. Jones[3], N. Barsoum[4], J. E. Cottrell[4], S. W. A'Hara[4] & L. Fuller[5]

Ecological thresholds, which represent points of rapid change in ecological properties, are of major

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Stand dieback and collapse in a temperate forest and its impact on forest structure and biodiversity

Philip A. Martin *, Adrian C. Newton, Elena Cantarello, Paul Evans

New Forests
DOI 10.1007/s11056-015-9489-1

CrossMark

Restoration of forest resilience: An achievable goal?

Adrian C. Newton[1] · Elena Cantarello[1]

RESEARCH ARTICLE

Analysis of ecological thresholds in a temperate forest undergoing dieback

Philip Martin¤*, Adrian C. Newton, Elena Cantarello, Paul M. Evans