Chapter 4

DAMAGE AND CONTROL OF BAWBILT ORGANISMS AN OVERVIEW

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1. INTRODUCTION

The BAWBILT database on damage and control (Gilbert and Sauvard, chapter 3) was queried in January 2003. It then contained 478 entries, on 95 species of the BAWBILT list, with entries from 19 countries. In each entry, a series of fields concerned the total areas potentially affected, the types of damage (death of trees, caused by the insects themselves or by pathogenic fungi, timber degrade, impact on growth, on erosion, on avalanches,…), quantitative assessments of damage (periods, areas, volumes of timber, numbers of trees, financial losses), and scoring (+ to +++) for aggressivity and for territorial coverage. A series of fields regarding control practices (e.g. do nothing, sanitary thinning, clearfelling, traptrees, pheromone trapping, insecticide treatments) and monitoring options (e.g. visual assessments, pheromone trapping, questionnaires) was also available.

To avoid unnecessary duplication, damage and control are covered together in this section.

In this short overview, we shall first identify the most frequently cited species and then provide statistics per country. Finally, we shall analyse more closely the data available on the "top ten" species, i.e. those species that were scored +++ for aggressivity at least three times. This more detailed analysis will consider the types of damage, quantitative information when available (numbers of trees/volume killed, acreages, etc) and control methods.

F. Lieutier et al. (eds), Bark and Wood Boring Insects in Living Trees in Europe, A Synthesis, 19—37.

2. THE MOST DAMAGING PESTS

Table 1 lists important pest species which were scored +++, and Table 2 lists those which were either scored +++ or ++. Ten species, among which were seven Scolytids, received a +++ score at least three times: *Hylobius abietis* (Coleoptera: Curculionidae), *Ips typographus*; *Ips acuminatus*; *Pityogenes chalcographus*; *Scolytus multistriatus*; *Scolytus scolytus*; *Scolytus laevis*; *Tomicus piniperda* (Coleoptera: Scolytidae), *Phaenops cyanea* (Coleoptera: Cerambycidae) and *Rhyacionia buoliana* (Lepidoptera: Tortricidae). Two species received the most attention for both damage and, not surprisingly, control: *Ips typographus* (15 citations) and *Hylobius abietis* (12 citations).

Table 1. BAWBILT organisms scored +++ in the BAWBILT database

Species	Number of occurences
Ips typographus	15
Hylobius abietis	12
Pityogenes chalcographus ; Scolytus multistriatus ; Scolytus scolytus	6
Ips acuminatus	5
Tomicus piniperda	4
Phaenops cyanea ; Rhyacionia buoliana ; Scolytus laevis	3
Cryptorhynchus lapathi; Dendroctonus micans ; Ips duplicatus; Ips sexdentatus; Paranthrene tabaniformis; Pissodes castaneus; Tomicus minor; Trypodendron lineatum; Zeuzera pyrina	2
Agrilus biguttatus; Gnathotrichus materiarius; Hylastes ater; Hylastes cunicularius; Hylobius pinastri; Ips amitinus; Ips cembrae; Leperesinus varius; Monochamus sartor; Pissodes piniphilus; Pityokteines curvidens; Polygraphus poligraphus; Saperda carcharias; Saperda populnea; Scolytus intricatus; Scolytus triarmatus; Sirex juvencus; Tetropium gabrieli; Trypodendron domesticum; Urocerus gigas	1

3. SPECIES PER COUNTRY

The numbers of species considered to be significant pests varied greatly between countries (21 +++ pests in Romania, 16 in Germany, 1 in Belgium, France or The Netherlands): Fig. 1 and Table 3. It is unclear how much these differences can be explained by local variations in forest coverage, forest uses, tree species, silvicultural practices, climate, topography, etc. Part of these differences may also stem from divergences in damage assessment methods and criteria. For example, numbers of trees killed, cubic metres of timber lost, financial value of timber degrade or areas "hit" by a pest give quite different damage assessments. An important outcome of the BAWBILT programme could be to discuss more carefully the status of the species identified as aggressive and to determine the key factors leading to their highly damaging status.

Table 2. BAWBILT organisms scored either +++ or ++ in the BAWBILT database

Species	Number of countries
Ips typographus	16
Hylobius abietis	15
Scolytus scolytus; Tomicus piniperda	9
Ips acuminatus; Pityogenes chalcographus; Scolytus multistriatus; Tomicus minor	8
Ips amitinus	7
Hylastes cunicularius; Ips sexdentatus	6
Ips cembrae; Phaenops cyanea; Pityokteines curvidens; Polygraphus poligraphus; Rhyacionia buoliana; Scolytus intricatus	5
Agrilus biguttatus; Cryptorhynchus lapathi; Dendroctonus micans; Hylastes ater; Ips duplicatus; Pissodes castaneus; Pissodes piniphilus; Saperda carcharias; Tetropium gabrieli	4
Cryphalus piceae; Paranthrene tabaniformis; Pityokteines vorontzovi; Saperda populnea; Scolytus laevis; Trypodendron domesticum; Trypodendron lineatum; Zeuzera pyrina	3
Cossus cossus; Leperesinus varius; Pissodes piceae; Pityokteines spinidens; Pityophthorus pityographus; Sesia apiformis; Tetropium castaneum; Urocerus gigas; Xyleborus dispar	2
Agrilus populneus; Aradus cinnamomeus; Gnathotrichus materiarius; Hylesinus crenatus; Hylobius pinastri; Hylurgus ligniperda; Monochamus sartor; Orthotomicus erosus; Phloeotribus scarabaeoides; Phoracantha semipunctata; Pissodes pini; Pityogenes conjunctus; Scolytus ratzeburgi; Scolytus triarmatus; Sirex juvencus; Trypodendron signatum	1

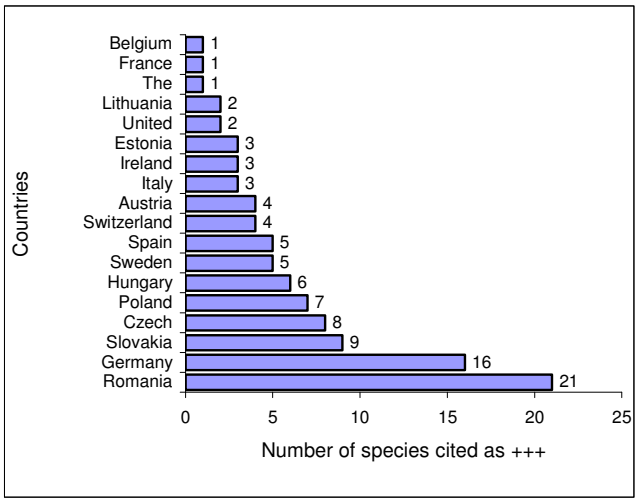

Figure 1. Numbers of +++ species in the different BAWBILT countries

Table 3. Pests scored +++ in the different BAWBILT countries

Species	Countries
Ips typographus	Austria; Belgium; Czech Republic; Estonia; France; Germany; Hungary; Ireland; Lithuania; Poland; Romania; Slovakia; Sweden; Switzerland; United Kingdom
Hylobius abietis	Austria; Czech Republic; Estonia; Germany; Hungary; Ireland; Lithuania; Poland; Romania; Slovakia; Sweden; United Kingdom
Pityogenes chalcographus	Austria; Czech Republic; Germany; Hungary; Romania; Slovakia
Scolytus multistriatus	Czech Republic; Germany; Slovakia; Spain; Sweden; Switzerland
Scolytus scolytus	Czech Republic; Germany; Slovakia; Spain; Switzerland; The Netherlands
Ips acuminatus	Germany; Romania; Slovakia; Spain; Switzerland
Tomicus piniperda	Czech Republic; Poland; Slovakia; Spain
Phaenops cyanea	Czech Republic; Germany; Poland
Rhyacionia buoliana	Hungary; Ireland; Romania)
Scolytus laevis	Germany; Slovakia; Sweden
Cossus cossus	Italy; Romania
Cryptorhynchus lapathi	Hungary; Romania
Dendroctonus micans	Germany; Romania
Ips duplicatus	Poland; Slovakia
Ips sexdentatus	Germany; Spain
Paranthrene tabaniformis	Italy; Romania
Pissodes castaneus	Hungary; Poland
Tomicus minor	Czech Republic; Romania
Trypodendron lineatum	Germany; Romania
Zeuzera pyrina	Italy; Romania
Agrilus biguttatus	Germany
Aradus cinnamomeus	Finland
Gnathotrichus materiarius	Germany
Hylastes ater	Romania
Hylastes cunicularius	Romania
Hylobius pinastri	Estonia
Ips amitinus	Romania
Ips cembrae	Germany
Leperesinus varius	Italy
Monochamus sartor	Romania
Pissodes piniphilus	Austria
Pityokteines curvidens	Romania
Polygraphus poligraphus	Romania
Saperda carcharias	Romania
Saperda populnea	Romania
Scolytus intricatus	Poland
Scolytus triarmatus	Sweden
Sirex juvencus	Romania
Tetropium gabrieli	Germany
Trypodendron domesticum	Germany
Urocerus gigas	Romania

4. DAMAGE OF THE "TOP TEN" SPECIES

4.1. Ips typographus

Table 4 provides scoring and quantitative data for *Ips typographus*. Although incomplete, available information from ten countries indicates that over a potentially threatened area of 7,640,000 ha, at least 2,819,000 ha were attacked between 1990 and 2001, resulting in the death of 31,643,000 m³ of spruce. Most of the data are connected to the 1990 storms. Austria (11,000,000 m³), Poland (6,270,000 m³), Germany (5,900,000 m³) and Slovakia (4,490,000 m³) reported the highest losses.

Table 4. Damage caused by Ips typographus

Country	Host age	Threatened Area (ha)	Tree death[1]	Timber[1] degrade	Avalanche[1]	Erosion[1]	Cosmetic[1]	Physical danger for people[1]	Period	Volume (m³)	Area (ha)
Austria	Pole	2,000,000	2		2	2			1992-2000	11,000,000	no data
Belgium	Older	no data	2	2			2		1992	250,000	no data
France	Older	no data	3						1990-01	1,500,000	no data
Germany	Older	3,233,001	2						1990-98	5,901,254	192,760
Hungary	Pole	24,000	2	2					1990-97	420,000	no data
Lithuania	Older	221,155	3	1					1998-2001	no data	27,462
Poland	Older	230,000	3			3		3	1990-99	6,270,000	no data
Romania	Older	600,000	3	3	3	3	3		1991-2000	811,195	2,598,833
Slovakia	Pole	600,000	3		2	2	3		1990-99	4,490,086	no data
Switzerland	Older	492,000	2	2	2	2			1993-95	1,000,000	no data
Total (of available figures)		7,640,156	35	12	9	12	8	3	1990-2001	31,642,535	2,819,055

[1] Scoring from 1 to 3

4.2. Hylobius abietis

Death of coniferous transplants is, expectedly, the major impact of this species. A total of 3,418,000 ha is regarded as threatened, of which 88,000 ha were seriously damaged between 1980 and 2000 in Germany, Hungary, Lithuania, Romania, and Slovakia (Table 5).

4.3. Pityogenes chalcographus

Available information from eight countries indicates that over a potentially threatened area of 8,784,000 ha, at least 595,400 ha were attacked between 1990 and 2000, resulting in the death of 7,828,000 m³ of conifers (Table 6). Although Poland reported the highest losses (6,270,000 m³), this volume concerns the damage caused by the complex of species occurring on Norway spruce, in which *I. typographus* is dominating .

Table 5. Damage caused by Hylobius abietis

Country	Threatened Area (ha)	Tree death[1]	Period	Area (ha)
Austria	3,000,000	2		
Germany	6,466,455	2	1990-98	14,643
Hungary	246,000	2	1980-98	2,400
Ireland	8,000	3		
Lithuania	7,264	2	1997-2001	9,142
Poland	27,000	2		
Portugal	1 080 800	2		
Romania	180,000	3	1991-2000	60,719
Slovakia	15,000	3	1990-99	1,354
Spain	100,000	2		
United Kingdom	15,000	3		
Total	3,418,264	39	1980-2000	88,258

[1] Scoring from 1 to 3

Table 6. Damage caused by Pityogenes chalcographus

Country	Threatened Area (ha)	Period	Number of trees	Volume (m³)	Area (ha)
Austria	2,500,000	1992-01		600,000	
Germany	3,233,001				
Hungary	246,000				
Poland	513,000	1999		6,270,000	
Portugal	1 080 800				
Romania	1,200,000	1999-2000	730,049	730,049	595,400
Slovakia	600,000	1900-99		227,457	
Switzerland	492,000				
Total	8,784,001	1900-2000	730,049	7,827,506	595,400

4.4. Scolytus multistriatus and S. scolytus

Damage by these two species was usually reported together, as the vectors for Dutch Elm Disease have not always been identified with complete accuracy. Much greater damage obviously occurred throughout Europe from the late 1970s, but was not reported in the BAWBILT database. The reason for this is probably the generally doubtful status of Ulmus species as forest trees (Table 7).

Table 7. Damage caused by Scolytus multistriatus *and* S. scolytus

Country	Threatened Area (ha)	Period	Number of trees	Volume (m³)	Area (ha)
Spain		1984-99	3,000,000		
Slovakia	1,500	1990-99		10,711	
Romania	1,000	1991-2000			524
Portugal	221,600				
Total	224,100	1991-2000	3,000,000	10,711	524

4.5. Ips acuminatus

Although nine countries provided quantitative data on this species, only Poland reported high losses on pines (a total of 12,838,000 m³ killed by BAWBILT organisms between 1990 and 1999: Table 8). The same 12,838,000 m³ are also cited in connection with *Tomicus piniperda* and *Phaenops cyanea* in Poland (Tables 9 and 10). The specific status of these three species found on the same dead pines in Poland is unclear in the database; it results from the method used for data collection in this country, namely the evidence of the volume of killed trees regardless the insect specied causing the mortality (the volume of tree killed by *I. acuminatus* is much lower).

4.6. Tomicus piniperda

Eight countries provided quantitative data for this species. Its status in Poland is unclear (see above), however this species is one of the most aggressive and important pine pests in this country. Significant losses were reported in Slovakia (93,000 m³) and large acreages were reported in Spain (200,000 ha: Table 9).

Table 8. Damage caused by Ips acuminatus

Country	Threatened Area (ha)	Period	Number of trees	Volume (m^3)	Area (ha)
Austria	200,000	1993-2002 (?)		3,000	
Germany	2,800,433				
Poland	6,780,000	1990-99		12,838,000	
Romania	90,000	1991-2000	8,109	2,028	2,235
Slovakia	120,000	1990-99		7,400	
Spain	1,100,000	1990-99	10,000		
Switzerland	45,000	1992-2000			30
Total	11,135,433	1990-2000	18,109	12,850,428	2,265

Table 9. Damage caused by Tomicus piniperda

Country	Threatened Area (ha)	Period	Number of trees	Volume (m^3)	Area (ha)
Switzerland	45,000				
Spain	4,500,000	1990-99			200,000
Slovakia	120,000	1990-99		93,177	
Romania	45,000	1991-2000	8109	2,028	2,235
Portugal	1 080 800				
Poland	6,780,000	1990-99		12,838,000	
Hungary	217,000				
Germany	2,800,433				
Total	14,507,433	1990-2000	8,109	12,933,205	202,235

4.7. Phaenops cyanea

Five countries provided quantitative data for this species (Table 9). The larger figures concern Poland; the status of *P. cyanea* in this country is similar as for *T.piniperda*, which is not resulting clearly from the data in BAWBILT database (see comments in previous section) .

Table 10. Damage caused by Phaenops cyanea

Country	Threatened Area (ha)	Period	Volume (m^3)
Slovakia	110,000	1990-99	1,159
Romania	50,000		
Poland	4,400,000	1990-99	12,838,000
Hungary	217,000		
Germany	3,233,001		
Total	8,010,001	1990-99	12,839,159

4.8. Rhyacionia buoliana

Four countries provided quantitative information on this species. Significant damage was reported on young pines in Hungary (17,300 ha) and in Romania (2,500 ha: Table 11).

*Table 11. Damage caused by R*hyacionia buoliana

Country	Threatened Area (ha)	Period	Area (ha)
Slovakia	100000	1990-99	343
Romania	10,000	1991-2000	2,495
Ireland	100,000		
Hungary	217,000	1980-98	17,300
Total	327,000	1980-2000	20,138

4.9. Scolytus laevis

A total of 1,500 ha was reported to be potentially threatened by this species in Slovakia, but no quantitative information on damage is available.

4.10. Synthesis of quantitative data on damage

Table 12 provides a synthetic account of the information above.

Table 12. A synthesis of quantitative data on damage caused by the "top ten" species

Species	Number of countries where data available	Threatened Area (ha)	Period	Number of trees	Volume	Area (ha)
Ips typographus	10	7,640,156	1990-2001		31,642,535	2,819,055
Hylobius abietis	11	3,418,264	1980-2000			88,258
Pityogenes chalcographus	8	8,784,001	1900-2000	730,049	7,827,506	595,400
Scolytus multistriatus and *Scolytus scolytus*	4	224,100	1991-2000	3,000,000	10,711	524
Ips acuminatus	7	11,135,433	1990-2000	18,109	12,850,428	2,265
Tomicus piniperda	8	14,507,433	1990-2000	8,109	12,933,205	202,235
Phaenops cyanea	5	8,010,001	1990-99		12,839,159	
Rhyacionia buoliana	4	327,000	1980-2000			20,138

5. CONTROL

During the early stages of BAWBILT there was considerable discussion on the types of control measures that should be included in the database. General agreement was reached on a number of categories of control which are shown in Appendix 1. On-line data entry was carried out by 19 countries and most of the control options were accessed, although not for all organisms in the list. However, it was interesting to note that the number of control measures adopted was related to the degree of aggressivity indicated in the Damage part of the database. Consequently, we have analysed the control data using the list of organisms, in the same order of agressivity summarised in Table 3. This is presented as a series of Tables for each of the principal control categories in Appendix 1, namely Quarantine, Silvicultural Management, Chemical Insecticide Application, Trapping Out, Biological Control, Other Control Strategies, Monitoring, Risk Rating and Decision Support Systems. The degree of employment of each strategy varied with the type of pest and, particularly with the damage rating of that pest.

5.1. Quarantine

This category is concerned principally with prevention of movement of pests between countries and, in some cases, within countries. The results are shown in Table 13. In many respects, it is surprising that there were so many entries in this category. It can only be assumed that the measures are related to the international movement of wood and wood products from the countries concerned to other countries with restrictions on importation of the named pests.

5.2. Silvicultural Management

This category contains the most commonly employed management options for BAWBILT organisms. This reflects the possibility of enhancing tree health and, thereby, increasing the ability of living trees to defend themselves against attack by a range of pests, especially those entering through the bark. The results are shown in Table 14.

Removal of breeding material through forest sanitation or, as an extreme measure, clearfelling is practised for most of the pests in Table 14. These are traditional measures and, although expensive to implement if they have to be carried out early in the economic life of a crop, can provide some financial return from sales of extracted timber.

5.3. Chemical Insecticide Application

Results for this analysis are shown in Table 15. Not all the organisms in the table have been managed using insecticides and relatively few were treated as standing trees; in this category the target is universally the adult stage. The most common usage was for treatment of felled trees either to prevent attack or to prevent emergence of the organisms that were breeding in the felled material.

5.4. Trapping Out

This is an alternative approach to silvicultural management and involves the deliberate use of material to attract the adult stages of the BAWBILT pests and then to remove the material before a full breeding cycle and subsequent emergence can take place or, in the case of pheromone traps, to prevent adult pests from reaching susceptible host trees. The results are shown in Table 16. The measures have been most commonly employed against Scolytidae, aided by the known attraction of the adult stages to freshly cut or damaged trees. There are also commercially available pheromone lures for the majority of the most damaging Scolytidae.

Table 13. Quarantine control measures employed against the most aggressive BAWBILT organisms as listed in Table 3. The figures represent the numbers of countries which implemented different types of quarantine measures against each species

Species	Movement restrictions	Storage restrictions	Physical Treatment						
			Debarking	Covering	Processing	Composting	HT/KD	Wet storage	Burning
Ips typographus	3	3	9	4	3	1	2	5	2
Hylobius abietis	1	1	1						1
Pityogenes chalcographus			4	3	2	1	1		4
Scolytus multistriatus	1	1	3		1				4
Scolytus scolytus	2	1	3		1				3
Ips acuminatus		1	4	2	3				3
Tomicus piniperda		1	5	1	1			2	3
Phaenops cyanea			2	1	1				2
Rhyacionia buoliana									1
Scolytus laevis	1	1	1						1
Cossus cossus									1
Cryptorhynchus lapathi					1				2
Dendroctonus micans	4		6	3	1	1	2		2
Ips duplicatus	2		4	1	1	1	2		1
Ips sexdentatus	1	1	4	2	1		1		
Paranthrene tabaniformis									1
Pissodes castaneus			2						2
Tomicus minor		1	4	1	2			2	3
Trypodendron lineatum	1	3	2	1	1	1		3	1
Zeuzera pyrina					1				2
Agrilus biguttatus									
Gnathotrichus materiarius	1	1	1	1				1	
Hylastes ater			1						
Hylastes cunicularius			1						1
Hylobius pinastri									
Ips amitinus	1		8	3	3	1	2		4
Ips cembrae	1		4	3	1		1		
Leperesinus varius			2		1				2
Monochamus sartor			1						
Pissodes piniphilus			2	1					
Pityokteines curvidens			4	2	1				3
Polygraphus poligraphus			2	1	1				1
Saperda carcharias	1								1
Saperda populnea									1
Scolytus intricatus			2						1
Scolytus triarmatus									
Sirex juvencus			1		1				1
Tetropium gabrieli			2	2	1				1
Trypodendron domesticum	1	1						1	
Urocerus gigas			1		1				1

Table 14. Silvicultural management measures employed against the most aggressive BAWBILT organisms as listed in Table 3. The figures represent the numbers of countries which implemented silvicultural management methods of each category for each species

Species	Sanitary felling		Site preparation	Pruning	Physical protection	Silvicultural choice	Forest sanitation
	Clear felling	Selective thinning					
Ips typographus	9	9				3	12
Hylobius abietis			10		7	8	4
Pityogenes chalcographus	3	5		1		2	5
Scolytus multistriatus	2	10		2		4	6
Scolytus scolytus	3	8		2		2	5
Ips acuminatus	3	8		1		1	7
Tomicus piniperda	4	8		1			12
Phaenops cyanea	1	3		1		2	2
Rhyacionia buoliana		1		1		1	1
Scolytus laevis		5				2	2
Cossus cossus	1	4		4	2	1	3
Cryptorhynchus lapathi	2	3	1	1	1		3
Dendroctonus micans	2	7			1	2	5
Ips duplicatus	1	3				1	4
Ips sexdentatus	3	7					5
Paranthrene tabaniformis	1	3		3	1	1	3
Pissodes castaneus	1	4				2	9
Tomicus minor	2	4		1		2	8
Trypodendron lineatum					1		1
Zeuzera pyrina		3	1	5		1	2
Agrilus biguttatus	2	4		1		1	2
Gnathotrichus materiarius		1					1
Hylastes ater		1	2		1	1	4
Hylastes cunicularius			1		1	2	3
Hylobius pinastri			1			1	
Ips amitinus	3	5				1	5
Ips cembrae	1	6				1	4
Leperesinus varius		2			1	1	2
Monochamus sartor							1
Pissodes piniphilus	2	3					1
Pityokteines curvidens	2	4		1		2	2
Polygraphus poligraphus	1	3					1
Saperda carcharias	1	4	1				3
Saperda populnea		4	1	1			2
Scolytus intricatus		4				1	4
Scolytus triarmatus		1				1	
Sirex juvencus		1					5
Tetropium gabrieli	1	2					
Trypodendron domesticum	1	1			1	1	2
Urocerus gigas		1					6

Table 15. Chemical insecticide measures employed against the most aggressive BAWBILT organisms as listed in Table 3. The figures represent the numbers of countries which use chemical insecticide treatments on each category of trees for each pest species.

				Systemic	
	Standing trees	Transplants	Felled trees	Transplants	Mature trees
Ips typographus			10		
Hylobius abietis	2	14		6	
Pityogenes chalcographus			5		
Scolytus multistriatus	3		2		2
Scolytus scolytus	2		2		1
Ips acuminatus			6		
Tomicus piniperda	1		6		
Phaenops cyanea			2		
Rhyacionia buoliana	2	1			
Scolytus laevis			1		
Cossus cossus	4				
Cryptorhynchus lapathi	2	2		1	1
Dendroctonus micans			3		1
Ips duplicatus			1		
Ips sexdentatus			4		
Paranthrene tabaniformis	4	2		2	
Pissodes castaneus	1	1	1	1	
Tomicus minor			5		
Trypodendron lineatum			4		
Zeuzera pyrina	5				
Agrilus biguttatus			1		
Gnathotrichus materiarius			1		
Hylastes ater		5		3	
Hylastes cunicularius		6		3	
Hylobius pinastri		1			
Ips amitinus			4	1	
Ips cembrae			3		
Leperesinus varius			1		
Monochamus sartor			1		
Pissodes piniphilus			2		
Pityokteines curvidens			4		
Polygraphus poligraphus			3		
Saperda carcharias	3				
Saperda populnea	1	2		1	
Scolytus intricatus			2		
Scolytus triarmatus					
Sirex juvencus			1		
Tetropium gabrieli			1		
Trypodendron domesticum	1		3		
Urocerus gigas			2		

Table 16. Trapping out measures employed against the most aggressive BAWBILT organisms as listed in Table 3. The figures represent the numbers of countries which use different types of trapping out measures against each species.

	Trap trees	Trap logs	Pheromone traps	Baited trees	Baited slash
Ips typographus	7	9	12	7	1
Hylobius abietis		4	2		1
Pityogenes chalcographus	3	3	7	2	1
Scolytus multistriatus	3	2	4	1	
Scolytus scolytus	3	2	4	1	
Ips acuminatus	5	4	1	1	
Tomicus piniperda	7	8	1		
Phaenops cyanea	3	1			
Rhyacionia buoliana			2		
Scolytus laevis	1	1	1		
Cossus cossus	1	1	1		
Cryptorhynchus lapathi					
Dendroctonus micans	1				
Ips duplicatus	2		2		
Ips sexdentatus	4	5	2	1	
Paranthrene tabaniformis	1		1		
Pissodes castaneus		5			
Tomicus minor	6	7	1		
Trypodendron lineatum	1	1	2	1	
Zeuzera pyrina	1	1			
Agrilus biguttatus	1	1			
Gnathotrichus materiarius					
Hylastes ater	1	2			
Hylastes cunicularius	1	1			
Hylobius pinastri					
Ips amitinus	6	3			
Ips cembrae	1	1	2		1
Leperesinus varius	1	1			
Monochamus sartor	1	1			
Pissodes piniphilus	1	1			
Pityokteines curvidens	3		1	1	
Polygraphus poligraphus	2				
Saperda carcharias					
Saperda populnea					
Scolytus intricatus	2	1			
Scolytus triarmatus					
Sirex juvencus	1	1			
Tetropium gabrieli					
Trypodendron domesticum	2		1	1	
Urocerus gigas	1	1			

5.5. Biological Control

Although this category was included in the list of control measures, there were very few records of use of biological control agents and, therefore, a full analysis has not been carried out. However, this is covered in more detail elsewhere in this book (Kenis *et al*., chapters 11 and 18; Kenis and Hilszczanski, chapter 21).

5.6. Monitoring

Part of effective management of pests is knowledge of their distribution and abundance, especially in relation to availability of breeding material. Monitoring is, therefore, an important element in making decisions about whether to apply active control measures. Most countries implemented some form of monitoring system and these are listed for the major pests in Table 17. The most commonly employed measures use a combination of visual surveys, supplemented by use of various trap systems using pheromones/attractants or trap trees/logs. Remote sensing has rarely been employed and may offer opportunities for further development in the future.

5.7. Risk Rating and Decision Support Systems

This category received relatively few responses, but would appear to offer promise for future integrated management of the most serious pests. Results of the analysis are shown in Table 18. As with other control measures, the development of risk models and decision support systems has made most progress with the most serious pests, especially for *I. typographus*. It is likely that this approach will expand in the future, especially with the increasing use and sophistication of GIS systems that are now available.

6. CONCLUSIONS

Overall the information in the BAWBILT database has provided useful summaries of the range of control measures employed by the member countries. The range of measures has, predictably, been linked to the degree of severity of the damage caused by the listed pests. It was not, however, possible to carry out cost-benefit analyses of the various control measures carried out or even to assess the relative efficacy of those measures. This indicates that improved quantification of the cost and effectiveness of pest management for BAWBILT organisms could be a priority for the future. In addition, work should aim to integrate experiences from the countries involved in this COST action to develop procedures of wide applicability for management of BAWBILT pests.

Table 17. Monitoring systems employed against the most aggressive BAWBILT organisms as listed in Table 3. The figures represent the numbers of countries which use different types of monitoring systems against each species

Species	Pheromones/ attractants	Trap trees/logs	Visual survey/ sampling	Remote sensing	Questionnaire
Ips typographus	14	9	13	3	4
Hylobius abietis	3	5	11	0	3
Pityogenes chalcographus	7	4	9	0	3
Scolytus multistriatus	1	3	6	0	1
Scolytus scolytus	2	3	6	0	2
Ips acuminatus	1	4	6	0	1
Tomicus piniperda	1	5	8	0	2
Phaenops cyanea	0	2	4	0	2
Rhyacionia buoliana	2	1	5	1	2
Scolytus laevis	0	2	2	0	1
Cossus cossus	1	0	5	1	2
Cryptorhynchus lapathi	0	0	5	0	2
Dendroctonus micans	0	3	9	2	1
Ips duplicatus	4	4	3	0	2
Ips sexdentatus	3	3	7	0	1
Paranthrene tabaniformis	1	0	2	0	2
Pissodes castaneus	1	3	5	0	0
Tomicus minor	1	5	7	0	1
Trypodendron lineatum	3	1	3	0	1
Zeuzera pyrina	3	0	6	1	0
Agrilus biguttatus	0	2	3	0	2
Gnathotrichus materiarius	0	0	2	0	0
Hylastes ater	0	0	3	0	1
Hylastes cunicularius	0	0	5	0	1
Hylobius pinastri	0	0	1	0	0
Ips amitinus	3	7	7	0	2
Ips cembrae	3	3	4	0	2
Leperesinus varius	0	0	4	0	1
Monochamus sartor	0	0	0	0	0
Pissodes piniphilus	0	0	4	0	0
Pityokteines curvidens	0	1	4	0	2
Polygraphus poligraphus	1	1	4	0	1
Saperda carcharias	0	0	5	0	1
Saperda populnea	0	0	3	0	1
Scolytus intricatus	0	1	3	0	3
Scolytus triarmatus	0	0	1	0	0
Sirex juvencus	0	0	1	0	0
Tetropium gabrieli	0	0	1	0	1
Trypodendron domesticum	1	0	3	0	2
Urocerus gigas	0	0	1	0	0

Table 18. Risk rating and decision support systems employed against the most aggressive BAWBILT organisms as listed in Table 3. The figures represent the numbers of countries which use different risk rating and decision support systems for each species.

Species	Risk models			GIS	Decision support systems
	Local scale	Regional scale	National scale		
Ips typographus	3	7	1	2	1
Hylobius abietis	1	2			1
Pityogenes chalcographus	3	2			1
Scolytus multistriatus		1			
Scolytus scolytus	1	1			
Ips acuminatus	3	2			
Tomicus piniperda	2	2		1	
Phaenops cyanea					1
Rhyacionia buoliana	2				
Scolytus laevis		1			
Cossus cossus	1				
Cryptorhynchus lapathi	1				
Dendroctonus micans	1			1	
Ips duplicatus		1			
Ips sexdentatus	1	1			1
Paranthrene tabaniformis	1	1			
Pissodes castaneus					
Tomicus minor	2				
Trypodendron lineatum	1				1
Zeuzera pyrina	1				
Agrilus biguttatus					1
Gnathotrichus materiarius					
Hylastes ater	1				
Hylastes cunicularius	1				
Hylobius pinastri					
Ips amitinus	3			1	
Ips cembrae	1				1
Lesperesinus varius					
Monochamus sartor	1				
Pissodes piniphilus	1	1			
Pityokteines curvidens	1				1
Polygraphus poligraphus	1				
Saperda carcharias	1				
Saperda populnea	1				
Scolytus intricatus		1			
Scolytus triarmatus					
Sirex juvencus	1				
Tetropium gabrieli					
Trypodendron domesticum					1
Urocerus gigas					

Appendix 1: Categories of control measures in the BAWBILT Database

Quarantine	Movement restrictions	
	Storage restrictions	
	Physical treatment	Debarking
		Covering
		Processing
		Composting
		Heat treatment/KD
		Wet storage
		Burning
Silvicultural management	Sanitary felling	Clear felling
		Selective thinning
	Site preparation	
	Pruning	
	Physical protection	
	Silvicultural choice	
	Forest sanitation	
	Other	
Chemical insecticide application	Standing trees	
	Transplants	
	Felled trees	
	Systemic	Transplants
		Mature trees
Trapping out	Trap trees	
	Trap logs	
	Pheromone traps	
	Baited trees	
	Baited slash	
	Other	
Biological control	Predators	
	Parasitoids	
	Microbial control	Bacteria
		Fungi
		Nematodes
		Protozoa
		Viruses
		Other
Other control strategies	Interruption of attack: thinning	
	Prevention of attack	
	Fallow period	
	Ectomycorrhizae	
Monitoring	Pheromone traps	
	Trap trees/logs	
	Visual surveys	
	Remote sensing	
	Other	
Risk rating and Decision Support Systems	Risk models	Local scale
		Regional scale
		National scale
	GIS	
	Decision support systems	