SAPROXYLIC BEETLE AS INDICATOR SPECIES FOR DIFFERENT FOREST HABITATS IN GREENZONE OF ULAANBAATAR

Batchudur B.

Institute of Geography and Geoecology, Mongolian Academy of Science

Abstract: Indicator species are species that are used as ecological indicators of community or habitat types, environmental conditions, or environmental changes. In this paper, we suggest improving indicator species analysis by considering all possible combinations of groups of sites and selecting the combination for which the species can be best used as indicator. Generally, we found more indicator species of saproxylic beetle in burnt mixed forest. We identified the conspicuous Cerambycidae as the family with the highest percentage of indicator species thus recommends it as a priority indicator group for monitoring. Therefore, disturbed boreal forest has higher species richness of insects than undisturbed forest, e.g. saproxylic beetles.

Keywords: Saproxylic beetle, indicators, Greenzone forest

Introduction

The use of indicator species to evaluate effects of anthropogenic and natural disturbances in forests has been suggested as an important and realistic tool for defining sustainable forest management in elsewhere (Lindenmayer et al. 2000). They have been used to reflect forest habitat changes associated with a variety of management conditions including specific harvesting practices, such as clear-cutting and natural disturbances such as wildfire (Wikars 1997; Lachat, T. 2012). Fire creates substrate for a wide range of organisms, including several saproxylic beetles and one of the most important processes in boreal forest and widely recognized for its major impact on boreal forest ecosystem (Wikars, 1997). Thus, many species in the boreal forest are adapted to and even dependent on fire for their long term survival (Wikars 1997). Saproxylic species represent a rich group of organisms that depend on dead wood for at least part of their life cycle (Speight 1989). Saproxylic organisms are sensitive to forest management and their conservation should be central to the development of forest management practices aimed at maintaining biodiversity (Siitonen 2001). Here we found examine the evidence for wood eating beetle as bioindicators, using the boreal forests of Mongolia as a case study.

Research methods

The study was undertaken at the Greenbelt of Ulaanbaatar city, which lies on the Tuul barkh circle. The study design included fifteen forest study sites, each including five forest habitats (distance of 10-90 km within a study area) representing different forest types, and degradation: three burnt larch forest, three burnt mixed, three unburnt larch forest, three unburnt mixed forest, and three damaged by insect.

Unburnt mixed forest habitat (Khandgait I, Oinbulag, and Nukht I): This forest is a mixed dark taiga forest of Picea obovata Ledeb with varying amounts of Pinus sibirica Du Tour, Larix sibirica Led, Pinus sylvestris L and Betula platyphylla Suk that occur in the lower montane belt of Khandgait I, Oinbulag, and Nukht I. Pinus sibirica Du Tour and Pinus sylvestris L can be co-dominant or occur more rarely than Betula platyphylla Suk.

Burnt mixed forest habitat (Khandgait II, Artsat, Nukht II): These forest habitats have been subject to extensive human disturbance (fire, cutting) in the past. This boreal forest is mostly comprised of old growth stands dominated by birch (Betula platyphylla Suk) and cedar (Pinus sibirica Du Tour). Birch is a late-successional species that often comes to dominate over coniferous tree as time elapses.

Damaged by insect forest habitat **(**Bumbat, Chuluut and Khureltogoot**)**: The most common tree species in these forest is *Larix sibirica* Led, commonly known as Siberian larch. The sites of the mouth of Bumbat, Chuluut and Khureltogoot are completely defoliated and died after a gypsy moth invasion in 2005 and 2006.

Unburned larch forest habitat **(**Shadivlan, Zalaat, and Chuluut-I): This forest habitat was studied in three forest sites, namely Shadivlan, Zalaat, and Chuluut-I. These forests are not influenced by insect and fire.

Burnt Larch forest habitat **(**Shajin khurkh I, II, and Turkhurkh**)**: In the past, the Shajinkhurkh, and Turkhurkh have been impacted by fire. Fire occurred in 2006. Forest sites are located in mountainous larch (*L. sibirica* Led) dominated forest-steppe landscapes. Siberian larch is a light demanding, pioneer coniferous tree species. This species is well adapted to fire because of the dispersal ability of their lighter seeds and the fire-resistant characteristics of their bark.

The characteristics of each site are shown in Table 1.

Beetle sampling**:** Saproxylic beetles were captured using window traps and a sweep net. The window traps consisted of a 30 cm*60 cm wide transparent plastic pit with a cone-shape underneath (Jansson and Lundberg, 2000). Traps were filled with water and detergent to reduce surface tension, and a bactericide to prevent decomposition of the specimens. Samplings were conducted from July to September 2016 and 2017. The traps were placed in the trees in the middle of July, and were emptied 2 times in August and September. Eight pitfall traps in each site were spaced at least 20 m intervals. A total of 120 traps were hung from a tree stem, 1.50 m above ground. Collected insects were transferred to bottles to be killed containing cotton soaked with ethyl acetate and covered with paper. Some individuals were stored in ethanol.

Statistical analysis

IndVal method was proposed by Dufrкne and Legendre (1992) were used and ($IndVal_{ind}$) are specially designed to assess the predictive value of a species as indicator of a combination of forest site groups (Dufrкne and Legendre 1997). We used indicator species analysis (Dufrene and Legendre, 1997) and extended the method with combinations of site groups according to De Caceres and Legendre (2009).

The Ind Val index is defined as follows. For each species j in each cluster of sites k, one computes the product of two values, A_{kj} and B_{kj}*A_{kj} is a measure of specificity based on abundance values whereas B_{kj} is a measure of fidelity computed from presence data:

$$A_{kj}\text{-}N\ individualis_{kj}/N\ individualis_{k}$$

$$B_{kj}=Nsites_{kj}/Nsites_{k}$$

$$Ind\ Val_{kj}=A_{kj}*B_{kj}$$

n the formula for specificity (A_{kj}), N individualis $_{kj}$ is the mean abundance of species j across the sites pertaining to cluster k and N individual $_{k}$ is the sum of the mean abundance of species j within the various clusters.

Indicator Species: Computation

Table 1. Numerical example: Abundance of three species at 15 sites divided into five groups

Groups	Group			Group 2			Group 3		
Sites	1	2	3	4	5	6	7	8	9
Species 1	9	9	9	6	6	6	5	5	5
Species 2	8	8	8	4	4	4	6	6	6
Species 3	12	12	12	2	2	2	0	0	0

Species 1

Ak	9/15	6/15	5/15
Bk	3/3=1	3/3=1	3/3=1
IndVal	0.6	0.4	0.3

Species 2

Ak	8/15	4/15	6/15
Bk	3/3=1	3/3=1	3/3=1
IndVal	0.5	0.3	0.4

Species 3

Ak	12/15	2/15	0/15
Bk	3/3=1	3/3=1	
IndVal	0.8	0.1	0

Top panel: Species abundance data. Bottom: Calculation of the specificity (Akj), fidelity (Bkj) and IndVal kj index for each species (j) in each group of sites (k). The maximum value of IndValkj for each species is in bold. Source: Modified from Dufrene M and Legendre P (1997). Species assemblages and indicator species: The need for a flexible asymmetrical approach. Ecological Monographs 67. 345-36.

Results

***Indicator species*:** We considered a total of 1035 indviduals representing 112 species and 29 families of saproxylic beetle in this study. Using the IndVal, 61 indicator species which respresented 20.5% of the 112 species were computed for the 15 selected site combinations, (see indicator list in Table A1). These indicator species belong to 10 families of saproxylic beetle. Considering the absolute number of indicator species, the Cerambycidae had the highest number of indicator species (n=21), followed by the Buprestidae (n=9), Scolytidae (n=5), Elateridae (n=6). Therefore, over 60% of the collected families comprise indicator species for habitat conditions. In general, more indicator species were found at damaged by insect forest and burnt mixed forest sites than at burnt larch forest sites. The value of best indicator species (Ind Val>0.25) was 0.25. For species *Ampedus balteaus*, IndVal has the highest value for damaged by insect forest so Ind Val =1.6. Also, *Antaxia quadripunctata* has a value of 1.2 for damaged by insect forest and a value of 1.2 for the unburnt larch forest (Table 3). It seemed peculiar to find the Antaxia as an indicator species for larch forests with large amounts of dead wood. Tetropium castaneum lin, 1758 (IndV-0) and *Tetropium gracilicorne Reitt*, 1889 (IndV-0) was not sensitive to the unburnt forest, but was an indicator for burnt forest site. In contrast, *Phaenops guttulatus* Gebl (IndV-0.7) was associated with drying larch which is weakened by drought and outbreak of pest insects. *Necydalis major* (IndV-) can be considered as an indicator for sun-exposed large-size deciduous snags. *Exocentrus conjuga, Hylobius abietes, Hylopgops glabratus, Thanasimus, Elateroides dermestoides* L, 1761, which occurred only in the unburnt mixed forest habitat, are potential bioindicators for the deciduous (with larch) forest habitat.

Table 2. List of the indicator species of saproxlic beetle, with their indicator value (IndVal).

Groups	DBI	UM F	UL F	BL F	BM F
Sites	Indval				
Anobium rufipes F, 1792	0.1	-	-	-	0.2
Dalopius marginatus Linnaeus, 1758	-	0.3	-	-	-
Mordellistena humeralis L, 1758	0.3	-	-	-	-
Acanthocinus carinulatus Gebl, 1833	-	-	-	0.3	-
Acmaeops marginatus F	-	-	0.1	-	-
Acmaeops pratensis Laich, 1784	-	-	-	-	1.0
Acmaeops septentroinis Thoms, 1866	-	-	-	-	0.3
Agonum sp	-	-	-	-	0.3
Agrilus betuleti Ratzeburg, 1837	-	-	-	-	0.3
Ampedus balteatus Linn, 1758	1.6	-	-	-	0.1
Ampedus sobrinus Motsch, 1860	0.2	0.2	-	-	-
Anaspis sp	-	-	0.3	-	-
Anoplodera rubra	-	-	-	0.1	-

Anostrirus boeberi Germ., 1824	-	-	-	-	0.3
Antaxia quadrifoveolata Solsky, 1871	1.2	0.2	1.6	0.1	0.5
Antaxia quadripuntata	1.0	-	-	0.9	0.3
Aphodius melanostictus Schmidt, 1840	0.7	-	-	-	-
Aphodius mongolicus Mnnh, 1852	0.9	-	-	-	-
Aphodius satellitus Hbst, 1789	-	-	-	0.3	-
Asemum striatum L., 1978	-	-	-	-	0.7
Asproparthenis sp	0.3	-	0.1	-	0.1
Athous sp	-	0.1	-	-	-
Bitoma crenata F., 1775	-	0.3	-	-	-
Boros schneideri Panz., 1795	0.1	-	0.1	-	0.3
Buprestis haemmorrhoidalis sibiricus Herbst, 1780	1.8	-	0.2	-	0.4
Buprestis rustica Linn, 1758	0.5	-	-	0.3	-
Buprestis strigosa Gebl., 1830	0.9	-	0.8	-	0.8
Callidium violaceum Linn, 1758	-	-	-	-	-
Canifa sp	-	-	-	-	0.3
Cantharis daurica Mnnh	-	-	0.1	-	-
Carabus canaliculatus Adams	-	-	-	0.1	-
Catops angustitarsis	-	-	-	-	-
Chlorophorus gracilipes Fald, 1835	-	-	0.3	-	-
Chrysobothrus chrystigma Linn., 1758	-	-	0.3	-	-
Cis sp	-	0.1	-	-	0.3
Cossonus linearis F., 1775	-	-	0.3	-	-
Cryptophagous corticinus	-	-	0.1	-	-
Cryptophagus dorsalis Sahlb., 1834	-	-	0.1	-	0.2
Cryptophus corticinus Thoms., 1863	-	0.3	-	-	-
Ctenicera cuprea F	0.1	-	-	-	-
Curculio sibiricus	0.3	-	-	-	-

Thunb, C.P., 1799					
Cylister sp	-	-	-	-	0.1
Dacne notata Gm., 1788	0.3	-	-	-	0.3
Danosoma fasciatus Linn, 1758	-	-	-	-	0.3
Denticolis borealis Payk., 1800	-	-	0.7	-	-
Diacanthous undulatus De Geer, 1774	0.3	-	-	-	-
Dicerca furcata Thunb., 1787	-	-	-	-	1.0
Dorcatoma dresdensis Herbst, 1792	-	0.3	-	-	-
Elateroides dermestoides L, 1761	-	2.0	-	-	-
Eodorcadion carinatum Fabr, 1781	2.0	-	-	-	-
Exocentrus conjugatofasciatus Tsher, 1973	-	0.7	-	-	-
Harminius undulatus, De Geer, 1774	-	0.3	-	-	-
Harphalus	0.1	-	1.1	-	-
Hylobius abietis Linn, 1758	-	0.7	-	-	-
Hylurgops sp	-	0.3	-	-	-
Hylurgops glabratus Zetterstedt 1828	-	0.7	-	-	-
Ips sexdentatus Boerner,1767	-	0.2	-	-	-
Ips subelongatus Motsch	-	-	-	0.3	-
Judolia sexmaculata Linn 1758	0.3	0.1	0.1	-	1.0
Leiodes ciliaris Schmidt, 1841	0.3	-	-	-	-
Leperina squamulata Geb, 1830	-	-	-	0.2	-
Leptura duodecimguttata Fabr, 1801	-	-	-	-	1.0
Leptura nigripes De Geer, 1775	-	-	-	-	0.3
Leptura sequence	1.1	-	0.8	0.1	1.7
Leptura variicornis Dalman, 1817	0.3	-	-	-	-
Lepura virens Linn., 1758	-	-	-	-	0.7
Lordithon trimaculatus Payk., 1800	-	-	-	-	0.7

Loricera sp	-	-	0.7	-	-
Magadalis violacea	0.1	-	-	-	-
Melanophila acuminata	0.1	-	-	-	-
Mesosa myops Dalm, 1817	-	-	-	-	0.7
Monochamus galloprovincialis pistor Germ, 1818	-	0.7	-	-	-
Monochamus salttuarius Gebl, 1830	-	0.3	-	-	-
Monochamus sutor L,	-	-	-	-	0.3
Mordella holomelaena Apfel, 1914	-	-	-	-	0.3
Mordella mongolica Ermisch, 1964	-	-	-	-	0.3
Neatus picipes	-	-	-	-	0.1
Necydalis major L, 1758	-	-	0.1	-	0.9
Nivellia sanguinosa Gyll, 1827	0.2	-	-	-	0.1
Oberea oculata L, 1758	-	-	-	0.3	-
Oedostethus kaszabi	-	-	-	-	0.3
Orchesia acicularis Rtt., 1886	-	*0.3*	-	-	0.7
Orthotomicus larix F., 1792	-	-	0.3	-	-
Ostoma ferruginea	0.1	-	-	-	-
Phaenops guttulatus Gebl., 1830	0.7	-	-	-	-
Phytho depressus L., 1767	-	-	0.3	-	-
Plastysomus albinus	0.1	-	-	-	-
Platycis cosnardi Chev, 1839	0.1	0.3	-	-	0.1
Podabrus dilabicollis Motsch	-	-	-	0.1	-
Ptinus quadripunctatus Gebl, 1847	0.3	-	0.3	-	-
Rhagium inquisitor L, 1758	-	0.3	-	-	-
Saperda scalaris L, 1758	-	-	0.1	-	-
Saperda sp	-	-	0.3	-	-
Scaphisoma assimile Erich 1845	-	-	-	-	0.3
Scolytus ratzeburgi Jans 1856	-	-	0.3	-	0.4
Selatosomus aeneus Linn, 1883	-	0.3	-	-	-

Selatsomus confluens confluens Gebl., 1830	0.8	-	-	-	0.6
Selatsomus melanchoicus Fab, 1798	-	-	-	-	1.9
Serrophipus barbatus Schall	-	-	-	0.1	-
Stephanopachys substriatus Payk, 1800	-	-	-	-	0.3
Stictoleptura variicornis Dalman, 1817	-	-	0.3	-	-
Strangalia nigripes rufiventris Bless, 1872	-	-	-	-	0.7
Tachyta nana Gyll., 1810	-	0.3	-	-	-
Tetropium castaneum Linn, 1758	-	-	-	0.4	0.6
Tetropium gracilicorne Reitt, 1889	-	-	-	0.3	0.3
Thanasimus femoralis Zett., 1828	-	1.7	-	-	-
Thanasimus femoralis Zett., 1828	-	0.4	-	0.1	-
Thymalus sp	-	-	0.1	0.1	0.3
Trichodes ircutensis Laxm, 1759	-	-	2.0	-	0.8
Triplax rufiventris Gebl., 1823	-	-	-	-	0.7
Trypophloeus sp	-	-	0.7	-	-
Ups ceramboides L, 1758	-	-	-	-	0.1

Generally, disturbed boreal forest has higher species richness of insects than undisturbed forest, e.g. saproxylic beetles. Several species of saproxylic beetles are known to attack fire-injured trees. Wherever *Larix sibirica* trees were killed by fire, *Boros schneideri* larvae were found under the bark. Also, the wood with different qualities is necessary for high species individuals and diversity. The Tenebrionid *Upis ceramboides* was common on burned birch trees, with many larvae in trees of advanced stages of decomposition. The Cerambycid *Mesosa myops* was also common and occurred mostly on burned birch trees, often together with *Monochamus urussovii*.

Conclusion

Our study provides a list of indicator species for different forest habitats with the different quality and amounts of dead wood and forest type and condition. This is a first step toward list of indicator species as a baseline for conservation activities in selecting priority sites and improving monitoring.

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References

Dufrкne, M. & Legendre, P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs, 67(3). p 345-366

Holland JD. 2007. Sensitivity of Cerambycid biodiversity indicators to definition of high diversity. Biodiversity and Conservation 16: 2599–2609.

Jansson, N. & Lundberg, S. 2000. Beetles in hollow broadleaved deciduous trees–Two species new to Sweden and the staphylinid beetles (Coleoptera: Staphylinidae) Hypnogyra glabra and Meliceria tragardhi found again in Sweden. Entomol. Tidskr., 121:93-97.

Jennie L. Pearce, Lisa A. Venier. 2006. The use of ground beetles (Coleoptera: Carabidae) and spiders (Araneae) as bioindicators of sustainable forest management: Ecological indicators 6. p780-793

Lindenmayer et al. Biodiversity Indicators for Ecologically Sustainable Forestry. Conservation Biology. Volume 14, No. 4, August 2000

Martikainen, P., Siitonen, J., Punttila, P., Kaila, L., and Rauh, J. 2000. Species richness of Coleoptera in mature managed and old-growth boreal forests in southern Finland. Biological Conservation, 94: 199-209.

Speight, M.C.D. 1989. Saproxylic Invertebrates and Their Conservation. Council of Europe Publications, France.

Lachat, T. Wermelinger, B. Gossner, (2012). Saproxylic beetles as indicator species for dead-wood amount and temperature in European beech forests. Ecological Indicators 23, 323–331.

Wikars, L.-O., 1997. Effects of forest fire and the ecology of fire adapted insects. Ph.D. thesis. University of Uppsala, Uppsala, Sweden.

Speight M.C.D., 1989. Saproxylic Invertebrates and Their Conservation. Council of Europe Publications, France p 15-30

Siitonen J., 2001. Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. Ecological Bulletin, 49, 11-14