Blowdown in the High Tatra
19 November 2004

Comments by Oliver Rackham
Corpus Christi College, Cambridge CB2 1RH
or10001@cam.ac.uk
June 2005

The blowdown area lies within the forest of the High Tatra National Park, Slovakia. It forms a nearly continuous belt just above the lower margin of the forest, 34 km long and 1 to 5 km wide, from Podbanské to Tatranská Kotlina. It is within a narrow altitudinal zone, from 800 to 1200 m, generally with a south aspect. There is a big outlier of blowdown on the steep slopes of Mount Grúnik, at 1400—1500 m. Single trees and small groups were blown down in otherwise intact forests in a wider area.

Within the blowdown area, or immediately adjacent, is a chain of villages and hamlets, from Strbské Pleso to Tatranská Kotlina, and the towns of Stary Smokovec and Tatranská Lomnica. These result from tourist development between 1875 and 1900. The Tatra, then part of Hungary, had become easily accessible by railway to Poprad. Hotels and health resorts were built in the mountains; they are now historic buildings. At first they were reached by road from below. The Clotilde Road, now called Freedom Road, was built from Strbské Pleso to Stary Smokovec in 1889, and extended in 1893 as the Maria Theresa Road to Tatranska Kotlina. Branch railways came first to Tatranská Lomnica, then to Strbské Pleso in 1895-6, and joined Strbské Pleso to Lomnica by 1916. Whether the resorts had a previous existence as summer settlements I have not ascertained.

The area was declared a National Park in 1948. This, I am told, resulted in the expulsion of shepherds and graziers, but did not affect forestry, hunting, or tourism.

By way of comparison, I draw on experience of the 1987 and 1990 blowdowns in England. These covered a much wider area; both affected the south-eastern one-third of England and parts of continental Europe. Not everywhere were their effects as severe as those of the Tatra blowdown. Many more species of tree were involved.

I refer to what some of the speakers said at the conference in Tatranská Strba in June 2005.

Character of the Blowdown

The forests affected are at least 80% spruce. Among other trees, larch is the commonest, followed by pine. Fir (*Abies alba*) is virtually confined to the eastern end of the blowdown (other than in towns). Birch, aspen, and alder are less common.

Within the blowdown area about one-third of the forest trees were broken and two-thirds uprooted; often a thin scatter of trees was left standing. Above and below the blowdown area, patches of trees and single individuals were broken or uprooted.

Age and structure of stands

Virtually all the forests that blew down, and those on the edge of blowdown areas, are composed of young, crowded, tall, slender trees, many of them suppressed or dead. There are few or no stumps and no old trees. They give the impression of plantations in which thinning has been neglected.

On closer inspection this is not so. Counts of annual rings on windblown and logged trees reveal a fairly wide range of ages: a continuous distribution from about 30 to 60 years, with fewer middle-aged trees up to about 150 years. In any one place I found a range of ages, some trees being twice the age of their neighbours. The growth rate is very variable, and there is little relation between the age of a tree and its diameter. I have not enough information to say whether other species differ systematically in age from spruce.

There can be little doubt that many forests in the blowdown belt are recent, no older than one generation of trees, resulting from spruces and other trees colonizing former grassland. There were already scattered trees in the grassland; the gaps between them gradually filled in over many years, leaving the original trees embedded and hemmed in. Some of these trees still exist and can be recognized by their open-grown shape.

In some places there may have been more recent cycles of blowdowns or logging followed by regeneration, so that the present trees are the second or third generation on the site. There may also have been planting, although I did not find evidence of it. Lack of stumps shows that there has been little thinning or logging in most of the forests for at least 30 years.

Many of the trees, though quite young, are butt-rotted.

Intact areas of forest usually have a very poor ground flora, except at roadsides. Often there are no visible plants. Dominant species — if any — include *Vaccinium myrtillus, Molinia cærulea,* or *Luzula sylvatica.* If there are small gaps there may be scattered individuals of a few other species: *Maianthemum bifolium, Hieracium murorum, Luzula luzulina,Asperula odorata,* etc.

A similar structure continues outside the main forest belt. In the Kôprová valley the forest is diversified by avalanche tracks with deciduous trees, but even here there are no old trees. Even this remote valley cannot be called 'near-natural' in its stand structure.

It has been remarked that the spruces in the blowdown zone have a tendency to spreading branches and broad tops, whereas those at higher altitudes have a narrower shape with a sharp-pointed top. The inference is that the former are not indigenous but are lowland trees unsuited to this altitude. I would confirm the observation but doubt the inference. Even older trees in the blowdown zone, which are unlikely to have been planted, are of the lowland type. I would propose instead that both variants are native to the Tatra, their distribution being determined by altitude.

Effect of forest structure

In England in 1987 the blowdown was aggravated by crowding. Trees were affected in the following order:

1. Trees in the interior of plantations (most affected both by uprooting and breakage).
2. Trees in the interior of natural woods.
3. Trees on the edges of plantations and woods.
4. Free-standing trees (least affected).

In the Tatra in 2004 most of the trees in the blowdown belt behaved as trees in the interior of plantations. Free-standing or widely-spaced trees, mostly in villages and towns, were less affected. Each of the villages is now a patch of upstanding trees in the midst of a vast area of blowdown. *There can be no doubt that overcrowding was a predisposing factor in the blowdown.*

The edge effect was less prominent in the Tatra than in England, although air photographs show a tendency for edges between forest and farmland to be marked by a row of upright trees. There was not a row of trees left upstanding along roads and railways. Although road and railway are both a century old, older than most of the trees bordering them, it is possible that the edge trees, that might have resisted the storm, were removed when the road and railway were rebuilt *c.*1970.

Comment

As regards uprooting, the amount of root needed to supply a tree with water and minerals is less than the amount needed to hold it up against a storm. Trees in the interior of plantations have room for only the minimum amount of root, and so are more vulnerable to uprooting than marginal or free-standing trees which have more root-space. This is a normal risk of plantation forestry. It is the business of foresters to grow stems, not roots. They accept the risk of windblow, and indeed aggravate it by their habit of planting trees too close together, intending to thin them later, and then not thinning. Trees sheltered from ordinary winds develop weaker wood than exposed trees, and so are more liable to breakage when a storm comes.[1]

Effect of species

Examples can be found of almost any tree broken or uprooted, but there is no doubt that spruce was disproportionately susceptible. Throughout the blowdown belt, larch was much less common than spruce, yet wherever there is a scatter of upstanding trees they are wholly or predominantly larch. Stacks of spruce and larch logs awaiting removal always contained less larch than the trees that remained standing.

To take a typical example, immediately east of Visne Hagy is an area of pure spruce, all of which were broken or uprooted. Adjacent and further east is an area of mixed spruce and larch, 80—130 years old. Here I counted the following:

	Broken	Uprooted	Standing	Total
Spruce	31	55	2	88
Larch	11	15	30	56
Total	42	70	32	144

54% of the larch but only 2% of the spruce remained upstanding; the difference is highly statistically significant.[2] The data are not sufficient to determine whether larch or spruce differ in the rate of breakage *versus* uprooting.

1 BF Wilson 1970 *The Growing Tree* University of Massachusetts Press, Amherst (chapters 9, 10).

2 χ^2 test: P>>>0.001.

In the north-east of the blowdown area, fir occurs as well as larch. Fir forms a small minority of all the trees, but a majority of the standing trees. This is a count from near Kezmarske Zlaby:

	Broken	Uprooted	Standing	Total
Spruce	23	34	0	57
Fir	0	5	3	8
Larch	0	1	1	2
Total	23	40	4	67

Significantly more fir than spruce remained upstanding.[3]

The same was observed less formally with pine, alder, and birch. For example, on the edge of Tatranská Lomnica, in a mixed stand of birch, alder, and spruce, the spruceswereplucked out. Other things being equal, spruce was much more prone to windblow than all other species.

In 1987 in England, spruce was particularly severely affected. I attributed this to the fact that spruce was always in crowded plantations, but it may also be that the species was inherently susceptible. I could not check this point because spruce (which is always a planted tree in Britain) did not occur as a freestanding tree or in a mixed plantation.

Strength of the storm

The effects of a storm depend on the strength of the wind and on the stability of the trees. Exceptional winds are seldom adequately measured, but their strength can be gauged by their effects on buildings.

The numerous buildings within the blowdown belt suffered remarkably little direct damage from wind: most damage to buildings was from trees falling on them. This is not because they were specially designed to resist wind. Many buildings have low-pitched sheet-metal roofs, not weighted down with boulders as they would be in wind-exposed places in the Alps. Many are in poor repair and thus more vulnerable.

I infer that *the storm was not of exceptional strength.* The scale of damage to trees was due to a moderate windstorm affecting forests whose structure made them unstable.

Much the same happened in 1987 in England, where damage to buildings (other than by trees falling on them) was not very severe compared to other storms, but damage to trees was exceptionally severe. The same conclusion must be drawn: the stand structure was such that a not very exceptional storm resulted in severe damage.

Origin of the stand structure

The High Tatra, having long been a tourist area, is well provided with maps. I have consulted the following:
1:50,000 published 2005
1:75,000 published 1967 and 1955
I:100,000 published 1944 (United States military map, based on earlier Czechoslovak original)
1:75,000 surveyed 1905 (Austro-Hungarian military map)
1:100,000 published by Singer & Wolfner,1896, but probably surveyed earlier.
All these purport to show the area of forest roughly the same as it is now, except south-west of Strbské Pleso. Here the open areas (up to 1957) extended somewhat higher, and were dotted with hay-barns, implying meadow; some of the hay-barns, however, are shown inside forest. A smaller open area is shown in the valley east of Strbske Pleso. A small, diminishing amount of grassland still survives in the Kôprová valley.

Photographs tell a different story. As Dr Koren has shown, views of the Tatra from the south, dating from *c.*1890 to *c.*1940, show apparently treeless areas, or areas with scattered trees, covering roughly two-thirds of the land in and around the present blowdown. Some of these resulted from previous blowdowns such as that of 1915, but others were permanent grassland. A picture by Dr H.J. McLachlan, a climber, in 1933—4 near Lomnica, probably within the present blowdown, shows a permanently grazed pasture, with scattered larches and spruces of various sizes and the stumps of previous non-forest trees (Fig. ••).[4]

The cartographers evidently had difficulty in handling a mosaic of patches of forest and patches of grassland with trees, and chose to call it forest.

With the decline of grassland, spruce and other trees filled in the gaps gradually over many years. New trees would arise, as they still do in open areas, so densely that they competed fiercely with each other. The result was a crowded, unevenaged stand of young trees, with a scatter of older trees dating from before the infill. This set the scene for the great windblow of 2004.

---

3 χ^2 test: P>0.001.
4 Cambridge University Library: Views.b.231(3).93.3.

Patches of continuous forest dating from before the infill include Uhliscatke Reserve, which has many spruces and larches 100—170 years old. This is on rugged, broken terrain, with trees less crowded than elsewhere and fewer young trees. Significantly, most of the trees remained upright.

How far back in time the grassland went I cannot say. It would have been, probably for centuries, the pasture or hay-meadow of the row of big villages below the blowdown belt, such as Strba, Mengusovce, Batizovce, and Gerlachov. Pasturage evidently declined in the twentieth century, as it did in much of Europe, and was extinguished when the National Park was declared in 1948.

Grassland at this altitude seems to have been neglected in the belief that it is of artificial origin and that continuous forest would have been the 'natural' vegetation. This may not be true: there may have been open grassy areas in the forest throughout prehistory, maintained by the grazing of wild ungulates.[5]

Pollen analysis

I have seen abstracts of two sets of pollen diagrams. One set covers the entire Holocene from sites at Spisska Belá and Podhoran, east of the blowdown area and in the agricultural belt at a much lower altitude (*c.*600 m).[6] The vegetation for most of the Holocene appears to be forest, with dominant spruce. Fir became prominent, along with spruce, in the last millennium but one. Deciduous trees remained sporadic; in particular there was never the great increase of beech that occurred in most of central Europe. Prehistoric human activity left no trace in the tree pollen record. The present agricultural landscape was apparently established quite rapidly in the later middle ages.

The other pollen data come from sites within the eastern part of the blowdown area itself, at Tatranská Lesná, Tatranská Lomnica, Prameniste (900 m), and Kezmarské Zlaby (Mokriny).[7] However, they are published in much less detail. The principal tree pollens are spruce, fir, alder, pine, and birch — all copious producers of pollen. Spruce is dominant or co-dominant at four of the five sites; pine usually in second or co-equal place; alder always present (as would be expected, since pollen sites are necessarily in wetlands). At one site birch is predominant, followed by alder. Larch and fir are not reported in significant quantities. There are no systematic changes within the period covered by the record; there are sporadic fluctuations which could be interpreted as the effects of periodic blowdown and regrowth. 5 to 10% of the pollen is of non-trees. Ordinarily this would be interpreted as meaning that the vegetation was predominantly forest, but here, where all the trees are much more copious producers of pollen than the non-trees would be, such a proportion may indicate substantial open areas.

Lack of old trees

Larches can easily live to 600 years old; spruces probably to 300. We were told that ancient *Pinus cembra* exist at higher altitudes, but I saw not a single old tree at middle altitudes, even in the Kôprová valley. Old trees and their individuality constitute much of the beauty of forest landscapes, especially in the Alps. They are an especially important habitat for invertebrate animals, fungi, and lichens. Their absence seriously diminishes the value of the National Park.

Old trees might be expected to be rare in a forest with this history. Their apparently complete absence could be due to a customary right entitling people to take rotten trees for firewood, or (more recently) to a foresters' custom of removing imperfect or 'dying' trees in the cause of sanitation.[8]

Previous blowdowns

There are records of many previous blowdowns, for example in 1915, 1919, 1925, 1941, and 1981, but none of so large an area as in 2004. Other blowdowns have occurred in spruce-dominated forests elsewhere, as in the Sumova and Bayerischer Wald national parks.

Blowdowns presumably have occurred at intervals throughout history and prehistory. In America they leave a permanent record in the form of tip-up mounds and pits left by the root-masses of the fallen trees. I have found such mounds in several places in forests just outside the 2004 blowdown. They are visible on the 1933—4 photograph in what was then pasture.

In the Sumova and Bayerischer Wald blowdowns and bark-beetle attacks tended to occur on a hundred-year cycle, regeneration after each event preparing the way for the next event.[9] This seems not yet to be so here, although regeneration or replanting after the 2004 storm may set the scene for future blowdowns.

---

[5] FWM Vera 2000 *Grazing Ecology and Forest History* CABI, Wallingford.

[6] V Jankovská 1991 •••

[7] Kucerova et al. 1999 •••

[8] Dr Peter Szabó, of Budapest, attributes the lack of old trees to a 'Germanic' forestry tradition since the 16th and 17th centuries. He points out that the University of Mining and Forestry was founded in 1735 at Banska Stiavnica.

[9] Hartmut Strunz and Jaromir Bláha, this conference.

Consequences of the Storm

What happens to windblown trees?
At the meeting in June 2005 most speakers and participants assumed that trees broken or uprooted by storms die. This appears not to be based on much observation. Because fallen trees, by custom, are thoroughly sought out and removed, there is probably little information on whether they survive if left.

In England there is abundant information from the 1987 and 1990 storms, which were on so vast a scale that the task of removing fallen trees was never finished. The woods are now full of horizontal living trees that have adjusted to the new direction of gravity. The outcome depends on the species, whether broken or uprooted, and the circumstances. To summarize:

1. Most uprooted trees stay alive if one-sixth of the roots remains in the ground. They react by sending up branches from the upper side of the trunk.
2. Whether they continue to live depends on whether the fallen tree is shaded by neighbouring upright trees. Large areas of fallen trees are more likely to live and recover than single trees fallen in a forest.
3. Uprooted lime (*Tilia*) and chestnut (*Castanea*) are almost certain to survive. Their survival rate, and that of beech (*Fagus*), is high even if shaded. Birch (*Betula*), being light-demanding, survived less often. Evergreens in general are less likely to survive than deciduous trees.
4. Almost all broadleaved trees survive breakage of the top or middle of the trunk: they send up new shoots, becoming, in effect, pollards.
5. Whether conifers survivebreakage depends on the height of the break. They are unlikely to survive a break that leaves them with no foliage.

In the Tatra, in late June 2005, most uprooted trees, of all species, were alive if some roots remained in the ground. Larches and birches had produced new leaves as normal. Most spruces had produced new shoots, but from only the upper part of the crown. Some were recognized as alive by the pineapple-gall insect *Adelges abietis*, which had formed new galls. A few young uprooted spruces had produced new leaves and cones as normal.

Most broken trees were reduced to leafless stumps and showed no signs of life.

Predictions are uncertain, but I would make the following *very tentative* prognosis of what is likely to happen where trees are left:

1. Spruce is the tree least likely to survive uprooting. Uprooted spruces may be killed if there is a bark-beetle outbreak. If there is not, then the prospects for survival of spruces in the middle of forests (already struggling to stay alive before the storm) are not good. Spruces on the edge or in gaps, with more abundant and lower foliage, may survive.
2. The survival rate of uprooted larches and other species is likely to be higher.
3. Broken trees with little or no remaining foliage will probably die.
4. Trees broken high up, with at least half the foliage remaining, will probably live and grow a new top.

Previous windblows and ground vegetation
I was shown the area between Kezmarské Zlaby and Tatranská Kotlina, where blowdowns are particularly frequent. I studied briefly the site of several blowdowns within the last ten years. Fallen trees had apparently been removed in the same way as is now being done, though probably to a better standard of workmanship. Nothing else had apparently been done, except anointing spruce and fir with a deer repellent.

It was instantly apparent that blowdown areas were much richer in plant life than any other part of the forest. These three lists are the result of a brief visit, and could easily be much extended.

Table 1. Lists of species (and approximate abundance) in three areas of 4—10-year-old blowdown.
sb: plants known or suspected of having seed-banks.
c: other plants characteristic of coppice-woods in England.

	Fl'ak 1	Fl'ak 2	Fl'ak 3	Comment
TREES: Alder		(+)		
Birch			+	
Elder			+	
Fir	++++	+++		
Larch	++++	+++		
Rowan	++	++	++	
Sallow	+++		+++	
Spruce	+++++	++++	++	
Sycamore	(+)		++	

HERBS & UNDERSHRUBS: *Ajuga* cf *chamæpitys*	(+)			
Alchemilla cf *gracilis*	+			
Alopecurus pratensis	(+)			
Angelica sylvestris		+		sb
Anthriscus sylvestris	+		(+)	
Artemisia vulgaris			(+)	
Athyrium filix-fœmina			(+)	
Briza media		(+)	+	
Calamagrostis sp.	(+)		++	c
Caltha palustris		+		
Campanula patula	+			
Carex cf *ovalis*	(+)			
Carex pallescens	+			sb
Carex sylvatica	(+)	+		sb
Cerastium vulgatum	++		(+)	sb
Chærophyllum sp.	+			
Chamænerion angustifolium	+++		+++	c
Cirsium arvense	(+)			
Cirsium oleraceum		+		
Clematis vitalba	(+)			
Dactylis glomerata	+	++	++	sb
Dactylorchis fuchsii		(+)		c
Deschampsia cæspitosa			+	sb
Digitalis grandiflora	+	(+)	(+)	sb
Dryopteris dilatata	+	+	++	
Dryopteris filix-mas	+	+	(+)	
Equisetum cf *pratense*		(+)		
Equisetum sylvaticum		++		
Euphorbia amygdaloides	+			sb
Festuca arundinacea			(+)	
Filipendula ulmaria		++		c
Fragaria vesca	+		++	sb
Galeopsis tetrahit	(+)		+	sb
Galium erectum	++	+	++	sb
Gentiana asclepiadea	+	(+)	(+)	sb
Geranium phæum		(+)		
Geum rivale	(+)	++		c
Hieracium murorum			(+)	
Hypericum hirsutum			+	sb
Hypericum tetrapterum	+		+	sb
Lamium maculatum	(+)			
Lathyrus cf *pratensis*		+++	+	
Lilium martagon			(+)	rarity
Lonicera xylosteum	+			
Lotus corniculatus		++		sb
Luzula luzuloides	+	++	++	sb
Luzula pilosa		+		sb
Melampyrum nemorosum	+			sb
Melampyrum cf *pratense*		+		sb
Melandrium rubrum	(+)	+	(+)	sb
Milium effusum	+	(+)	+	sb
Molinia cærulea	++++		+++	
Myosotis arvensis	+	+	+	sb
Orobanche sp.			(+)	
Plantago major			+	sb
Poa trivialis	++			sb
Primula elatior		+		c
Prunella vulgaris		+	(+)	sb
Ranunculus aconitifolius	(+)	+		sb
Ranunculus repens	++	+++		sb
Rosa sp.		+	+	
Rubus idæus	++		+	sb
Rumex cf crispus			(+)	sb

Scrophularia nodosa			(+)	sb
Senecio fuchsii/nemorensis	(+)	+	+	sb
Trifolium pratense			++	
Trifolium repens			+	
Tussilago farfara	+	+	++	
Urtica dioica	++			sb
Veratrum album		+		
Veronica chamædrys	+			sb
Veronica officinalis		++		sb
Viburnum opulus		+++	(+)	
Vicia cracca	+			
Vicia cf *sativa*	(+)			
Vicia sylvatica		++	++	

Plants of these blowdown areas are strongly reminiscent of those of coppice-woods in England. These woods (of broadleaved species) are felled every 10—20 years and allowed to regenerate from the stumps, a process that has been going on long enough (a thousand years or more) for very specific woodland plant communities to have developed in response to it. In many English woods the richest areas in plant life are those that were felled two or three years ago. Plants have various types of response to felling, but many have long-lived seeds; felling the wood calls up seedlings from seed that was shed at the last felling. These seed-bank plants often dominate the coppicing flora, especially in woods of densely-shading trees like lime and hornbeam.[10]

Despite the geographical separation, areas of repeated blowdown have many species in common with those of coppice-woods in England; much the same process has evidently been going on here. As would be expected with densely-shading, evergreen conifers, most of the species involved are those that completely disappear under closed canopy and reappear from a seed-bank.

People's reactions

The storm was treated as a calamity of national proportions. The site was immediately taken over by state foresters, who organized a vast and hasty operation of harvesting the fallen trees. These considerations were evidently held to override the National Park management plan, non-intervention areas, rights of ownership, and safety regulations. There seems to have been no adequate Environmental Impact Assessment. I have no knowledge of the legal implications or on what authority this was done.

At the time of writing (June 2005) a substantial part of the task had already been completed. Men and machines were brought in from all over Central Europe, presumably neglecting routine felling elsewhere.

Logging fallen trees is a more difficult and dangerous task than felling standing trees. Workmanship was unskilled and technology primitive. Timber was spoilt by careless cutting. Soils were badly damaged by improperly using machines off roads in unsuitable terrain (notably in Uhliscatke Reserve). Extraction often amounted to no more than dragging logs behind a tractor, which badly damaged the remaining trees (spruce being very shallow-rooted). None of the workmen that I saw had any safety equipment.

Particular attention was given to finding and removing single fallen trees and small groups from otherwise intact forest, which probably did disproportionately much damage.

In England after 1987, the storm was immediately followed by hysterical over-reaction on the part of the public. It was made an affair of state by politicians who pretended to control its effects. *Clearing up fallen trees* was held to be an overriding priority; it killed more trees and *did more damage than the storm itself.* The mistake was repeated in 1990. Fortunately the storms were so extensive that the work was never finished.

The motives for removing fallen trees, as I understand them, are:

(i) Preventing an outbreak of spruce bark-beetle. This is thought to be so grave a risk that it must be forestalled throughout the entire National Park, overriding all other management considerations.

(ii) Harvesting fallen timber on private land within the windblow area.

(iii) Responding to people's emotional attachments to the forest as it was before the blowdown, and doing something — it hardly matters what — that can be presented as contributing to its restoration.

Bark-beetles

Spruce bark-beetle, *Ips typographus,* is peculiar to spruce. It kills trees, and is a vector for blue-stain fungi (*Ophiostoma* species) that spoil the appearance, though not the strength, of the timber. It runs in epidemics, killing whole areas of trees at once. Outbreaks are more likely in large continuous areas of spruce, in crowded or old stands, and especially after windblow. 'Sanitation felling' is the recommended control method, and has

[10] O Rackham 2003 *Ancient Woodland: its history, vegetation and uses in England,* 2nd edition. Castlepoint Press, Chapter 26.

some success in preventing outbreaks. Dead trees remain attractive to beetles 'for well over a year'. In sanitation felling, priority should be given to small areas and scattered damage, rather than large areas of affected trees.[11]

Spruce bark-beetle is the most important insect pest of forests throughout continental Europe, from Norway to Turkey. It can render commercial spruce-growing precarious: growers often expend one-fifth of their felling effort in finding and removing beetle-killed trees.

In ecological terms this insect is less hostile. It appears to be a native species, and should be regarded as part of the normal ecology and life-cycle of spruce. Spruce is a short-lived and catastrophist tree, and is evidently adapted to being removed every century or so by a combination of storm and bark-beetle and coming back from remaining young trees that were too small to be killed by the beetles.[12]

Will the removal of fallen trees prevent a beetle outbreak?

The standards of workmanship in this operation were not satisfactory. In many areas about 1 metre of the base of each tree has been left behind, together with the small-diameter top of the trunk. If this much bark is left behind on stumps and tops, will it support a beetle outbreak?

I observed many lorry- and trainloads of logs leaving the Tatra. Most of them were being removed with the bark attached; this is liable to shift the bark-beetle outbreak to wherever the logs were going. Some of the consignments had been through a bark-remover, but this still left one-third or more of the bark attached.

Removal of species other than larch

In most places logs of larch, fir, and other species were being removed along with the spruce. This will not affect the incidence of spruce bark-beetle. Why are they removed? Although, in general, fewer of these trees were blown down, in some places, if left, they would have met the environmentalists' demands that 10% of the fallen trees be left in the forest.

The Future

Immediately before the storm the forests were undistinguished and not particularly attractive. They would have been a forbidding monotonous monoculture of millions of young spruce, each exactly like each other to anyone who is not a forester or a botanist. They lacked the flowers, diversity, and old trees that make the beauty of forests. As far as can be ascertained, this landscape was very recent: only just beyond human memory it had been far more diverse and beautiful.

This view is evidently shared by photographers. Looking at picture postcards of the Tatra on sale, I found only four that were photographs of forests. Three of these were of the blowdown itself, regarded as a wonderful and picturesque phenomenon. The fourth featured a fallen log.

Continuous, young spruce forests are not a good habitat. They are poor in flowering-plants and lichens. Few mammals and birds use them: they contain little that is edible, and are impenetrable by deer and bears.

Even commercially, spruce monocultures are questionable. More than other conifers, they are forever vulnerable to storms and bark-beetles. They produce poor-quality timber, a low-grade commodity for which the market may disappear at any moment.

As with all monocultures, there is a risk not only from pests and diseases that are already known about but from the globalization of tree diseases. Most countries suffer from one or more foreign pathogens which, once established, can seldom be extirpated or even controlled. Slovakia is apparently fortunate in having had only one, Elm Disease. This is not a hypothetical risk. To take one among many examples, *Pinus densiflora,* as important in Japan as spruce is in Slovakia, has steadily been exterminated by a microscopic nematode worm said to have been introduced from America. Those who want to restore a spruce monoculture to the Tatra should consider what would happen if a parasite more deadly than bark-beetle appears, as it may well do in the next fifty years.

Conclusions

[11] KR Day & SE Leather 1997 'Threats to forestry by insect pests in Europe' *Forests and Insects* ed AD Watt, NE Stork, MD Hunter. Chapman & Hall, London 177—205.

[12] A parallel would be in the alpine woods of Japan, where the short-lived fir and spruce species *Abies mariesii, A. veitchii,* and *Picea yezoensis* have a pattern of cyclical regeneration that results in the mountainsides being striped with ribbons of young, older, and dead trees.

1. *The storm was not a calamity;* it is part of the normal workings of nature, although aggravated by the peculiar history of the site.
2. The situation that it has created needs to be treated with vision and foresight. The National Park authorities should not merely reinforce popular dismay, but should emphasize the positive aspects. *The storm was a rare and wonderful event, to be celebrated and made the most of. It gives an opportunity to reverse seventy years of landscape deterioration.*
3. The previous situation resulted from a sequence of events that cannot be repeated. Any attempt to restore it (for example by large-scale tree-planting) will be counter-productive and will set the scene for another windblow later this century.
4. Clearing-up operations so far have killed more trees than the storm itself (an unknown number of which would have died later); they have aggravated the damage. Some of this damage could still be mitigated by better supervision and less haste.
5. Some of the clearing-up seems to be irrational, such as removing larch logs in order to avoid spruce bark-beetle; or removing incombustible big logs in the cause of preventing fire, while leaving the flammable branches.
6. *There is too much forest in the National Park.* Having 10% less forest would restore the historic grasslands on which much of its beauty and value as a habitat used to depend.
7. *There is too much spruce.* Spruce will probably always be dominant, whatever is done, as it has largely been in the past; but every effort should be made to promote larch, fir, birch, alder, rowan, and sallow. These will reduce the dangerous dependency on a species that is particularly prone to windblow and bark-beetle. They will add greatly to the beauty of the Tatra and its value as a habitat.
8. The National Park is sadly lacking in old trees. This cannot immediately be remedied; but a search should be made for any that have escaped destruction, and they should be mapped and protected in the management plan.
9. The National Park is sadly lacking in large dead wood.
10. In the absence of old trees, the most ecologically important parts of the National Park at this altitude are those that were blown down in previous storms.
11. *Storms and bark-beetle attacks are part of the natural ecology of spruce* and should be resisted as little as practicable. The ecosystems that they create are of value in themselves, of much more value than continuous, young, spruce forest that never gets a chance to grow old.
12. Information is needed on the effects of storms: for example, on what proportion of trees survive windblow. To this end, areas of windblow should be left undisturbed *and periodically recorded.*
13. The storm will benefit large mammals. Deer, especially, can be expected to increase (as happened after the 1999 storm in France). They will alter their habits as food becomes available in the middle altitudes, which previously had been too forested to be of much use to deer. This may give rise to browsing problems which I will not try to foresee.
14. *No attempt should be made to hasten the regeneration of windblown tracts.* They are of ecological value in their own right. If they lead to temporary or permanent open areas this will enhance, not diminish, the purposes of the National Park.
15. The National Park needs a stable long-term management plan, independent of the whims of politicians. This should make it clear that *the objectives of modern forestry and of a National Park are not the same.* The relations between foresters and the National Park should be defined. The management plan should be legally enforceable, if necessary, against the forestry authorities.
16. That is not to say that forestry should be abandoned. It may be argued that in some places it is a traditional land-use that should be upheld under the title of 'taking into account the needs of indigenous people' (International Union for the Conservation of Nature: definition of a national park). But I would not expect this to cover any large part of the total area.
17. The management plan needs to state what (if anything) will be done about future windblow, bark-beetle attacks, and fire.
18. It is essential not to decide in advance what a 'natural' landscape should consist of — still less to set up an international standard for natural landscapes — and force the Tatra to conform to that preconception.

I am grateful to Robin Rigg for inviting me to the conference, and to Juraj Svajda for help and discussion in the field.