

Supplementary materials for Maaß and Kehlenbeck (2024). Cost–Benefit Analysis of Monitoring Insect Pests and Aerial Spraying of Insecticides: The Case of Protecting Pine Forests against *Dendrolimus pini* in Brandenburg (Germany).

S1: Questionnaires for collecting information on the costs of monitoring insect pests and aerial spraying of insecticides.

Questionnaire I	
Topic:	Costs of monitoring <i>Dendrolimus pini</i> L.
Study area:	Cottbus forest district and Lieberose forest district
Study year:	2014

Please refer all your information exclusively to the study area and study year indicated above.

1. Area Monitored

Please indicate,

- (1) the total area monitored for *D. pini* in the study area and study year during winter (basic monitoring),
- (2) the total area monitored for *D. pini* in the study area and study year during spring (advanced monitoring).

	Total area (ha)
(1) Basic monitoring	
(2) Advanced monitoring	

2. Costs of Materials

Please indicate for the basic and advanced monitoring of *D. pini*,

- (1) what materials were used in the study area and study year,
- (2) how much of the materials was used in total,
- (3) what costs accrued per unit of material.

(1) Material (basic monitoring)	(2) Quantity (unit)	(3) Costs per unit (EUR/unit)

(1) Material (advanced monitoring)	(2) Quantity (unit)	(3) Costs per unit (EUR/unit)

3. Costs of Labor

Please indicate for the basic and advanced monitoring of *D. pini*,

- (1) what work steps were carried out to monitor *D. pini* in the study area and study year,
- (2) which workers carried out the steps,
- (3) how many hours were needed in total by the workers to perform the steps,
- (4) what costs (i.e., gross wage) accrued per hour worked.

(1) Work steps (basic monitoring)	(2) Workers ¹⁾	(3) Total hours worked (h)	(4) Costs per hour (EUR/h)

¹⁾ Workers: e.g., head of the forest district, forest ranger, office worker, forest worker.

(1) Work steps (advanced monitoring)	(2) Workers ¹⁾	(3) Total hours worked (h)	(4) Costs per hour (EUR/h)

¹⁾ Workers: e.g., head of the forest district, forest ranger, office worker, forest worker.

4. Costs of Car Use

Please indicate for the basic and advanced monitoring of *D. pini*,

- (1) what work steps included the use of cars in the study area and study year,
- (2) how many kilometers were driven by car to carry out the work steps,
- (3) what costs accrued per kilometer driven.

(1) Work steps with car use (basic monitoring)	(2) Kilometers driven (km)	(3) Costs per kilometer (EUR/km)

(1) Work steps with car use (advanced monitoring)	(2) Kilometers driven (km)	(3) Costs per kilometer (EUR/km)

5. Other Costs

Please indicate what other costs accrued for the basic and advanced monitoring of *D. pini* in the study area and study year.

Other costs (basic monitoring)	Total costs (EUR)

Other costs (advanced monitoring)	Total costs (EUR)

Questionnaire II	
Topic:	Costs of aerial spraying of insecticides against <i>Dendrolimus pini</i> L.
Study area:	Cottbus forest district and Lieberose forest district
Study year:	2014

Please refer all information exclusively to the study area and study year indicated above.

1. Forest Area Sprayed with Insecticides

Please indicate,

- (1) the total area forested with Scots pine (*Pinus sylvestris* L.) in the study area and study year,
- (2) the total area predicted to be totally defoliated by caterpillars of *D. pini* in the study area and study year,
- (3) the total area actually treated with insecticides in the study area and study year.

	Cottbus forest district (ha)	Lieberose forest district (ha)
(1) Total area forested with Scots pine		
(2) Total area at risk of total defoliation		
(3) Total area treated with insecticides		

2. Technical Information

Please indicate,

- (1) the technique used for the aerial spraying of insecticides in the study area and study year,
- (2) the date of the spraying,
- (3) the trade name of the insecticide sprayed,
- (4) the active substance of the insecticide,
- (5) the application rate of the insecticide per hectare,
- (6) the volume of water sprayed per hectare.

	Cottbus forest district	Lieberose forest district
(1) Technique used for the spraying		
(2) Date of the spraying		
(3) Trade name of the insecticide		
(4) Active substance		
(5) Application rate (mL ha ⁻¹ ; g ha ⁻¹)		
(6) Spray volume of water (L ha ⁻¹)		

3. Costs of Helicopter Services, Insecticides and Water

Please indicate,

- (1) what costs accrued in total for helicopter services (without costs of insecticides and water) in the study area and study year,
- (2) what costs accrued in total for the insecticides used,
- (3) what costs accrued in total for the water used.

	Cottbus forest district (EUR)	Lieberose forest district (EUR)
(1) Total costs of helicopter services		
(2) Total costs of insecticides		
(3) Total costs of water		

4. Costs of Materials

Please indicate,

- (1) what materials were used to prepare, to conduct and to follow up the aerial spraying of insecticides in the study area and study year,
- (2) how much of the materials was used in total,
- (3) what costs accrued per unit of material.

(1) Material	(2) Quantity (unit)	(3) Costs per unit (EUR/unit)

5. Costs of Labor

Please indicate,

- (1) what work steps were carried out to prepare, to conduct and to follow up the aerial spraying of insecticides in the study area and study year,
- (2) which workers carried out the steps,
- (3) how many hours were needed in total by the workers to perform the steps,
- (4) what costs (i.e., gross wage) accrued per hour worked.

(1) Work steps	(2) Workers ¹⁾	(3) Total hours worked (h)	(4) Costs per hour (EUR/h)

¹⁾ Workers: e.g., head of the forest district, forest ranger, office worker, forest worker.

6. Costs of Car Use

Please indicate,

- (1) which work steps included the use of cars in the study area and study year,
- (2) how many kilometers were driven by car to carry out the work steps,
- (3) what costs accrued per kilometer driven.

(1) Work steps with car use	(2) Kilometers driven (km)	(3) Costs per kilometer (EUR/km)

7. Other Costs

Please indicate what other costs accrued for the spraying of insecticides in the study area and study year.

Other costs	Total costs (EUR)

S2: Guidelines for Expert Interviews.

Interview Guideline I
Monitoring of Forest Insect Pests in Brandenburg

1 Introduction

- What is your professional background?
- What is your current field of activity and the field of activity of your organization?
- What personal experiences do you have with monitoring of insect pests?
- What aims do you and your organization pursue regarding the monitoring of insect pests?

2 Damages through Insect Pests

- What role do insect pests like *D. pini* play in pine production in Brandenburg?
- What damages do insect pests like *D. pini* cause in pine production?
- What costs can arise from insect pests in pine production?

3 Rules

- What rules apply for the monitoring of insect pests in Brandenburg?

4 Actors

- Which actors participate in the monitoring of insect pests in Brandenburg?
- What are the responsibilities of the actors?

5 Monitoring

- What is the aim of monitoring insect pests in Brandenburg?
- How is *D. pini* monitored in Brandenburg?
- What work steps are carried out to monitor *D. pini*?

6 Benefits

- What are the general benefits of monitoring insect pests like *D. pini*?
- What were the benefits of monitoring *D. pini* in the studied case?
- Which actors benefited from monitoring *D. pini* in the studied case?

7 Costs

- What are the general costs of monitoring of insect pests like *D. pini*?
- What were the costs of monitoring *D. pini* in the studied case?
- Which actors bore the costs in the studied case?

Interview Guideline II

Aerial Spraying of Insecticides in Brandenburg

1 Introduction

- What is your professional background?
- What is your current field of activity and the field of activity of your organization?
- What personal experiences do you have with aerial spraying of insecticides in forests?
- What aims do you and your organization pursue regarding the aerial spraying of insecticides in forests?

2 Stand and Site Characteristics

- What properties characterize the pine stands in Brandenburg?
- What properties characterize the climate in Brandenburg?
- What properties characterize the soils in Brandenburg?
- How do the characteristics facilitate mass propagations of insect pests?

3 Damages through Insect Pests

- What role do insect pests like *D. pini* play in pine production in Brandenburg?
- What damages do insect pests like *D. pini* cause in pine production?
- What costs can arise from insect pests in pine production?

4 Rules

- What rules apply for aerial spraying of insecticides in Brandenburg?
- What rules had to be followed in the studied case of spraying insecticides?

5 Actors

- Which actors participate in aerial spraying of insecticides in Brandenburg?
- What are the responsibilities of the actors?
- Which actors participated in the spraying of insecticides in the studied case?

6 Aerial Spraying of Insecticides

- What are the advantages of aerial spraying of insecticides via helicopter?
- What are the disadvantages of aerial spraying of insecticides via helicopter?
- What role does aerial spraying of insecticides play in the control of insect pests in Brandenburg?
- What is the aim of aerial spraying of insecticides in Brandenburg?
- What work steps are carried out to prepare, to conduct and to follow up aerial spraying of insecticides?
- How did you prepare, conduct and follow up the spraying of insecticides in the studied case?

7 **Benefits**

- What are the general benefits of aerial spraying of insecticides?
- What were the benefits of aerial spraying of insecticides in the studied case?
- Which actors benefited from the aerial spraying of insecticides in the studied case?

8 **Costs**

- What are the general costs of aerial spraying of insecticides?
- What were the costs of aerial spraying of insecticides in the studied case?
- Which actors bore the costs in the studied case?

Table S1. Age constants for evaluating the monetary value of pine stands in Germany [64].

Age	Age Constant	Age	Age Constant	Age	Age Constant
0	0	41	0.427	81	0.795
1	0.008	42	0.439	82	0.801
2	0.015	43	0.451	83	0.808
3	0.023	44	0.462	84	0.814
4	0.031	45	0.474	85	0.820
5	0.040	46	0.485	86	0.826
6	0.048	47	0.496	87	0.833
7	0.056	48	0.507	88	0.839
8	0.065	49	0.518	89	0.845
9	0.074	50	0.529	90	0.850
10	0.083	51	0.540	91	0.856
11	0.092	52	0.550	92	0.862
12	0.102	53	0.561	93	0.868
13	0.111	54	0.571	94	0.873
14	0.121	55	0.581	95	0.879
15	0.131	56	0.591	96	0.884
16	0.141	57	0.601	97	0.890
17	0.151	58	0.611	98	0.895
18	0.162	59	0.621	99	0.901
19	0.172	60	0.630	100	0.906
20	0.183	61	0.639	101	0.911
21	0.194	62	0.648	102	0.916
22	0.205	63	0.657	103	0.921
23	0.216	64	0.666	104	0.926
24	0.227	65	0.675	105	0.931
25	0.238	66	0.683	106	0.936
26	0.250	67	0.692	107	0.940
27	0.261	68	0.700	108	0.945
28	0.273	69	0.708	109	0.950
29	0.285	70	0.716	110	0.954
30	0.297	71	0.723	111	0.959
31	0.308	72	0.731	112	0.963
32	0.320	73	0.739	113	0.968
33	0.332	74	0.746	114	0.972
34	0.344	75	0.753	115	0.977
35	0.356	76	0.760	116	0.981
36	0.368	77	0.767	117	0.986
37	0.380	78	0.774	118	0.990
38	0.392	79	0.781	119	0.995
39	0.404	80	0.788	120	1.000
40	0.415				

Table S2. Harvesting costs and timber prices of Scots pine for different site indices in Brandenburg (based on MIL [57]* and interpolation).

Site Index	Harvesting Costs (EUR m ⁻³ without bark)	Timber Price (EUR m ⁻³ without bark)
< 0.5	17.0	74.0
0.5	17.0*	74.0*
0.6	17.0	73.4
0.7	17.0	72.8
0.8	17.0	72.2
0.9	17.0	71.6
1.0	17.0*	71.0*
1.1	17.0	70.6
1.2	17.0	70.2
1.3	17.0	69.8
1.4	17.0	69.4
1.5	17.0*	69.0*
1.6	17.0	68.4
1.7	17.0	67.8
1.8	17.0	67.2
1.9	17.0	66.6
2.0	17.0*	66.0*
2.1	17.0	65.6
2.2	17.0	65.2
2.3	17.0	64.8
2.4	17.0	64.4
2.5	17.0*	64.0*
2.6	16.8	63.4
2.7	16.6	62.8
2.8	16.4	62.2
2.9	16.2	61.6
3.0	16.0*	61.0*
3.1	16.0	60.2
3.2	16.0	59.4
3.3	16.0	58.6
3.4	16.0	57.8
3.5	16.0*	57.0*
3.6	16.0	56.6
3.7	16.0	56.2
3.8	16.0	55.8
3.9	16.0	55.4
4.0	16.0*	55.0*
> 4.0	16.0	55.0

References

Reference numbers correspond to those in the main text.

57. MIL. *Richtlinie zur Waldbewertung des Landes Brandenburg*; Ministerium für Infrastruktur und Landwirtschaft des Landes Brandenburg: Potsdam, Germany, 2014.
64. BIMA. *Bekanntmachung der Anpassung der Richtlinien für die Ermittlung und Prüfung des Verkehrswerts von Waldflächen und für Nebenentschädigungen (Waldwertermittlungsrichtlinien 2000 – WaldR 2000)*; Bundesanstalt für Immobilienaufgaben: Bonn, Germany, 2019.