

# The biodiversity values of European virgin forests

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## Abstract

What makes virgin forests better forests? Biodiversity evaluation depends on the value systems of the stakeholders involved. Indicators for conservation value, ecosystem functions, wilderness, uniqueness, or species richness may not correlate, or even correlate negatively. Based on arthropod data from a comparative study in two types of virgin forests in core areas of the Carpathian Biosphere Reserve in Ukraine and managed forests in Switzerland with matching tree species composition, several biodiversity aspects and their underlying value systems are presented and discussed.

There were no significant differences in species richness between virgin and managed forests. Most arthropod groups tended to be more divers in managed forests, while saproxylic beetles, and fungi, millipedes and molluscs were more divers in virgin forests. The most obvious assets of virgin forests in terms of biodiversity values are wilderness and uniqueness. The conservation value, focussing on rare and threatened species, seems to be of lesser importance in Central European virgin forests. Other values of forest biodiversity such as species richness and ecosystem functions are unsuitable for valorising virgin forests in comparison to managed forests.

Keywords: virgin forests, biodiversity, evaluation, values

## 1 Introduction

The paradigm that virgin forests are treasures of biodiversity has its origin in the fact that tropical rain forests harbour a large proportion of global biodiversity – and that there is a lot more to be detected in those forests (GROOMBRIDGE 1992; WILSON 1992). People associate pristine forests with impenetrable undergrowth and areas never explored by science. The general assumption is that the more natural a forest is, the higher must be its species richness, and hence the more important it is for regional, national or global biodiversity. Our investigations in the Transcarpathian Biosphere Reserve have shown that this apparently is not the case for species richness in virgin beech forests in Central Europe (COMMARMOT *et al.* 2000). Further investigations in virgin fir-beech forests in Transcarpathia and in managed fir-beech forests in Switzerland have given similar results (CHUMAK *et al.* this issue). If species numbers are not significantly higher in virgin forests than in managed forests, what are the entities or aspects of biodiversity that are qualifying virgin forests as something special, something worthwhile being protected by law?

## 2 Tropical rain forests

Tropical rain forests have always been considered to be the most significant terrestrial biodiversity hot spots of the world (ERWIN 1982; HAMMOND 1992; STORK 1991). Especially the forest canopy is presently investigated in numerous projects with sometimes spectacular methods (<http://www.globalcanopy.org/canopycam/>).

One of the basic questions in biodiversity research was, and still is, how many species there are on this planet, and how many still undetected species live in the pristine tropical forests (MAY 1988; STORK 1993). When Terry Erwin, an American Entomologist, wanted to make an estimate on how many species are living on our planet, he started out with tropical rain forests, and with arthropods (ERWIN and SCOTT 1980), because they make up by far most of compositional and functional biodiversity (HAMMOND 1992). Terry Erwin and his crew fogged entire trees with huge insecticide canons and spread white sheets under the trees to collect all animals falling down from the foliage. Thus they were able to count the number of species per unit area of the forest. In Panama, they found 1200 beetle species on one single tree species (ERWIN and SCOTT 1980). In Peru, with the same method, one hectare of tropical rain forest yielded 41 000 arthropod species, which is more than the known species number in any Central European country. In the rain forests of Borneo, (STORK 1991) collected an average of 617 insect species per single tree, with maxima well over 1000 species. Compared to these figures, the species numbers of native British trees seem rather modest, with an average of 200 insect species per single tree (SOUTHWOOD 1961). Collecting areas of similar size (6–700 m<sup>2</sup>) yielded 151 beetle species in Richmond Park (UK) and 1056 species in the Dumoga-Bone National Park in Sulawesi (HAMMOND 1990; STORK 1995).

Since we have an approximate idea of how many percent of overall organismic species are arthropods, insects, or beetles (HAMMOND 1992), we can estimate, from those figures, the overall species richness of all organisms in these forests. But Terry Erwin went even further and extrapolated the number of species of all organisms on this planet. He came up with figures as high as 30 million species, other researchers in Asian rain forests got even higher estimates (STORK 1993).

A closer look at the publications on species diversity in tropical rainforests reveals that in fact not the canopy is the most specious stratum, but the forest floor. In an Indonesian forest, STORK (1991) found that only 24% of the arthropod species were collected in the canopy, but 70% in leaf litter and in the soil. Similarly, in a rain forest in Sulawesi, HAMMOND (1990) identified only one quarter of the beetle species as canopy specialists, but three quarters were ground specialists.

In summary we can safely assume that tropical rain forests harbour an essential proportion of overall species richness on this planet. Since most of them are pristine forests, the immense contribution of virgin forests to global biodiversity is indisputable.

But what about boreal or temperate natural forests, as we find them in Central and Eastern Europe?

## 3 Virgin forests in Central Europe

As far as we know, nobody has done any large scale fogging of entire trees in virgin forests in Europe. Occasional insecticide treatments against forest defoliators to our knowledge have never been used to assess overall species richness in those forests. But recently there have been some standardized samplings with flight- and pitfall traps, which allow for direct com-

parison of arthropod diversity between virgin forests in the Carpathian Biosphere Reserve and managed forests in Switzerland (COMMARMOT *et al.* 2000); CHUMAK *et al.* this issue). Furthermore, preliminary results of comparative samplings of Gastropoda (Rüetschi, unpublished) and xylobiont fungi (Kueffer and Senn-Irlet, unpublished), collected at the same locations as the above arthropod samplings, are available for assessing the relative importance of virgin forests for biodiversity.

Table 1 gives the species numbers of selected groups of invertebrates collected with standardised inventory methods in two types of virgin forests in the Carpathian Biosphere Reserve and in two types of managed Swiss forests with a similar tree species composition, altitude, and exposition as their Ukrainian counterparts.

For most taxa there was a trend for more species in the managed forests, albeit not statistically significant (CHUMAK *et al.* this issue). Even for saprophagous groups such as millipedes, gastropods or saproxylophagous beetles there was no consistently and significantly larger species richness in virgin forest plots. The xylobiont fungi were more numerous and more divers in the virgin forests, but due to the high variance and the limited number of replicates, the results are not statistically significant.

Tab. 1. Comparison of average species richness in virgin Ukrainian forests and managed Swiss forests (arthropod data from CHUMAK *et al.* this issue; snails from unpubl. data, J. Rüetschi; fungi from unpubl. data, N. Kueffer and B. Senn-Irlet).

Average number of species/plot	UA, Galio-Fagetum	p (t-test)	CH, Galio-Fagetum	UA, Abieti-Fagetum	p (t-test)	CH, Abieti-Fagetum
In total	210.7	0.643	217.3	203.7	0.213	268.5
Araneae	27.5	0.060	48.5	27.5	0.099	59.5
Myriapoda	19.5	0.090	23.0	23.5	0.356	15.5
Coleoptera	123.5	0.542	116.5	112.0	0.258	164.5
Carabidae	17.5	1.000	17.5	17.0	0.416	25.5
Staphylinidae	30.5	0.795	31.5	25.5	0.100	44.5
Mollusca	20.8	0.235	14.3	16.0	0.276	12.0
Xylobiont fungi	19.4	0.097	15.0	24.7	0.156	17.0

#### 4 Anthropocentric value systems

For biodiversity assessment, species numbers are the currency most often used indicator in practice. "Species are the units of biodiversity" is even a book title (CLARIDGE *et al.* 1997). While species richness is an important and easily comprehensible measure of biodiversity, it is by no means the only one. For most people the various species in a forest are not of equal importance. Large, nice, rare and threatened species are valued much higher than inconspicuous, small, common and widespread species. Furthermore, the notion of biodiversity goes far beyond organismic diversity (WILSON 1992). For an evaluation of the importance of virgin forests for biodiversity, we have to consider the most important anthropocentric value systems involved in forest biodiversity assessment. Six of them will be treated in the following.

**Conservation (of species and genotypes):** People have different motivations for species conservation. A very profound one for most human beings is the ethical or socio-cultural motivation, which tries to avoid doing harm to living creatures, or to force a species into extinction just for human need or greed. Another anthropocentric motivation for species conservation is to keep up the potential of genetic resources for later use. A highly underestimated motivation for conservation is the very human fascination for all things rare and endangered (arts, stamps, antiquities, etc.). Similarly, we value plant and animal species just for the fact that they are unique, irreplaceable singularities.

**Ecological resilience:** In general terms, the resilience paradigm reflects the old notion of “the balance of nature” (PIMM 1991). The more species there are in an ecosystem, the more flexible it can react to disturbances (CROPP and GABRIC 2002; NAEEM and LI 1997; NAEEM *et al.* 1994). The more niches in a habitat are filled, and the more seemingly redundant species there are in those niches, the better the insurance that in case of an environmental change or a sudden impact, such as a forest fire or wind-throw, the species community is able to react swiftly and adequately (ALLISON 2004). The higher the resilience of an ecosystem, the quicker the species composition will return to its original equilibrium state. Species numbers (alpha diversity) are the most practicable and straight-forward indicator for ecological resilience (DUELLI and OBRIST 2003). This indicator gives equal weight to all species and thus is basically different from an indicator for conservation value, such as the number and/or category of red listed species. It is very likely, that evenness also is linked with resilience, but so far we were unable to find scientific evidence in the literature.

**Ecosystem functions:** A value system, which focuses on specific subsets of the above ecological resilience value. A higher biodiversity in certain guilds or taxa enhances certain ecological performances (BOLGER 2001; LOREAU 2004). For forest ecosystems, the main ecosystem functions tentatively linked to biodiversity are pollination, biological control of potential pest organisms, preventing erosion, water retention, and providing clean water. A recent literature review on the link between forest diversity and pest outbreaks has shown that, by and large, higher tree species diversity is correlated with fewer pest organisms or less damage (JACTEL *et al.* 2005).

**Wilderness:** The trendy term wilderness today means different things to different people (KELLERT 1980). But it is always linked with naturalness (allowing natural processes), undisturbed nature (no visible human interference), and “authenticity” (SCHNITZLER und BORLEA 1998). BAUER (2005) found a prevalence of utilitarian motives for promoting wilderness in and around densely populated areas. Whether secondary undisturbed nature in formerly cultivated areas can also be called wilderness is a matter of debate (CRIST 2004). Wilderness areas have a very high appeal for eco-tourism and adventurous recreational activities.

**Uniqueness:** Managed forests have a tendency to look (or even be) very similar over large regions or continents. Virgin forests, however, can be unique in several respects: They often are small relicts from formerly much larger forest areas, they can be naturally isolated patches on mountain tops (e.g. cloud forests), or they are protected patches within larger, more or less intensely managed forest areas (e.g. core areas in Biosphere Reserves). Their species composition in most cases is rather unique, with a high potential for endemism, even if the forest type may look similar in different parts of the world.

**Cultural heritage:** Also in forests, traditionally cultivated areas over historical time have developed a particular flora and fauna. Many of these adapted species are threatened today by changes in management practice or by the human-induced immission load. Cultural heritage is a very important biodiversity value in Europe. Nature conservation is trying to find affordable management possibilities to protect those threatened species.

## 5 Comparison of biodiversity values in managed Swiss forests and virgin Ukrainian forests

The above six value systems for biodiversity evaluation may have either similar or different importance for virgin or managed forests. They are discussed here based on data from two forest types investigated recently in the core zones of the Carpathian Biosphere Reserve (virgin Fagetum and virgin Abieti-Fagetum) and in Swiss managed forests (peri-urban Fagetum close to Zürich and prealpine Abieti-Fagetum selection forest in the Emmental valley). In both countries the beech forests were at 600 to 700 m a.s.l., the fir-beech forests at 900 to 1000 m (CHUMAK *et al.* this issue).

### Species conservation

A direct comparison of the conservation value of the virgin forests in the Carpathian Biosphere Reserve with the managed forests in Switzerland is hampered by the fact that the red lists for the threatened species of the two countries are not comparable. Screening the species lists of beetles collected in the two countries (CHUMAK *et al.* this issue) with the help of the red list of beetles in Germany yielded a significant difference between the number of red listed species in virgin and managed forests. The percentage of threatened species was almost double in the virgin forests in Ukraine (16.4% vs 8.9% in beech forests, 15.3% vs 6.9% in fir-beech forests). A published list of saproxylic indicator species for pristine, old growth forests in Europe (SPEIGHT 1989) was not very helpful to highlight the importance for biodiversity of the Transcarpatian virgin forests: Virgin forests contributed four, managed forest two species from that list. On the other hand, MATELESHKO (in press) was able to assign 219 coleopteran species (5% of all 4378 beetle species found in the Ukrainian Carpathians) as being characteristic for virgin forests. Four of those species were collected in each of the two types of Swiss managed forests, 14 and 16 in the two types of virgin forests of the Carpathian Biosphere Reserve. Although our data for the species conservation value are rather circumstantial, there is a clear tendency towards more species of conservational interest in virgin forests, at least in beetles.

### Ecological resilience

Assuming that the best indicator for ecological resilience is local species richness (alpha diversity), virgin forests are definitely not of higher importance than managed forests. Table 1 shows that, all in all, some more species occurred in the managed forests in Switzerland. If, however, evenness is regarded as a good indicator for ecological stability and resilience, virgin forests are rating slightly better (CHUMAK *et al.* this issue).

### **Ecosystem functions**

Although we have no specific data available to compare the value of particular ecosystem functions in the virgin or managed plots of the two investigated types of forest, there is evidence that none of the ecosystem functions mentioned above (pollination, biological control of potential pest organisms, preventing erosion, water retention, providing clean water) is of significantly higher importance in virgin than in managed forests. This of course is true only for moderate management intensity and does not apply to monocultural plantation forests. In our comparative study, predatory arthropods such as carabid beetles and spiders, which are often used as indicators for the biological control value, were more numerous and specious in managed forests (CHUMAK *et al.* this issue).

### **Wilderness**

The easiest way to quantify wilderness for comparison between managed and virgin forests is the time span since the last silvicultural intervention. But for most people visiting a virgin forest there is much more to it than forest age. The sheer size of the trees and the amount of standing and lying dead wood in the Carpathian virgin forests is indeed awesome. Wilderness, in the sense of naturalness, lack of human intervention, and autochthonous wildlife, is clearly the biggest biodiversity asset of virgin forests in Central Europe. Seen either as a biodiversity value in itself (BENNETT 1994), or as an anthropocentric value for adventurous tourism and recreation, the inspiring wilderness of a virgin forest cannot be matched by any kind of managed forest.

### **Uniqueness**

In Europe, virgin forests are unique just by the fact that there are only very few of them left. The virgin beech forests (*Fagus sylvatica*) in the core areas of the Carpathian Biosphere Reserve are the largest of that kind in Europe (COMMARMOT *et al.* 2000). The size of them, and the state of their protection against human interference, provides these forests with a unique opportunity to observe and investigate processes of natural dynamics of these forest types at a larger scale than anywhere else in Europe.

### **Cultural heritage**

Being the counterpart to the wilderness value, cultural heritage highlights the biodiversity aspects and entities depending on particular, continuous, or regular human disturbance. Virgin forests by definition cannot contribute to this value.

## **6 Conclusions**

Given the definitions of the six anthropocentric biodiversity values (see chapter 4) and the evaluation of the contribution of virgin versus managed forests to these values (see 5), a priority list for the importance of virgin forests for local, regional and national biodiversity emerges: The most important values are wilderness and uniqueness. Species conservation, usually regarded as the prime motivation for biodiversity protection, appears to be of lesser importance in the types of virgin forests we investigated. Ecological resilience and ecosystem functions are not more important biodiversity values in virgin forests than in the moderately managed forests we investigated in Switzerland. The sixth biodiversity value, cultural heritage, is obviously more pertinent in managed forests.

The different reactions to management intensity of the main forest biodiversity values treated here can be interpreted in analogy to the intermediate disturbance hypothesis (HUSTON 1979). Figure 1 illustrates functions representing the dependence of the six values (or motivations) on anthropogenic disturbance (management intensity), based on value-specific units. Only for the value “ecological resilience” (species richness, alpha diversity) reliable data are available. For the “conservation” value, we lack directly comparable information on the red list status of the species collected in the two countries. The indicators and “currencies” of the other biodiversity values have not yet been established in a quantifiable way.

Functions 2 and 3 (for the values “ecological resilience” and “ecosystem functions”, here assumed to be identical) represent the classical “intermediate disturbance” model for species richness. They reach their maximum at intermediate levels of management intensity. Functions 4 and 5 illustrate the values most relevant for virgin forests, “naturalness” and “uniqueness”. 1 stands for the “species-conservation” value, 6 for the value “cultural heritage”.

In the study used here to exemplify the biodiversity values most characteristic for virgin and managed forests, only virgin forests had been investigated in Ukraine, and only managed forests in Switzerland. There are no virgin forests left to be studied in Switzerland, but there are numerous managed forests for direct comparison in Ukraine, waiting to be investigated.

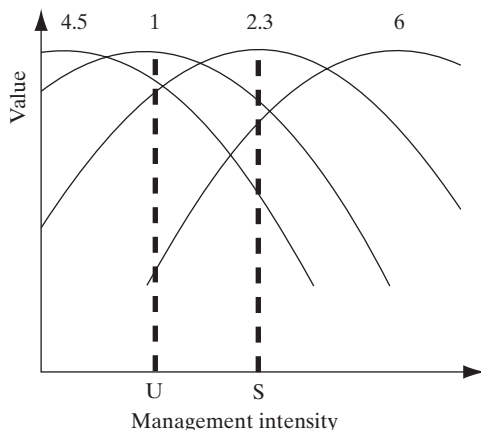


Fig. 1. Conceptual model to illustrate the reaction of the six different biodiversity values to management intensity (1 species conservation, 2 ecological resilience, 3 ecosystem functions, 4 wilderness, 5 uniqueness, 6 cultural heritage). The Swiss forests (S) are managed, but still rather natural, while the Ukrainian forests (U) are almost virgin.

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