# DEVELOPMENT OF BEECH BARK DISEASE DURING A SEVEN YEAR PERIOD ON TWO PLOTS IN NORTHERN BAVARIA [1]

Klaus J. Lang [2]

Abstract.-- Since 1976 on two observation plots in northern Bavaria 600 trees have been regularly observed. Preliminary results of disease development on 96 trees, formerly moderately or heavily infested by Cryptococcus fagisuga, are reported.

## *INTRODUCTION*

As we know, beech bark disease in Europe is repeatedly the cause of great financial losses and sometimes of silvicultural problems. Especially between forest-officers there is no unique opinion on causes and etiology of the disease. Moreover, the reports of foresters concerning the duration of the disease from the first symptoms to the death of a tree are contradictory and one question asked very often is that of the chance of survival of trees which have been attacked.

That is why two observation plots were established in 1976 in the northern part of Bavaria where beech bark disease was common during this time.

The first plot at the forest district of Rohrbrunn is situated within an area where many trees suffered from the disease. Many beeches were already killed at that time in the neigborhood of and within the plot and many fruitingbodies of wood deteriorating fungi, especially Fomes fomentarius were found on dead trees. The second plot is located at the forest district of Rothenbuch, a few kilometers away from the first one. In the vicinity of this plot there was rather little damage and comparatively very few fruitingbodies.

At Rohrbrunn on an area of 1 ha, 200 trees were marked and numbered in a pure beech stand (with only a few Norway spruces). At Rothenbuch we marked 400 beeches on 1.6 ha in a stand mixed with old oaks (Quercus petraea). On both plots the oldest trees were about 120 years old. At Rohrbrunn the stand was very uniform but at Rothenbuch there were also younger trees present.

Since 1976 the 600 trees were observed three times a year; once in the spring when the foliage was developing, once during summer and once in fall when the leaves were being shed. We recorded the intensity of scale infestation with a simplified method on the basis of Rhumbler's scheme (with a scale from 0 - 5) the condition of the crown, tarry spots (slime flux), fructifications of Nectria and Cylindrocarpon, fruitingbodies of wood decomposers, dead bark, and so on. Investigations about the spore discharge of Fomes fomentarius and Fomitopsis pinicola have already been reported at the meeting in Nancy (Lang 1980). In 1977, 1978 and 1980 the two plots were photographed from the air with Kodak Aerochrome IR on a scale of 1 : 5000.

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[2] Forest Pathologist, Lehrstuhl für Forstbotanik, Amalienstrasse 52, D-8000 München 40

These pictures should yield information about the earliest stage of the disease, which can be seen using this method, and the possibility of predicting the death of the trees utilizing variations in crown density from the aerial photographs.

## RESULTS

The observation period began at about the time the disease was culminating. Therefore, we have no dates from our plots that could tell us how much time was needed to reach this state. In 1976 on the plot at Rohrbrunn 73 trees (= 36,5%) were infested with scale insects, 23 of these trees were moderately or heavily attacked. Up to 1982 moderate or heavy scale infestation was observed on 36 trees (= 18%). Tarry spots occured during the years on 32 trees (= 16%). To date, of the 36 trees, 14 are dead (= 39%). On the larger plot at Rothenbuch the relationships are comparable. Of the 130 trees (= 32%) that were infested with scale insects in 1976, 60 showed medium or heavy infestation, slime flux was observed in 55 cases (= 14%) and 25 out of 95 trees (= 26%) have died (Table 1).

Table 1. -- Scale infestation intensity, slime flux, and tree mortality on two observation plots in northern Bavaria during a 7-year observation period.

| | Rohrbrunn | Rothenbuch |
|---|---|---|
| area of the plots | 1 ha | 1.6 ha |
| number of trees | 200 | 400 |
| stand type | beech | beech and oak |
| scale infestation 1-5 (1976) | 73 (36,5%) | 130 (32,5%) |
| 3-5 (1976) | 23 (11,5%) | 60 (15,0%) |
| 3-5 (1976-1982) | 36 (18,0%) | 95 (23,75%) |
| slime flux | 32 (16,0%) | 55 (13,75%) |
| trees killed by BBD | 14 ( 7,0%) | 25 ( 6,25%)* |

*) six trees that were heavily attacked and removed before they were killed can be added here.

Figure 1 shows the development of the disease on 36 (Rohrbrunn) and 60 (Rothenbuch) attacked trees, respectively, during the observation period.

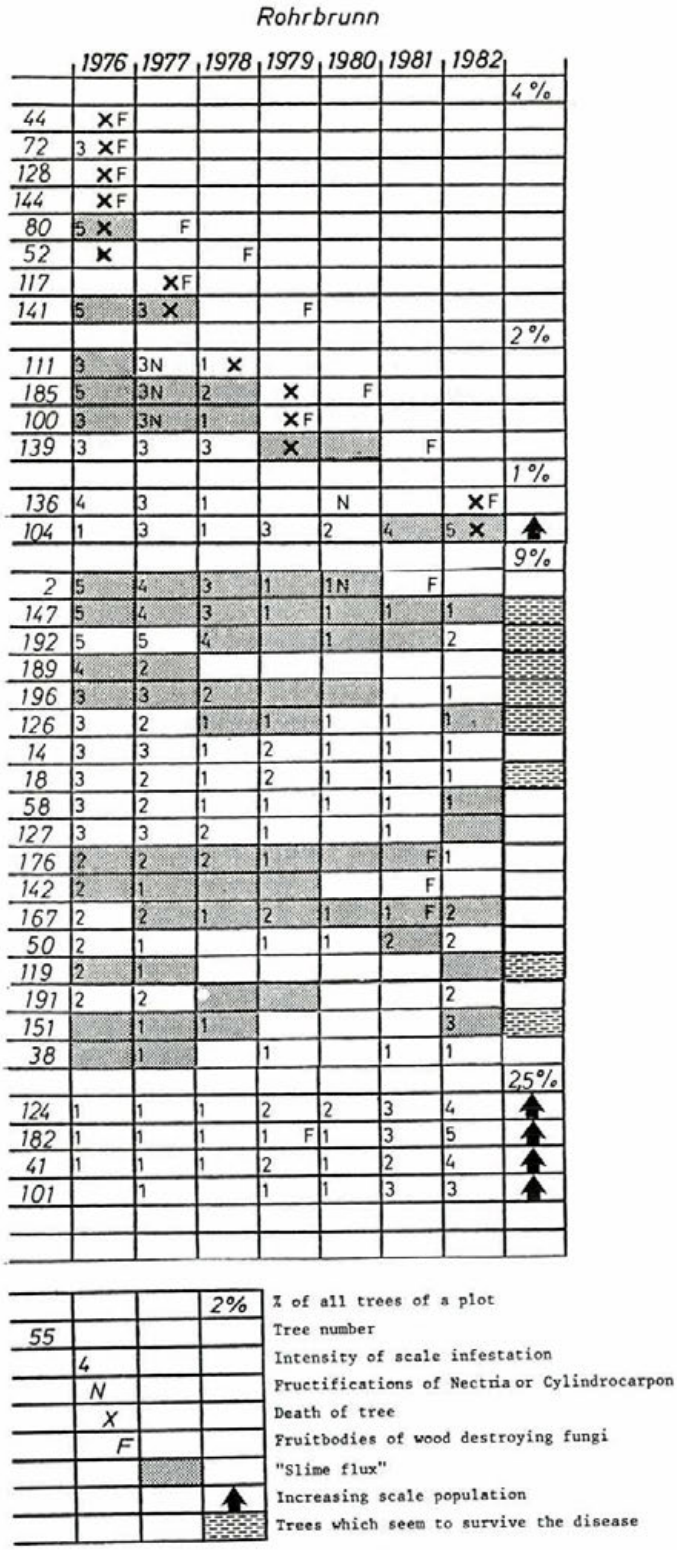
The figure shows that infestation of the trees by the scale insect decreases after a culmination point or remains rather unchanged for a long time. During the first 5 years no drastic increase in the scale population was observed. Normally, slime flux appears during or after the stage of most intensive infestation. Although they were heavily infested, some trees showed no slime flux. Perithecia of Nectria and sporodochia of Cylindrocarpon also occured during or after heavy attack. On the trees which are still alive it is apparent that rather few fructifications occur. This does not mean, however, that the fungus is absolutely absent, since the Nectria fungus isolations made from the non-fruitingbody material present on the margin of tarry spots were normally successful.

Sporodochia of Cylindrocarpon also appeared after the inoculation with spore suspension after the wounding of bark of healthy beeches outside the plots. The sporodochia appeared two years after inoculation. Today, after five years, all 25 wounds have healed.

After 1976, which was characterized by drought, no clear increase of the scale population was noticed, but on both plots there were some trees with increasing scale infestation. This development apparently took place gradually or rapidly within two years. The number of observations is not yet great enough to present exact data. Some trees with very different infestation intensity showed signs of recovery in the sense of healing-up old or relatively fresh necroses. There were scars and longitudinally running rolls on the trunk but bark necrosis was not evident to any great extent. These individuals showed either moderate scale infestation throughout the 7 year period or were heavily infested 7 years ago.

On some of the trees the scale insects were concentrated on one side of the trunk. This could not have been the only explanation for their recovery, however, because most of the trees which were still alive showed heavy infestation all around the stem. Eventually differences in the vitality, whatever this means, play a role in limiting bark necroses by a periderm. Another possibility could be the absence of Nectria but there was no evidence for this.

The duration of the disease, as it looks at the moment, seems to reach about 10 years from the installation of a strong scale population until the death of the tree. Here the time needed for the build-up of the scale population must be added. Fruitingbodies of wood deteriorating fungi are formed at different times on the



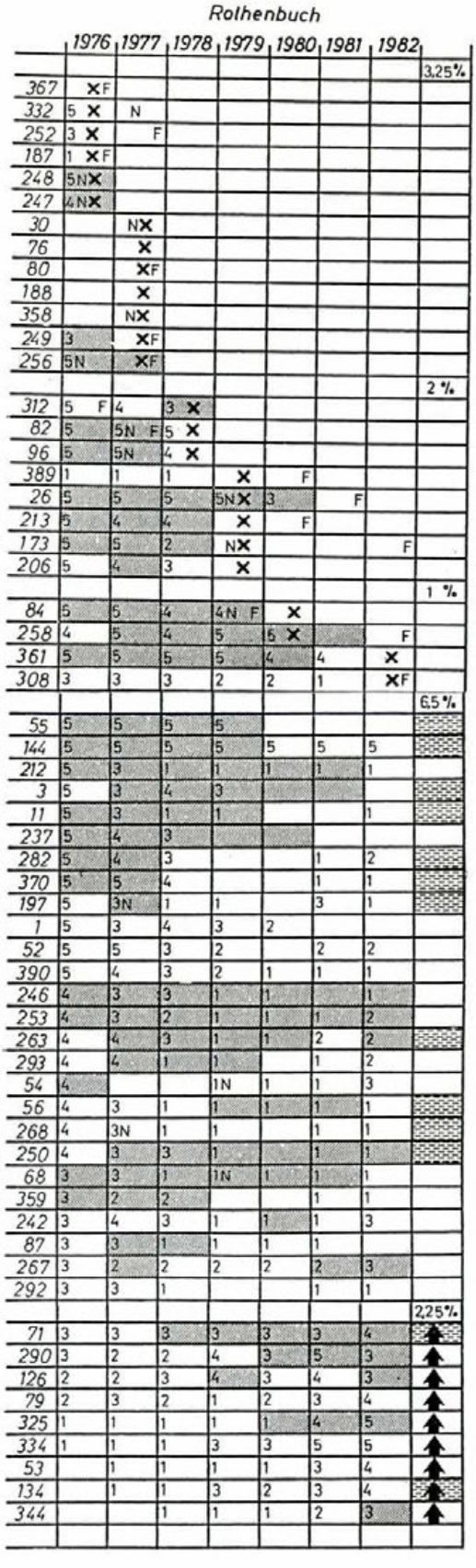




Figure 1.-- Development of beech bark disease on two plots during a seven year period.

heavily attacked trees. We can find them in the year of the death of the tree, 1 to 3 years before, or 1-3 years later. Because the fructification time is to be considered, infection by those fungi may take place very early, perhaps at the time when tarry spots appear. In 1982 the following fungi could be detected on dead or still-living trees (Table 2).

Table 2. -- Wood decomposing fungi on dead and still-living trees.

| | Rohrbrunn | Rothenbuch |
|---|---|---|
| dead trees with fruitingbodies | 12/14 (85,7%) | 15/25 (60%) |
| living trees with fruitingbodies | 5/22 (22,7%) | 0/35 ( 0%) |
| Fomes fomentarius | 17 | 4 |
| Fomitopsis pinicola | 3 | 1 |
| Stereum spp. | 2 | 2 |
| Bjerkandera adusta | - | 2 |
| Inonotus nodulosus | - | 1 |
| Trametes gibbosa | 1 | 2 |
| Ganoderma applanatum | - | 2 |
| Armillaria sp. | + | + |

It is conspicuous that Fomes fomentarius occurs four times more frequently at Rohrbrunn than at Rothenbuch and also that 5 living trees were attacked by this fungus at Rohrbrunn. The first plot is located in a forest with many dead trees which were not removed and were crowded with fruitingbodies, especially of Fomes fomentarius. Thus, this fungus was dominant in this region. Near the second plot there were only few dead trees and Fomes fomentarius did not yet play (1976) a dominant role. This fact had clear consequences for the infection of beeches on the different plots and also for the infection of living trees which took place probably under high infection pressure.

Fomes fomentarius and Fomitopsis pinicola produce many fruitingbodies and it seems that normally, a tree is invaded only by one species at first. If both fungi occur on the same tree their fruitingbodies appear far from one another.

Trametes gibbosa and Ganoderma applanatum appear much later (after some years). Then we can find them on broken stems and near the soil surface on the base of broken trees. Many dead trees are also attacked by Armillaria.

Since 1976 the foliage of all 600 trees was observed in spring, summer, and fall. Although heavily damaged, some trees show no significant symptoms in the crown, but most of the trees which died during the last years previously had poor foliage during the summer, late flushing, and early defoliation.

On the aerial photographs we took in 1977, 1978, and 1980 the regions of heavy attack were clearly seen. Although the scale of the pictures (1 : 5000) was rather small, many single trees could be identified when compared with an exact map of the plots. Therefore it was possible to pursue the development of the disease, to some extent, on aerial photographs.

It is true that many trees which show clear alteration in the foliage will be dead in a few years. This is interesting in as far as forestry practices are concerned, since small areas with heavily attacked trees can be detected before the trees are dead and useless. The completely exact prediction of the future of an attacked tree and also the detection of slightor moderately attacked trees seem not to be possible by this method. This is probably a reason why we get no significant correlation between scale infestation and foliation if we include trees with a few scale insects on the bark (Figure 2).

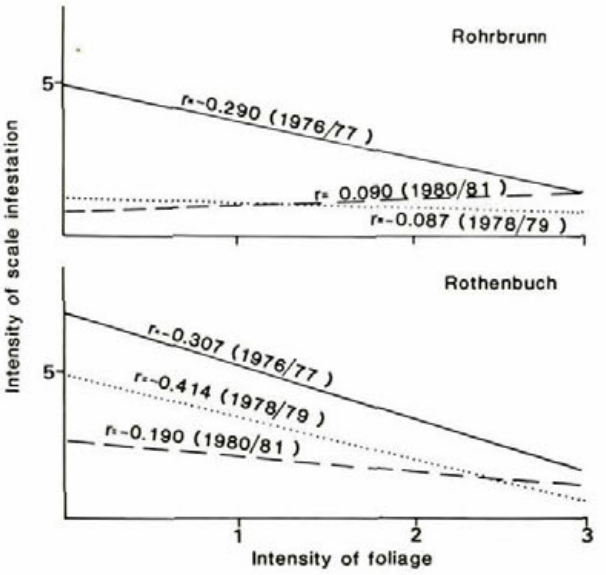



Figure 2. -- "Correlations" between the intensity of scale infestation and the alteration of foliage.

These observations will be partly finished in 1982 but we wish to also continue the observation of single trees in the future. We hope to complete the picture, that we have obtained to present under our conditions in the northern part of Bavaria.

## DISCUSSION

Because the observations are not yet finished and the data are not completely evaluated, the preliminary results shall only be briefly discussed.

On the two observation plots 7% and 6.25% respectively of all beeches died between 1976 and 1982 after heavy attack by beech bark disease. This is much more than reported by Rhumbler (1931) who found 2% of the trees to be dead. Also the proportion of trees with heavy scale infestation and tarry spots was clearly higher and explains the higher mortality. Sporodochia of Cylindrocarpon could be found for a short time after the inoculation of healthy bark but the fungus could not spread into the unwounded tissue. That means that heavy scale infestation enables the fungus to grow within the tissue which is perhaps weakened and predisposed by the scales (Lonsdale 1980).

It seems to be possible that climatic conditions also play a role in predisposing trees (Parker 1974, Lonsdale 1980), for example the fungus cannot be restricted by the formation of a periderm and the disease development could be accelerated. The fact that many heavily attacked trees are still alive could be explained by the favorable climatic conditions in the last several years which effectively increased their vitality or by a different degree of resistance against fungal attack. We have to wait and to see if the development of healing and recovery will take place as Ehrlich (1934), Rhumbler (1931), and Piraux (1980) observed or if the process of dying is only delayed. Rhumbler (1931) observed that trees may die about 15 years after the outbreak of the disease.

The drought of 1976 seemed not to have an influence on the scale population on our plots. An increase of the scale population of some trees started much later. On the other hand such a connection is often proposed by foresters (Lang 1982).

Different degrees of resistance against Cryptococcus fagisuga (Wainhouse 1980) could also explain the great differences in scale infestation. Schimitschek (1980) found that there is some relationship between the number and size of sclereids in the bark and the intensity of scale infestation.

The fact that heavily attacked beeches can be detected on aerial photographs is well known (Parker 1977, Perrin 1977, Heeschen 1977). A prognosis of the further development of single attacked individuals is still doubtful. Therefore the recommendation to the foresters remains the same as it has been for 100 years, namely to remove heavily attacked trees from the stand because wood deteriorating fungi invade the trees very early, especially where the infection pressure from the surroundings is high, and also because after a healing process, which may take place, there remain damages in the wood which devaluate the quality of the stem (Wujciak 1975).

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## SUMMARY

Since 1976 the development of beech bark disease was observed on two plots in northern Bavaria. Of 600 trees marked for our experiment about 200 have been infested by Cryptococcus fagisuga. Between 1976 and 1982 about 125 of them had, at least for some time, moderate or heavy infestation. Tarry spots were observed on 87 trees during this time, and 39 beeches (= 6,5%) are dead now. Slime flux nearly always appeared in connexion with heavy scale infestation. Fructifications of Nectria and Cylindrocarpon were found on many of these trees. The fungus could also frequently be isolated from the margins of bark necroses. On the other hand fructifications were rare on trees which are still alive.

Fruitingbodies of wood deteriorating fungi occured on the two plots to different degrees. On the plot at Rohrbrunn Fomes fomentarius dominated, on the plot at Rothenbuch the distribution of Fomes fomentarius, Fomitopsis pinicola, Stereum spp., Bjerkandera adusta and Inonotus nodulosus was rather uniform.

The high infection pressure at Rohrbrunn also seemed to be responsible for the invasion of Fomes fomentarius on the relatively great number of dead and still-living trees.

With the aid of aerial photographs at a scale of 1 : 5000 areas with beech bark disease were

easily detected. In some cases alterations of the crown of single trees could be persued for some years until the death of the tree. It seems, however, that only heavily attacked trees could be located with sufficient certainty.

On both plots the duration of the disease from the installation of a strong scale population to the break down of the tree took about 10 years. The development of the scale population required two years in some cases but longer in other cases.
On the bark of some beeches there were signs of recovery and healing from the disease.


RESUME

L'évolution de la maladie de l'écorce du hêtre sur deux parcelles expérimentales en Bavière du nord. Résultats préliminaires.

Le développement de la maladie de l'écorce du hêtre est observé depuis 1976 sur deux parcelles expérimentales en Bavière du nord. Sur 600 arbres marqués, environ 200 sont attaqués par Cryptococcus fagisuga. A peu près 125 d'entre-eux présentaient entre 1976 et 1980, en partie de manière discontinue, de fortes ou moyennes pullulations de l'insecte. Dans le même intervalle, on constata un suintement sur 87 arbres dont 39 (= 6,5%) sont morts depuis lors.

Dans presque tous les cas, une forte pullulation était liée à un suintement, souvent pendant une assez longue période. Un grand nombre de ces arbres portait des périthèces de Nectria et des coussinets conidiens de Cylindrocarpon. Nectria spp. fut également régulièrement isolé à partir de la zone periphérique de nécroses corticales. D'un autre côté, on ne put qu'assez rarement relever des carpophores de ce champignon sur les arbres encore vivants.

L'observation des carpophores de champignons lignivores sur les deux parcelles donna des résultats nettement divergents. Sur la parcelle de Rohrbrunn, on releva principalement Fomes fomentarius , tandis qu'à Rothenbuch Fomes fomentarius, Fomitopsis pinicola, Stereum sp. et Bjerkandera adusta étaient présents dans des porportions presque identiques. Sur la parcelle de Rohrbrunn, également en raison de conditions plus favorables à une infection, un nombre relativement plus élevé d'arbres morts, au même encore vivants, portait des carpophores.

L'observation de photographies aériennes à l'échelle 1/5000 permet de reconnaître aisément les peuplements atteints de la maladie de l'écorce du hêtre. Dans de nombreux cas, on put également suivre pendant plusieurs années l'évolution du houppier d'arbres bien délimités. Il semble toutefois que seul des dommages importants puissent ainsi être décelés d'une manière sûre.

La durée de la maladie, à compter de l'apparition d'une forte population de cochenilles jusqu'à la mort de l'arbre, devrait se situer sur les deux parcelles aux alentours de 10 années à peine.

Les populations de cochenilles se développent dans certains cas très rapidement, en l'espace de deux années; mais cette évolution peut demander également beaucoup plus de temps.
L'écorce de plusieurs hêtres presentent des indices qu'une cicatrisation et guérison des plaies est en cours.



ZUSAMMENFASSUNG

Entwicklung der Buchen-Rindennekrose auf zwei Beobachtungsflächen in Nordbayern im Verlauf von 7 Jahren.

Auf zwei Beobachtungsflächen in Nordbayern wird seit 1976 die Entwicklung der Buchen-Rindennekrose beobachtet. Von den 600 markierten Bäumen sind rund 200 von Cryptococcus fagisuga befallen. Zwischen 1976 und 1982 wiesen etwa 125 von ihnen zumindest zeitweise mittleren oder starken Lausbefall auf. Schleimfluß war im gleichen Zeitraum an 87 Bäumen festzustellen, 39 Bäume (= 6,5%) sind inzwischen abgestorben.

Im Zusammenhang mit starkem Lausbefall wurde fast regelmäßig und oft über einen längeren Zeitraum Schleimfluß beobachtet. Fruchtformen von Nectria und Cylindrocarpon waren an vielen dieser Bäume zu finden. Auch aus dem Randbereich nekrotischer Rindenpartien konnte Nectria spp. fast regelmäßig isoliert werden. Andererseits hat dieser Pilz an den noch lebenden Buchen relativ selten Fruchtkörper gebildet.

Fruchtkörper holzzerstörender Pilze kommen auf den beiden Beobachtungsflächen in deutlich unterschiedlichem Maße vor. Während in Rohrbrunn überwiegend Fomes fomentarius vorkommt, sind in Rothenbuch Fomes fomentarius, Fomitopsis pinicola, Stereum spp., Bjerkandera adusta und Inonotus nodulosus fast in gleichem Maße vertreten. Der starke Infektionsdruck auf der Fläche in Rohrbrunn ist auch dafür verantwortlich zu machen, daß hier verhältnismäßig mehr abgestorbene und sogar noch lebende Bäume Fruchtkörper tragen.

Auf Luftbildern im Maßstab 1 : 5000 lassen sich Gebiete, in denen die Buchen-Rindennekrose

auftritt, deutlich erkennen. In einer Reihe von Fällen lassen sich auch die Veränderungen an der Krone einzelner Bäume über mehrere Jahre verfolgen. Es scheint jedoch, daß nur starke Schäden mit ausreichender Sicherheit nachgewiesen werden können.

Auf den beiden Beobachtungsflächen ist mit einer Krankheitsdauer der einzelnen Bäume, von der Entwicklung einer starken Lauspopulation bis zum Absterben, von schätzungsweise knapp 10 Jahren zu rechnen. Die Entwicklung der Lauspopulation verläuft in einzelnen Fällen sehr rasch innerhalb von zwei Jahren, kann jedoch auch erheblich länger dauern. An der Rinde einer Reihe von Buchen sind Anzeichen von Überwallung und Ausheilung der Schäden erkennbar.

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