KUNGL. SKOGSHÖGSKOLANS SKRIFTER

BULLETIN OF THE ROYAL SCHOOL OF FORESTRY
STOCKHOLM, SWEDEN

Nr 16 Redaktör: Professor OLOF TAMM 1953

# The Occurrence and Significance of Storage Decay in Birch and Aspen Wood with Special Reference to Experimental Preventive Measures

**Om uppkomsten och betydelsen av lagringsröta i björk och aspvirke samt försök att förebygga dylika skador**

Av

ERIK BJÖRKMAN

Särtryck ur "Skogshögskolan 125 år"

Reprinted from "The Royal School of Forestry of Sweden 125 Years"

SKOGSBIBLIOTEKET, SKOGSHÖGSKOLAN. STOCKHOLM
(I distribution)

# *The Occurrence and Significance of Storage Decay in Birch and Aspen Wood with Special Reference to Experimental Preventive Measures*

By

ERIK BJÖRKMAN

It has long been known that birch and aspen wood is very susceptible to storage decay. Such damage is particularly critical in birch intended for joinery purposes. However, due to the relatively small consumption of this class of wood it has been a fairly simple matter to take precautionary measures. But the increasingly wide use of hardwoods for the production of chemical pulp in Sweden in recent years has spotlighted the risk of storage damage due to decay (*cf.* SCHAFER 1947, ZASADA 1947, BROWN & MCGOVERN 1950 and others). For, so far as pulpwood is concerned, we must reckon with both very large quantities and inferior wood that does not permit as high an outlay, *e. g.*, on protective measures against rot, as the more expensive high-quality wood. Hence it is of considerable importance, in the normal handling of wood, to know how best to adapt one's measures so as to ensure the least possible amount of storage decay. As regards pulpwood, for instance, it may be a question of finding the most appropriate mode of barking and piling, or time of felling. In the last-named respect it may also be advisable to investigate whether the work in the forest can be spread over a greater part of the year, for example with regard to the cutting of pulpwood, without it being damaged during subsequent storage.

To throw light on these problems not yet sufficiently known (*cf.* SCHANTZ-HANSEN 1948), and to investigate the magnitude of rot damage in the production of sulphate pulp from birch (*Betula verrucosa* Ehrh.) and sulphite pulp from aspen (*Populus tremula* L.), there were arranged in 1947—1951 certain storage experiments with birch and aspen wood, as well as experimental cooking of damaged wood, at the Mo & Domsjö Company. The storage experiments were carried out at Björna Forest Administration under the supervision of Forest Supervisor Gottfrid Sjölund, Forest Officer Kurt Björklund, Forester C. Bjuggstam and others, who also assisted with the taking of samples and inspection of experimental results.

The experimental forest storage of birch and aspen pulpwood demonstrated, among other things, the advisability under certain conditions of measures to protect hardwood — notably the more expensive kinds — against storage decay by the use of chemical

Fig. 1. Experimental piles of birch and aspen pulpwood, cut and stacked in the forest at different times. Gruvberget, Björna.

*Försöksvältor av björk- och aspmassaved, avverkad och upplagd i skogen vid olika tidpunkter. Gruvberget, Björna.*

agents. Indeed, one such experimental series with matchwood (aspen) for purposes of guidance was conducted under the direction of the Swedish Match Company in 1951—1953.

## I. *Experimental Forest Storage of Unbarked and Clean-Barked Birch and Aspen Pulpwood*

The experiments were conducted in two series — one in 1947—1951 and the other in 1948—1951 — along small forest roads in a mixed stand at Gruvberget, Björna, in the province of Ångermanland.

*Method.* In the experiments of 1947, birch and aspen logs were used, some having top diameters of 3—4 inches and some 6—7 inches, both types being approximately 3.5 metres in length. The experimental wood was cut about May 1, June 1, July 1, August 1 and September 1, the logs subsequently being bulk-piled on single transverse foundations. Half the logs obtained at each cutting were clean-barked prior to piling, the other half were left unbarked. About ten of each type of log were piled on each occasion.

Fig. 2. Triangular pile of 6—7 inch unbarked birch and aspen pulpwood. Sampling for recording of rot following storage. Gruvberget, Björna.

*Triangelkista av 6—7" obarkad björk- och aspmassaved. Provtagning för registrering av förekommande röta efter lagring. Gruvberget, Björna.*

On October 1, 1947 a large number of discs were sawn from the ends and from the middle of each type of log, and sent immediately to the Royal School of Forestry, where decay and blue stain were recorded planimetrically. Similar inspections were carried out around October 1, 1948 and 1949 too.

In the experiments of 1948, for purposes of comparison with coniferous wood, pine (*Pinus silvestris* L.) and spruce (*Picea Abies* Karst.) logs with top diameters of 3—4 and 6—7 inches were stored in addition to birch and aspen logs. The cutting was done, as in previous years, around May 1, June 1, July 1, August 1 and September 1, the wood being piled each time in a clean-barked and an unbarked portion, each comprising about twenty logs. Of these, one half were stacked crosswise (fig. 1) and the other half in triangular piles (fig. 2).

Damage due to decay and to blue stain was inspected around October 1, 1948 and 1949, discs being sawn off, as in the series of 1947, and forwarded to the Royal School of Forestry for measurement and identification of the damage. In the logs of 1948 and 1949, the variations in moisture content were investigated too. In so doing, increment cores were taken from specially selected representative logs of each kind in the cross-

TABLE 1

Moisture content (water content in percentage of dry weight) in birch and aspen logs cut and stored in triangular piles in the forest at Gruvberget, Björna, at various times in the summer of 1948. Moisture content recorded on October 1, 1948 and 1949.

*Fuktkvot (vattenhalt i % av torrvikt) i björk- och aspstockar, avverkade och upplagda i triangelkistor i skogen å Gruvberget, Björna, vid olika tidpunkter sommaren 1948. Fuktigheten i stockarna registrerad den 1 oktober 1948 och 1949.*

| Date of cutting and piling, 1948 | Moisture content | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unbarked logs | | | | | | | | | | | | Barked logs | | | | | | | | | | | |
| | Butt end | | | | Middle | | | | Top end | | | | Butt end | | | | Middle | | | | Top end | | | |
| | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | |
| | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 |
| *Birch* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/5 | 50 | 36 | 53 | 40 | 60 | 51 | 71 | 64 | 44 | 32 | 48 | 36 | 21 | 20 | 21 | 20 | 21 | 17 | 21 | 18 | 20 | 17 | 21 | 20 |
| 1/6 | 52 | 44 | 56 | 42 | 64 | 60 | 80 | 70 | 50 | 35 | 50 | 41 | 22 | 18 | 21 | 18 | 24 | 17 | 21 | 18 | 21 | 17 | 23 | 19 |
| 1/7 | 60 | 42 | 68 | 36 | 71 | 61 | 76 | 63 | 52 | 39 | 61 | 47 | 24 | 19 | 24 | 20 | 23 | 17 | 24 | 19 | 22 | 18 | 26 | 21 |
| 1/8 | 71 | 50 | 75 | 47 | 70 | 58 | 81 | 74 | 66 | 34 | 70 | 45 | 28 | 21 | 29 | 21 | 26 | 19 | 27 | 20 | 24 | 19 | 30 | 20 |
| 1/9 | 78 | 55 | 82 | 49 | 84 | 68 | 89 | 76 | 72 | 43 | 76 | 45 | 28 | 24 | 28 | 25 | 31 | 22 | 32 | 28 | 26 | 19 | 29 | 25 |
| *Aspen* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/5 | 65 | 42 | 67 | 45 | 67 | 57 | 68 | 57 | 49 | 36 | 54 | 47 | 21 | 20 | 22 | 21 | 22 | 19 | 23 | 19 | 21 | 18 | 21 | 19 |
| 1/6 | 62 | 48 | 71 | 51 | 65 | 55 | 66 | 60 | 56 | 39 | 53 | 46 | 22 | 20 | 23 | 20 | 21 | 19 | 24 | 20 | 21 | 18 | 22 | 20 |
| 1/7 | 71 | 51 | 69 | 48 | 74 | 67 | 72 | 64 | 66 | 46 | 59 | 53 | 23 | 22 | 25 | 21 | 24 | 20 | 25 | 21 | 23 | 19 | 23 | 20 |
| 1/8 | 80 | 60 | 86 | 54 | 75 | 68 | 78 | 63 | 70 | 57 | 72 | 55 | 27 | 21 | 28 | 22 | 26 | 22 | 29 | 23 | 25 | 20 | 28 | 23 |
| 1/9 | 84 | 57 | 84 | 57 | 87 | 72 | 81 | 74 | 75 | 59 | 78 | 61 | 29 | 25 | 29 | 26 | 29 | 23 | 27 | 27 | 28 | 21 | 29 | 24 |

## TABLE 2

Damage due to storage decay in birch and aspen logs cut and bulk-piled in the forest at Gruvberget, Björna, at various times in the summer of 1947. Inspection and recording of rot damage (measured in sawn-off discs and expressed in percentage of their sapwood area) took place in October, 1947, 1948 and 1949

*Skador genom lagringsröta i björk- och aspstockar, avverkade och upplagda i klosslagda vältor i skogen å Gruvberget, Björna, vid olika tidpunkter sommaren 1947. Inventering av förekommande rötskador (uppmätta på utsågade trissor och uttryckta i % av dessas splintyta) i oktober 1947, 1948 och 1949.*

| Date of cutting and piling, 1947 | Storage decay in per cent of sapwood | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unbarked logs | | | | | | | | | | | | | | | | | | Barked logs | | | | | | | | | | | | | | | | | |
| | Butt end | | | | | | Middle | | | | | | Top end | | | | | | Butt end | | | | | | Middle | | | | | | Top end | | | | | |
| | 3—4″ | | | 6—7″ | | | 3—4″ | | | 6—7″ | | | 3—4″ | | | 6—7″ | | | 3—4″ | | | 6—7″ | | | 3—4″ | | | 6—7″ | | | 3—4″ | | | 6—7″ | | |
| | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 | 47 | 48 | 49 |
| *Birch* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/5 | 12 | 39 | 50 | 16 | 52 | 63 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 38 | 44 | 22 | 60 | 72 | 5 | 7 | 10 | 7 | 10 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 5 | 5 | 7 | 7 |
| 1/6 | 20 | 48 | 56 | 18 | 50 | 68 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 32 | 46 | 24 | 62 | 85 | 4 | 6 | 8 | 5 | 8 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 4 | 4 | 5 | 6 |
| 1/7 | 10 | 30 | 50 | 12 | 38 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 30 | 38 | 18 | 50 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1/8 | 0 | 31 | 48 | 0 | 35 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 16 | 30 | 5 | 42 | 62 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1/9 | 0 | 15 | 25 | 0 | 29 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 11 | 24 | 0 | 22 | 50 | 0 | 0 | 0 | 0 | 5 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 |
| *Aspen* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/5 | 14 | 30 | 38 | 15 | 36 | 42 | 2 | 3 | 5 | 2 | 5 | 6 | 11 | 28 | 39 | 18 | 52 | 68 | 11 | 13 | 16 | 10 | 14 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 6 | 8 | 12 | 16 |
| 1/6 | 10 | 32 | 36 | 12 | 40 | 46 | 2 | 4 | 6 | 3 | 5 | 5 | 14 | 35 | 44 | 16 | 63 | 74 | 8 | 10 | 13 | 9 | 12 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 5 | 5 | 11 | 14 |
| 1/7 | 9 | 25 | 28 | 15 | 22 | 33 | 2 | 3 | 4 | 0 | 0 | 0 | 12 | 32 | 40 | 14 | 36 | 52 | 4 | 5 | 7 | 5 | 8 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 5 |
| 1/8 | 7 | 12 | 15 | 7 | 11 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 11 | 26 | 10 | 27 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1/9 | 6 | 10 | 17 | 4 | 8 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 25 | 5 | 28 | 40 | 2 | 4 | 6 | 3 | 5 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 7 |

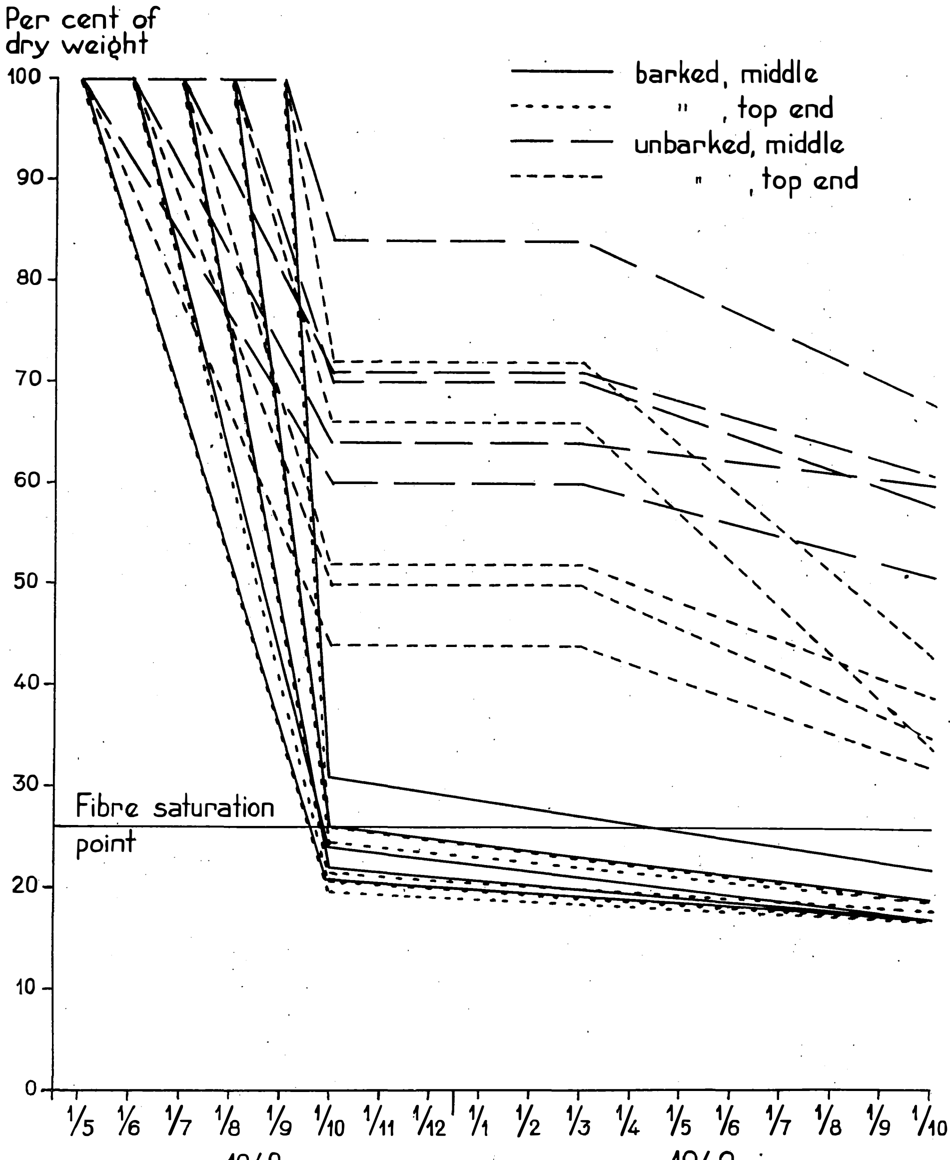


Fig. 3. Moisture content in 3—4" inch birch logs cut and stacked in triangular piles at different times in 1948.

*Fuktkvot i 3—4" björkstockar avverkade och upplagda i triangelkistor i skog vid olika tidpunkter 1948.*

wise and triangular piles on May 15, July 17, September 16 and December 3, 1948 and on May 3 and July 1 1949. These samples, however, were found to be too few in several experimental series to warrant any definite conclusions on the course of dry-

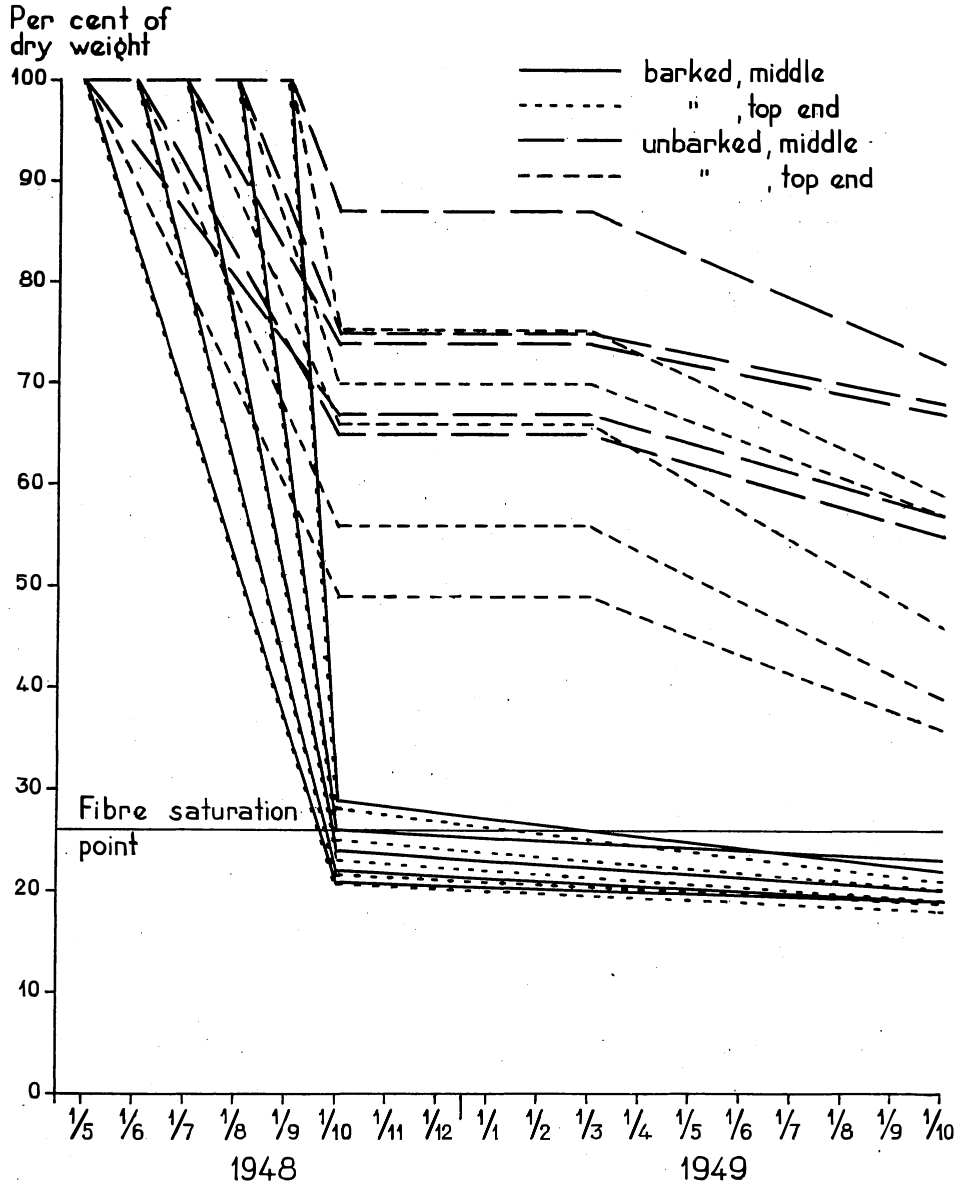


Fig. 4. Moisture content in 3—4 inch aspen logs cut and stacked in triangular piles at different times in 1948.

*Fuktkvot i 3—4" aspstockar, avverkade och upplagda i triangelkistor i skog vid olika tidpunkter 1948.*

ing. Table 1 and figures 3—4 show instead the mean values of moisture content determinations by removal and immediate weighing of a great number of large pieces from the sapwood on October 1, 1948 and 1949, and subsequent weighing after drying

## TABLE 3

Damage due to storage decay in birch and aspen logs cut and stored in triangular piles in the forest at Gruvberget, Björna, at various times in the summer of 1948. Inspection and recording of rot damage (measured in sawn-off discs and expressed in percentage of their sapwood area) took place in October, 1948 and 1949.

*Skador genom lagringsröta i björk- och aspstockar, avverkade och upplagda i triangelkistor i skogen å Gruvberget, Björna, vid olika tidpunkter sommaren 1948. Inventering av förekommande rötskador (uppmätta på utsågade trissor och uttryckta i % av dessas splintyta) i oktober 1948 och 1949.*

| Date of cutting and piling, 1948 | Storage decay in per cent of sapwood | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unbarked logs | | | | | | | | | | | | Barked logs | | | | | | | | | | | |
| | Butt end | | | | Middle | | | | Top end | | | | Butt end | | | | Middle | | | | Top end | | | |
| | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | | 3–4″ | | 6–7″ | |
| | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 | 48 | 49 |
| *Birch* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/5 | 24 | 42 | 18 | 60 | 0 | 0 | 0 | 0 | 18 | 47 | 21 | 62 | 5 | 9 | 6 | 10 | 0 | 5 | 0 | 8 | 0 | 5 | 5 | 8 |
| 1/6 | 21 | 44 | 25 | 52 | 0 | 0 | 0 | 0 | 13 | 41 | 23 | 60 | 3 | 6 | 3 | 5 | 0 | 0 | 0 | 5 | 0 | 3 | 6 | 8 |
| 1/7 | 16 | 26 | 7 | 40 | 0 | 0 | 0 | 0 | 10 | 28 | 14 | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1/8 | 7 | 30 | 0 | 35 | 0 | 0 | 0 | 0 | 5 | 27 | 0 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1/9 | 0 | 13 | 0 | 21 | 0 | 0 | 0 | 0 | 1 | 21 | 0 | 26 | 0 | 0 | 0 | 5 | 0 | 3 | 0 | 4 | 0 | 3 | 0 | 7 |
| *Aspen* | | | | | | | | | | | | | | | | | | | | | | | | |
| 1/5 | 18 | 38 | 18 | 40 | 3 | 8 | 3 | 7 | 12 | 26 | 18 | 37 | 4 | 10 | 5 | 13 | 4 | 7 | 6 | 10 | 3 | 4 | 3 | 7 |
| 1/6 | 20 | 43 | 21 | 34 | 4 | 10 | 2 | 5 | 14 | 23 | 21 | 40 | 3 | 9 | 6 | 8 | 3 | 6 | 5 | 8 | 0 | 3 | 4 | 6 |
| 1/7 | 13 | 21 | 11 | 27 | 0 | 0 | 0 | 0 | 7 | 18 | 13 | 31 | 2 | 7 | 0 | 0 | 2 | 5 | 2 | 4 | 0 | 0 | 0 | 0 |
| 1/8 | 5 | 20 | 0 | 18 | 0 | 0 | 0 | 0 | 4 | 10 | 5 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| 1/9 | 0 | 15 | 0 | 14 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 8 | 0 | 0 | 0 | 5 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 5 |

for three days at 100° C. In figures 3 and 4 the moisture content of these logs at cutting is shown in highly schematic form and, for the sake of simplicity, is assumed to be 100 per cent of the dry weight.

*Results.* The principal experimental results are condensed in table 1 and figures 3—4 with regard to the drying of birch and aspen wood, and in tables 2—3 and figures 5—6 with respect to damage caused by storage decay in birch and aspen pulpwood. The figures in the tables represent the arithmetical means of values very consistent with each other. Occasional markedly divergent values for the moisture content, which were usually found to be due to secondary soaking by rain etc., are excluded.

The experimental results can be briefly summarized as follows.

The moisture in unbarked birch and aspen logs, both thick and thin, is retained, even after forest storage for two summers, to a very high degree except at the top and butt, where drying proceeds more rapidly and a »semi-moist» state — which constitutes the best prerequisite for decay damage in wood (*cf.* BJÖRKMAN, 1946) — already sets in after storage for one summer (*cf.* table 1 and figs. 3—4). The later in the year cutting takes place, the more slowly is the moisture lost. Drying occurs in unbarked pine and spruce logs of corresponding thickness, so that a »semi-moist» state already occurs in the autumn, at all events in slender logs cut in the spring or early summer of the same year.

The moisture in clean-barked birch, aspen, pine and spruce logs is lost very rapidly in the summer, and faster in slender logs. Pine logs dry the slowest.

In unbarked birch and aspen logs, storage decay occurs only at the tops and butts, where the moisture content promotes the development of decay fungi (tables 2—3 and figs. 5—6). Thicker logs cut between April and July already show incipient decay damage the same autumn (figs. 7—8), whereas logs cut later are not attacked until the following summer. After the second summer the decay damage at the ends is considerably greater in logs cut early in the previous year and which show severer incipient decay damage (table 3). Thin logs are more susceptible to decay than thick ones. Moreover, birch seems to be more susceptible than aspen to storage decay.

In unbarked pine and spruce logs cut between April and July, decay damage already starts in the same autumn. The damage, which most often takes the form of reddish brown streaks in the wood, is greater in thin than in thick logs (*cf.* LAGERBERG, LUNDBERG & MELIN, 1927). In the former, incipient damage can also be observed at the middle of the log. After storage for two summers the damage caused by storage decay is fairly extensive, both in pine and spruce, at the middle of the logs too, where corresponding birch and aspen logs are virtually undamaged.[1]

[1] The extent of storage damage in pine and spruce, compared with birch and aspen, relative to various modes of forest storage is at present under special investigation, the results of which will be communicated in a later paper.

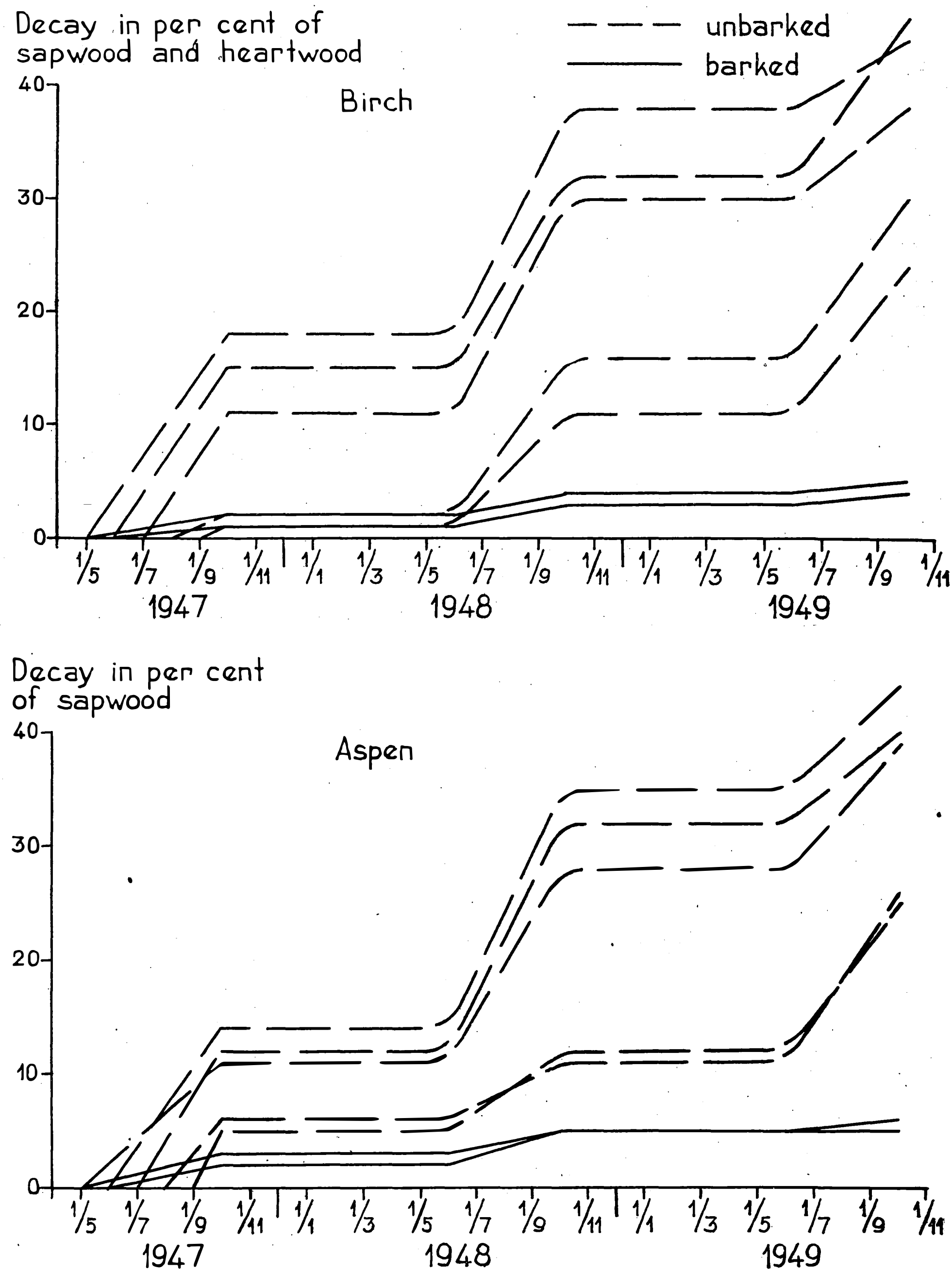


Fig. 5. Storage decay at top ends of 3—4 inch birch and aspen logs cut and bulk-piled at different times in 1947.

*Lagringsröta i toppändan av björk- och aspstockar avverkade och upplagda i klosslagda vältor i skog vid olika tidpunkter 1947.*

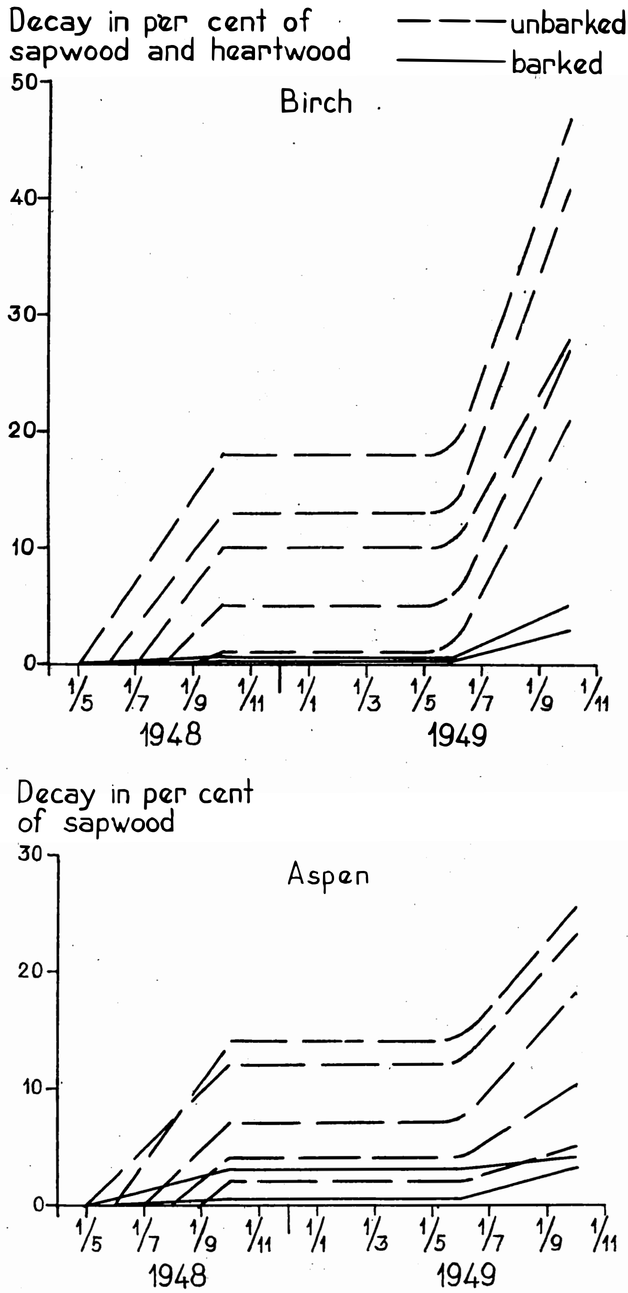


Fig. 6. Storage decay at top ends of 3—4 inch birch and aspen logs cut and stacked in triangular piles at different times in 1948.

*Lagringsröta i toppändan av 3—4" björk- och aspstockar avverkade och upplagda i triangelkistor i skog vid olika tidpunkter 1948.*

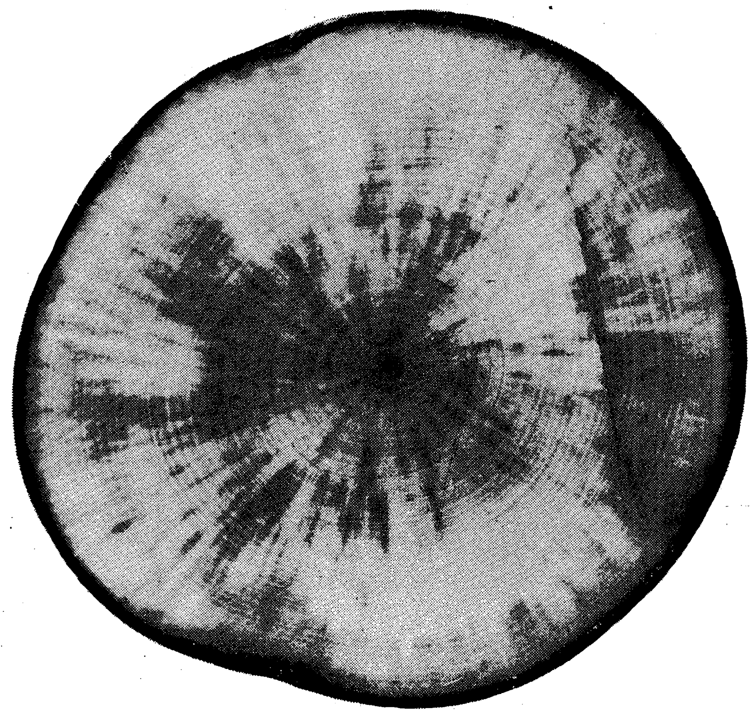

Fig. 7. Storage decay developing during one summer at the end of an unbarked drying birch log, cut on May 1. Gruvberget, Björna.

*Under 1 sommar utbildad lagringsröta i ändytan av obarkad torkande björkstock, avverkad 1 maj. Gruvberget, Björna.*

In clean-barked birch and aspen logs (tables 2—3), storage decay occurs to such a slight extent as to be of no practical significance, at all events in aspen, even after forest storage for three summers. Occasionally, however, more servere damage occurs in logs which have been exposed to secondary soaking, notably by rain. Clean-barked logs felled in July and August are apt to show superficial discoloration by blue stain fungi, which develop very rapidly on the surface of these semi-moist logs (fig. 9; *cf.* the frequently black surface, due to blue-stain fungi, of spruce felled in summer and barked in periods of sap flow). Storage decay develops more slowly, and is not demonstrably more extensive, in these logs than in those felled earlier.

Storage decay already commences after one summer in clean-barked pine and spruce logs, and, due to the nature of the rot, causes severer damage than in hardwood under the same external conditions. The development of storage decay is largely dependent on how the wood is stored in the forest at different times of the year (*cf.* footnote, p. 61).

The principal storage decay fungi in birch and aspen wood are the white-yellow *Polyporus zonatus* Fr. (figs. 10—11), the violet *Stereum purpureum* Fr. (fig. 12), the brilliant yellow *Stereum hirsutum* Fr., the Grey-white-red *Corticium evolvens* Fr., the

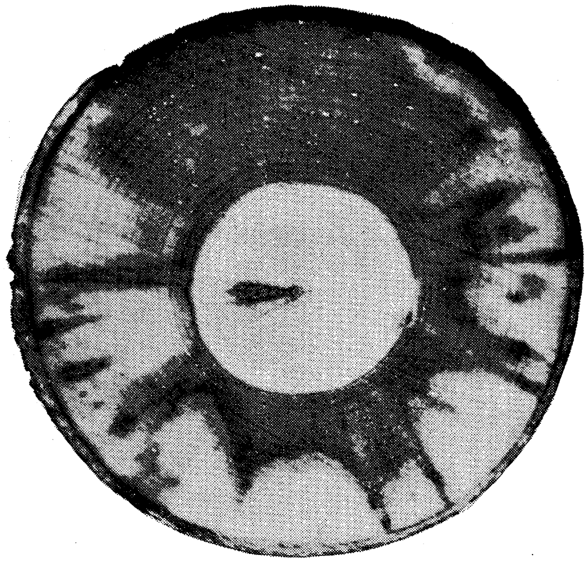

Fig. 8. Storage decay developing during one summer at the end of an unbarked drying aspen log, cut on May 1. Gruvberget, Björna.

*Under 1 sommar utbildad lagringsröta i ändytan av obarkad torkande aspstock, avverkad 1/5: Gruvberget, Björna.*

characteristic *Daedalia unicolor* Fr. and the grey-white *Polyporus hirsutus* Fr., *Polyporus versicolor* Fr. and *Schizophyllum commune* Fr., the last three of which mainly occur in southern Sweden. All these species develop an abundance of sporophores in the form of small bracket fungi or resupinate mantles; in particular, *Corticium evolvens*, although it seems to be virtually innocuous to the wood. Each of the aforementioned fungi gives rise to white rot, characterized by the assumption of a more or less white colour in the wood attacked and, in general, by the attack being largely confined to the lignin components, the cellulose to a large extent being left; however, the fibre is affected by the fungi (*cf.* p. 72 *et seq.*). A diametrically opposed type of decay, which occurs most often in coniferous wood, consists in destructive or shrink rot, the fungi of which mainly attack the cellulose. The commonest storage decay in coniferous wood in Sweden is caused, as is known, by *Stereum sanguinolentum* Fr., which forms grey-white or, in the presence of water, blood-red bracket fungi or mantles on the wood, but not nearly so profusely as the aforementioned hardwood fungi. The fungus causes corrosive or patchy rot, which occupies an intermediate position between white rot and shrink rot in so far as both lignin and cellulose are attacked to approximately the same degree; though at the start of the attack the lignin usually is affected most (*cf.* Björkman, 1946, Fritz, 1951).

---

In table 2 and figures 5 and 6 the extent of the storage decay is expressed in percentage of the sapwood area in the discs examined, and not in percentage of the whole

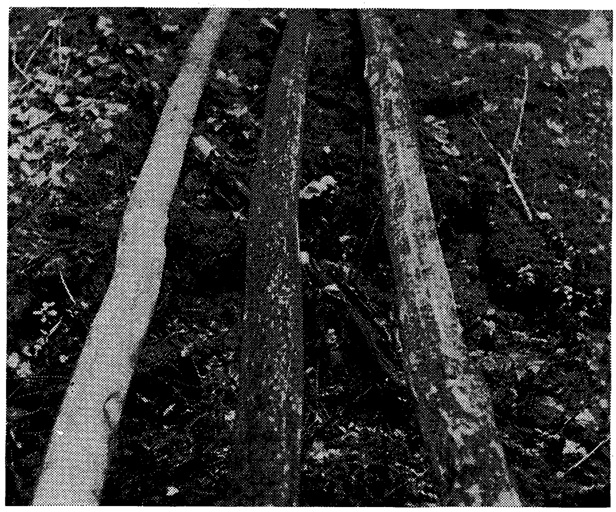

Fig. 9. Barked aspen logs cut (from left to right) on May 1, July 1 and September 1. Pronounced superficial blue stain on the middle log. Gruvberget, Björna. Photograph taken October 1 the same year.

*Barkade aspstockar avverkade (fr. v. t. h.) den 1/5, 1/7 och 1/9. Stark ytlig blånad på den mellersta stocken. Gruvberget, Björna.*

volume of the log. This has been done because when the decay damage was measured it was deemed most correct to express it in relation to that part of the log that is susceptible to fungal attack, namely, the sapwood. With regard to b i r c h, which has no clearly defined heartwood (fig. 7), the values in the table might just as well apply to the percentage of the whole wood. As regards a s p e n, on the other hand, this is not the case, for that species of tree, as is known, has a more or less conspicuous heartwood even in fairly thin logs (fig. 8). Hence it is necessary in each particular case to measure the heartwood. If the latter is assumed to take up one-fifth of a cross-section of the trunk, then the values in tables 2 and 3, so far as aspen is concerned, should be multiplied by four-fifths to obtain the rot damage in percentage of the volume of the whole log (in these approximate calculations the tapering of the trunk is ignored). But we must also take into account, as pointed out earlier, that damage due to storage decay in unbarked birch and aspen seldom exceeds about half a metre from each end during the first two years of storage in the forest (in contradistinction to coniferous wood, in which usually the entire log is decayed after two years' storage). After three years' storage, however, the damage usually extends about one metre from the ends. If, therefore, it is wished to express the decay damage i n p e r c e n t a g e o f t h e t r u e v o l u m e o f t h e w h o l e l o g, we must first know how much of the log is sound, or in other words, how long the log is, among other things. If we assume that the logs average 3.5 metres in length (as in the present experiments) only two-sevenths of the length will thus be attacked by rot after 1—2 years and five-sevenths will be quite

Fig. 10. Sporophores of the storage decay fungus *Polyporus zonatus,* at the butt and top ends of 6—7 inch unbarked birch log, forest-stored in a triangular stack for two summers (May 1, 1948—October 1, 1949). Gruvberget, Björna.

*Fruktkroppar av lagringsrötsvampen P o l y p o r u s z o n a t u s i rotända och toppända av 6—7" obarkad björkstock, lagrad i triangelkista i skogen under 2 somrar (1/5 1948 —1/10 1949). Gruvberget, Björna.*

Fig. 11. Storage decay at the butt and top ends of the same 6—7 inch unbarked birch log as in fig. 10.

*Lagringsröta i rotända och toppända av samma 6—7" obarkade björkstock som i fig. 10.*

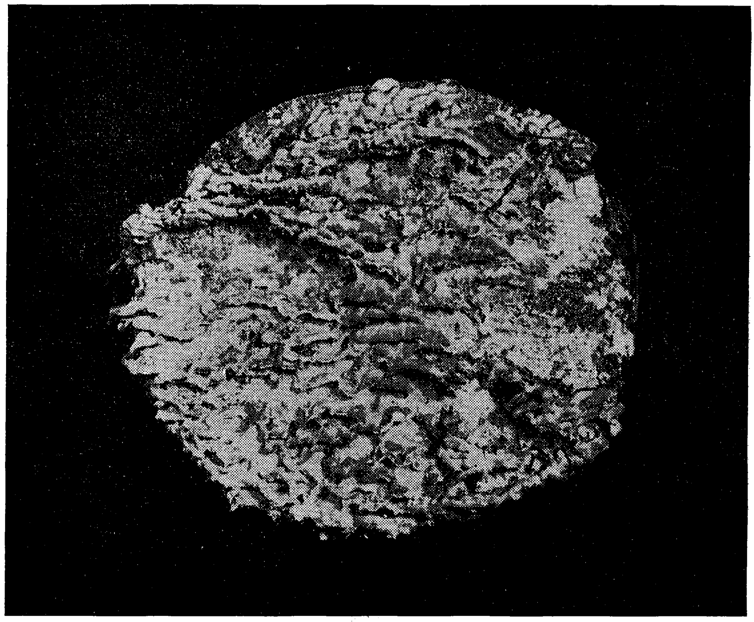

Fig. 12. Sporophores of the storage decay fungus *Stereum purpureum* at the top end of 3—4 inch unbarked aspen log, forest-stored in a triangular pile for two summers (May 1, 1948—October 1, 1949). Gruvberget, Björna.

*Fruktkroppar av lagringsrötsvampen Stereum purpureum i toppändan av 3—4" obarkad aspstock, lagrad i triangelkista i skogen under 2 somrar (1/5 1948—1/10 1949). Gruvberget, Björna.*

sound, and after 3 years four-sevenths of the length will be attacked and three-sevenths sound. If the wood is 2 metres long, one-half of the log will be attacked and one-half sound after 1—2 years, but the whole of the log attacked after 3 years. In the case of aspen, corresponding approximate calculations of the extent of the rot in percentage of the entire volume might be expressed as $4/5 \times 2/7$ of the sapwood value after 1—2 years, and as $4/5 \times 4/7$ after 3 years for wood 3.5 metres long, and as $4/5 \times 1/2$ and $4/5 \times 1$ respectively for wood 2 metres long. Table 8 shows the values from tables 5 and 6 converted in this way.

## II. *Experimental Storage of Birch Pulpwood Barked in Strips.*

Probably it is only in coniferous wood that any systematic investigation has hitherto been conducted regarding the damage caused by storage decay in the case of wood barked in strips. It is thus known that the damage may easily assume extensive proportions in such wood — particularly thick logs — due to the fungus growth-promoting »semi-moist» state, especially under the persisting strips of bark, which

TABLE 4

Moisture content and occurrence of storage decay, in June 1951, in unbarked, strip-barked and clean-barked birch pulpwood cut and piled at dry and damp sites at Gruvberget, Björna, in June 1950.

*Fuktkvot och förekomst av lagringsröta i juni 1951 i obarkad, randbarkad och helbarkad björkmassaved avverkad och upplagd i torrt och fuktigt läge i juni 1950. Gruvberget, Björna.*

| Type of wood | Moisture content in per cent | | Storage decay in per cent of sapwood | |
|---|---|---|---|---|
| | Dry location | Humid location | Dry location | Humid location |
| *6—7" birch* | | | | |
| *At end* | | | | |
| unbarked | 55.3 | 84.6 | 29 | 17 |
| strip-barked | 21.0 | 29.2 | 4 | 18 |
| clean-barked | 22.6 | 24.9 | 0 | 2 |
| *At middle* | | | | |
| unbarked | 87.8 | 96.3 | 0 | 0 |
| strip-barked | 31.1 | 39.3 | 5 | 24 |
| clean-barked | 23.2 | 28.8 | 1 | 5 |
| *3—4" birch* | | | | |
| *At end* | | | | |
| unbarked | 38.4 | 52.7 | 25 | 37 |
| strip-barked | 21.4 | 27.6 | 3 | 16 |
| clean-barked | 18.4 | 22.8 | 0 | 1 |
| *At middle* | | | | |
| unbarked | 52.1 | 70.2 | 2 | 0 |
| strip-barked | 23.4 | 36.5 | 3 | 20 |
| clean-barked | 20.2 | 23.2 | 0 | 2 |

results from such a method of treatment. But since hardwood dries faster than softwood — probably because true vessels occur in the former — it is possible that hardwood under suitable external conditions might dry out so effectively that barking in strips, conceivable in practice, would prevent the occurrence of damage. A further serial experiment was therefore conducted with birch wood barked in strips, also at Gruvberget, in May 1950.

A number of thick and thin logs (6—7 and 3—4 inches respectively at the top) were bulk-piled, partly in an open position at the middle of a small clearing, and partly in an enclosed mixed stand with relatively poor drying conditions. In the experimental piles were also placed a number of clean-barked and unbarked birch logs of the same thickness. In June of the following year samples were taken for determination of the moisture content in the various kinds of logs, and the results were studied with respect to the presence of storage decay. The findings are condensed in table 4.

It will be seen from table 4 that a close correlation exists between the logs barked in strips and the clean-barked logs, with regard to both moisture content and damage. In coniferous wood stored in a corresponding way, the correlation applies more to that barked in strips and the unbarked logs; and the damage in coniferous pulpwood barked in strips is usually substantial. In birch, on the other hand, storage decay is only very slight if the wood can be dried at a reasonably airy place. By this relatively inexpensive method birchwood can accordingly be got »dry» — which fact in itself is of considerable importance, for example, in transportation by road and, above all, because in this way it is protected against storage damage.

Even in those cases where the wood is transported to the pulpwood yard in its crude state — strip-barking in the forest may be found impossible from the standpoint of costs of labour — the experience of strip-barking which has been gained is now being turned to account, and indeed special machines have been designed that peel the birch in strips before it is stacked in the pulpwood yard. An inspection of samples taken at random in Hörnefors pulpwood yard, where this method is practiced, showed that storage decay was quite inappreciable in strip-barked wood (fig. 13). It must be ensured, of course, that the piles are located in a reasonably open place, so that the descending currents of cold, damp air can be eliminated and effective seasoning of the wood can proceed. In the bottommost layers of piles, drying proceeds more slowly, and sporophores at the log ends indicate that storage decay has developed. The same is frequently the case with projecting ends of logs which are repeatedly exposed to direct soaking by rain (fig. 14). It must not be thought, however, that the occurrence of sporophores in itself means that the wood is badly attacked; for this will depend on the species of fungus responsible. The most widespread and conspicuous sporophores frequently belong to *Corticium evolvens*, which, as pointed out above, is a relatively innocuous fungus (*cf.* fig. 14).

The forest storage experiments carried out here, and the application of the findings at a pulpwood yard, accordingly suggest that barking in strips is a highly commendable method, provided satisfactory drying conditions can be obtained and the wood is wanted to be »dry» before the use in the mill.

## III. *Experimental Cooking of Birch and Aspen Pulpwood Damaged by Storage Decay*

To elucidate the true significance of damage due to storage decay in birch and aspen pulpwood, a number of cooking tests of rot-damaged wood were conducted at the Mo & Domsjö Sulphate Mills at Husum, and at the same company's Research Laboratory at Örnsköldsvik.

Fig. 13. Piles of strip-barked birch pulpwood at Hörnefors pulpwood yard. July 1952.
*Massavedvältor av randbarkad björk i Hörnefors vedgård. Juli 1952.*

## A. *Experimental Cooking of Sulphate Pulp of Birchwood Damaged by Storage Decay* (carried out by E. Venemark)

The experimental material consisted of pieces, about half a metre long, of unbarked birchwood decayed by *Polyporus zonatus* for one, two and three summers respectively, and samples of corresponding sound wood, all sawn from the ends of logs of approximately the same growth type. In addition pieces were used about half a metre long, sawn from the ends and towards the middle of unbarked birch logs forest-stored for three summers and attacked by *Stereum purpureum.* As mentioned above, the decay damage was invariably greatest in the end sections and abated towards the middle, where it was still only very slight after three summers. In every case where possible, corresponding sound wood was taken from the same logs for experimental cooking, by which means the significance of the decay damage could be evaluated with the greatest possible degree of reliability. As regards the samples decayed for three years, there was no possibility of securing comparative sound wood from the same logs, wherefore the rot-damaged wood was compared with an assumed sound wood with a density of 0.500, which may be said to represent a common mean

Fig. 14. Strip-barked birch in large pulpwood pile at Hörnefors pulpwood yard. Pronounced sporophore formation of the virtually innocuous fungus *Corticium evolvens* on projecting log ends exposed to rain. July 1952.

*Randbarkad björk i stora massavedvältor i Hörnefors vedgård. Kraftig fruktkroppsutbildning av den i det närmaste ofarliga svampen C o r t i c i u m  e v o l v e n s på utskjutande för regn exponerade stockändar. Juli 1952.*

value. The tabulated values, however, are therefore more unreliable in respect of the wood stored for three years than in respect of the other wood. Besides samples of birch, further samples were collected of unbarked pine decayed for two summers, together with corresponding sound wood.

From the collected samples test discs were taken and used partly for determination of density and partly for preparation of chips. The sawdust thus obtained was used for analysis largely according to Husum's ordinary method, *i. e.*, drying *in vacuo* at room temperature, extraction by ethyl ether, alcohol and water consecutively in a Sohlet apparatus, drying of the residue, and thereafter determination of pentosan and lignin. The moisture content was determined in vacuum-dried samples.

The prepared chips were subjected to experimental cooking of sulphate pulp in one-litre autoclaves. The yield was determined in a certain part of the pulp and the remainder bleached according to the laboratory's standard method. The properties of the bleached pulp were then determined. The results, shown in table 5 only in condensed form, are given in percentage of the values obtained in corresponding sound wood.

TABLE 5

Yield and quality of sulphate pulp produced from representative samples of unbarked birch pulpwood, forest-stored for one to three summers and having the maximum amount of rot damage at the ends, and of unbarked pine pulpwood, stored for two summers, together with sound wood.

*Utbyte och kvalitet av sulfatmassa tillverkad av representativa provbitar av under 1—3 somrar skogslagrad obarkad björkmassaved med maximala rötskador i stockändarna samt av under 2 somrar lagrad obarkad tallmassaved jämte motsvarande frisk ved.*

| | | | | | | Unbleached pulp | | | Bleached pulp | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Relative yield of pulp | | Relative strength of pulp | | | |
| Wood | Distance of sample from log end in metres | Decay fungus | Storage time in years | Dry substance kg per $m^3$ of fresh wood | Loss of substance in per cent | Relative requirement of alkali in per cent | Yield in weight per cent | Weight yield in per cent per $m^3$ of corresponding sound wood | Burst factor | Tear factor | Product | Relative brightness in per cent |
| Birch | 0 —0.5 | *Polyporus zonatus* | 1 | 513 | 2.5 | 94 | 100 | 98.4 | — | — | — | 100 |
| | — | Sound wood | 1 | 521 | — | 100 | 100 | 100.0 | — | — | — | 100 |
| | 0 —0.5 | *Polyporus zonatus* | 2 | 423 | 20.0 | 108 | 97 | 76.5 | — | — | 74 | 99 |
| | — | Sound wood | 2 | 537 | — | 100 | 100 | 100.0 | — | — | 100 | 100 |
| | 0 —0.5 | *Polyporus zonatus* | 3 | 396 | 21.0 | 117 | 83 | 65.7 | 102 | 62 | 63 | 96 |
| | — | Sound wood | — | (500) | — | 100 | 100 | 100.0 | 100 | 100 | 100 | 100 |
| | 0 —0.5 | *Stereum purpureum* | 3 | 443 | 12,0 | 110 | 97 | 85.9 | 106 | 75 | 80 | 100 |
| | 0.5—1.0 | do. | 3 | 463 | 7.0 | 107 | 98 | 90.7 | 102 | 81 | 83 | 100 |
| | 1.0 —1.5 | do. | 3 | 469 | 6.0 | 100 | 100 | 93.8 | 102 | 83 | 85 | 100 |
| | — | Sound wood | — | (500) | — | 100 | 100 | 100.0 | 100 | 100 | 100 | 100 |
| Pine | 0 —0.5 | *Stereum sanguinolentum* | 2 | 367 | 5.0 | 96 | 90 | 85.0 | — | — | 90 | 98 |
| | — | Sound wood | 2 | 390 | — | 100 | 100 | 100.0 | — | — | 100 | 100 |

From table 5 it is evident that the yield per unit of weight was very slightly lower than for sound wood, at all events from the wood stored for only 1—2 years. However, because of the major loss of substance caused by decay damage the yield of pulp per unit of volume showed a very pronounced fall, particularly with regard to wood rotted by *Polyporus zonatus* for 2—3 years. From this the danger is also evident of underestimating the significance of decay damage if the yield is calculated in percentage of weight. Since hardwood fungi mainly attack the lignin, and the rotted wood thus contains proportionally more cellulose than does sound wood, it may even be possible in this way to obtain higher figures for the yield than in the case of corresponding sound wood. The requirement of alkali is appreciably greater for rot-damaged wood. In the series of wood samples taken at varying distances from the ends of logs with *Stereum purpureum* damage abating towards the middle, both the yield and the qualitative properties were found to be progressively better towards the middle.

The tests of strength showed considerably lower values in pulp produced from rot-damaged wood. The tear factor in such samples was thus found to be very low (*cf.* PERILÄ & SEPPÄLÄ, 1952), which finding is in general characteristic of decay damage, and indeed of any wood of low density. The burst factor was very good, however, even in pulp produced from severely decayed wood. At bleaching of the pulp, decay damage in the wood was found to entail a distinct fall in viscosity.

The brightness of the bleached pulp proved to be very good, except in samples originating from the wood that was severely damaged by *Polyporus zonatus* and that had been forest stored for three summers.

Regarding the properties of the pulp produced from fresch wood of birch *cf.* JENSEN, 1953.

### B. *Experimental Cooking by the Sulphite Method of Viscose Pulp from Aspen Wood Damaged by Storage Decay*

(carried out by S. O. REGESTAD)

The experimental material consisted of aspen wood (0—1 metre from the ends), rot-damaged for three years by *Polyporus zonatus* and *Stereum purpureum* respectively, together with corresponding sound wood. In this series, unfortunately, no sound wood could be obtained from the logs from which the rot samples had been taken, so that all figures for yields that have been converted according to the volume of wood tested are less reliable than would have been the case had fully comparable sound wood been taken.

Discs were sawn from the test logs, and subsequently used for determination of density, etc. and for the preparation of chips. The experimental cooking of rayon pulp was carried out in one-litre autoclaves made of acid-resistant steel and proceeded without gas relief. The autoclave rotated in a polyglycol bath, and the temperature recordings that were done, showed that the cooking experiments proceeded under identical conditions with respect to the schema applied. Further details will not be reported here; instead the reader should refer to the summary of the principal results in table 6.

Table 6 shows that the yield per unit of volume fell by 20 per cent in the sample most severely rot-damaged (by *Polyporus zonatus*) at approximately the same viscosity. If the yield in weight is given as a function of the viscosity of the pulp, we find that within the range of 20—50 cp the yields were about 1.5 per cent higher for the *Stereum purpureum* sample and 1.5 per cent lower for the *Polyporus zonatus* sample than for the sound wood; which finding could possibly be interpreted as implying that the fungus in the former sample had chiefly attacked the lignin and in the latter mainly the cellulose. This hypothesis is supported, moreover, by the fact that the

TABLE 6

Yield and quality of rayon (sulphite) pulp produced from representative samples (0—1 metre from the log ends) of unbarked aspen pulpwood, forest-stored for three summers and having the maximum amount of rot damage at the ends, together with corresponding sound wood.

*Utbyte och kvalitet av viskos(sulfit)massa tillverkad av representativa provbitar (0—1 m från stockändarna) av under 3 somrar skogslagrad obarkad aspmassaved med maximala rötskador i stockändarna samt av likartad frisk ved.*

| Decay fungus | Dry substance kg per $m^3$ of fresh wood | Viscosity TAPPI 206 Cp | Loss of substance in per cent | Cooking liquid | | Total cooking time | Permanganate number Östrand CCA 9 | Relative yield of screened pulp | | Alpha-cellulose content in pulp CCA 7 per cent | Relative yield of alpha-cellulose on volume basis per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ca 0 g/100 . ml | tot $SO_2$ g/100 ml | | | Weight basis per cent | Volume basis per cent | | |
| *Polyporus zonatus* | 320 | 39.1 | 12.1 | 0.92 | 5.66 | $13^{15}$ | 7.6 | 91.8 | 80.7 | 88.6 | 77.9 |
| *Stereum purpureum* | 351 | 35.1 | 3.6 | 0.92 | 5.56 | $13^{45}$ | 4.8 | 99.0 | 95.4 | 89.2 | 86.0 |
| Sound wood | 364 | 41.0 | — | 0.92 | 5.72 | $13^{05}$ | 6.5 | 100.0 | 100.0 | 87.8 | 100.0 |

permanganate numbers (*ad modum* ÖSTRAND, CCA 9), which are an expression of the degree of cooking, are lower for the *Stereum purpureum* wood than for sound wood, while the value for the *Polyporus zonatus* sample is higher. A not inconsiderable difference in the consumption of chemicals at bleaching and purification of pulps from these samples will accordingly exist. So far as the qualitative properties are concerned, the sample of wood that was slightly rot-damaged (by *Stereum purpureum*) yielded, from the chemical point of view, pulps superior to those both from sound wood and from wood severely rot-damaged (by *Polyporus zonatus*). Further, it may be mentioned that in none of the pulps produced here did the screenings exceed 0.1 per cent.

### C. *Experimental Cooking by the Sulphate Method of Birchwood Blocks Exposed for Four Months to Decay in Laboratory Experiments with Various Rot Fungi*

To investigate, under greater control, the effect on yield and quality of a number of rot fungi in hardwood, dried birchwood blocks measuring 5.0 by 2.5 by 1.5 cm were placed on cultures of the storage decay fungi, *Polyporus zonatus, Stereum hirsutum* and *Polyporus versicolor,* and the rot fungi *Polyporus igniarius* Fr. and *Polyporus betulinus* Fr., living in standing trees. After the decay fungi had acted for four months, the blocks were removed, weighed and converted into chips for experimental cooking. Corresponding sound wood was investigated at the same time. The results will be seen from table 7. The cooking experiments were carried out by E. Venemark, Husum.

TABLE 7

Yield and brightness of sulphate pulp produced from test blocks of birch, subjected for four months to attacks by various hardwood decay fungi in laboratory experiments.

*Utbyte och vithet av sulfatmassa tillverkad av försöksklossar av björk under 4 månader angripna av olika lövträdsrötsvampar i laboratorieförsök.*

| Decay fungus | Dry substance kg per m³ of fresh wood | Loss of substance in per cent | Unbleached pulp | | | Bleached pulp Relative brightness in per cent |
|---|---|---|---|---|---|---|
| | | | Relative requirement of alkali | Relative yield of pulp | | |
| | | | | Yield in weight per cent | Weight yield in per cent per m³ of corresponding sound wood | |
| *Polyporus zonatus* | 237 | 54.5 | 115 | 83 | 37.8 | 100 |
| *Stereum hirsutum* | 391 | 25.0 | 115 | 87 | 65.3 | 100 |
| *Polyporus versicolor* | 451 | 13.4 | 130 | 50 | 43.3 | 87 |
| *Polyporus igniarius* | 343 | 34.2 | 105 | 91 | 60.0 | — |
| *Polyporus betulinus* | 173 | 66.8 | — | 10 | 3.5 | — |
| Corresponding sound wood | 521 | — | 100 | 100 | 100.0 | 100 |

Table 7 shows that different decay fungi cause a markedly varying decrease in the yield and quality in the same length of time (*cf.* tables 5 and 6 too). All the fungi cause typical white rot with the exception of *Polyporus betulinus,* which gives rise to shrinkage rot and which, therefore, as shown in table 7, is also responsible for an exceptionally low yield of cellulose. Worthy of note is that the colour of the bleached pulp was not affected at all, even by particularly severe attacks by the common storage decay fungi in hardwood, *Polyporus zonatus* and *Stereum hirsutum*. Further investigations into the influence of various storage decay fungi on yield and quality are in progress at the Research Laboratory of the Swedish Pulp Company, Sundsvall.

## D. *Summary of the Results of Experimental Cooking*

To illuminate more directly the results obtained, table 8 shows the impairment of yield and quality due to attack by rot fungi after storage of the wood in the forest for one to three summers. However, the values in this table have been converted in

TABLE 8

Estimated i m p a i r m e n t of yield and quality of pulp produced from unbarked birch, pine and aspen pulpwood in logs 2 and 3.5 metres long, forest-stored for one to three years. The estimates are based on data in tables 5 and 6 and were done according to the principles described on pages 65—68. The same mode of calculation was used in respect of pine and aspen.

*Approximativ beräkning av n e d s ä t t n i n g av utbyte och kvalitet av massa tillverkad av lagringsrötskadad 2 resp. 3,5 m lång obarkad björk, tall- och aspmassaved lagrad 1—3 år i skogen. Beräkningarna grunda sig på uppgifter i tab. 5 och 6 och ha utförts enligt principerna å sid 65—68. För tall har samma beräkningssätt använts som för asp.*

| Wood and pulp | Time of storage year | Decay fungus | Loss of substanee in per cent | | Decrease in relative yield of pulp: loss of weight per cent | | Decrease in relative yield of pulp: per volume unit of corresponding sound wood per cent | | Decrease in relative strength of pulp | | Decrease in relative brightness of bleached pulp | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2 m | 3.5 m | 2 m | 3.5 m | 2 m | 3.5 m | 2 m | 3.5 m | 2 m | 3.5 m |
| *Birch* Sulphate pulp | 1 | *Polyporus zonatus* | 1.2 | 0.7 | 0 | 0 | 0.8 | 0.5 | — | — | 0 | 0 |
| | 2 | do. | 10.0 | 5.7 | 1.5 | 0.9 | 11.8 | 6.7 | 13.0 | 7.4 | 0.5 | 0.3 |
| | 3 | do. | 21.0 | 12.0 | 17.0 | 9.7 | 34.3 | 19.6 | 37.0 | 21.2 | 4.0 | 2.3 |
| | 3 | *Stereum purpureum* | 12.0 | 6.9 | 2.5 | 1.4 | 11.7 | 8.5 | 18.5 | 14.9 | 0 | 0 |
| *Aspen* Rayon (sulphite) pulp | 3 | *Polyporus zonatus* | 9.7 | 5.5 | 6.6 | 3.7 | 15.5 | 8.8 | — | — | — | — |
| | 3 | *Stereum purpureum* | 2.9 | 1.6 | 0.8 | 0.5 | 3.7 | 2.1 | — | — | — | — |
| *Pine* Sulphate pulp | 2 | *Stereum sanguinolentum* | 2.0 | 1.1 | 4.0 | 2.3 | 6.0 | 3.4 | 4.0 | 2.3 | 0.8 | 0.5 |

the aforementioned manner (pp. 65—68), so that the decrease is referable to t h e v o l u m e o f t h e w h o l e l o g in respect of lengths of 2 and 3.5 metres respectively. The findings in table 8 include the following.

Losses due to storage decay are considerably greater in birch than in aspen pulpwood.

Different fungi break down the wood with varying intensity. Thus, in the samples of wood investigated, *Polyporus zonatus* was consistently found to be more aggressive than *Stereum purpureum*. However, these two fungi (together with *Stereum hirsutum* and *Corticium evolvens*) frequently coexist.

The damage caused by storage decay in unbarked birch and aspen pulpwood which has been forest-stored for one year does not reach such a magnitude as to have any appreciable significance. After storage for two years the y i e l d of pulp (sulphate pulp) from birch logs 3.5 metres long and damaged by storage decay diminished — calculated per unit of volume of corresponding sound wood — by about 5 per cent, and after three years' storage by 10—20 per cent. In the case of aspen logs 3.5 metres long and used for the production of rayon pulp, the corresponding values can be estimated at approximately one-half of the losses in respect of birch. If we take only the weight percentage into account, the loss figures will be too low, partly because decayed hardwood contains proportionally more cellulose than does sound wood, and partly because pulpwood is sold by volume but the resulting pulp by weight.

It is the strength of the pulp that suffers most from storage decay in birch used for the production of sulphate pulp. The losses here are even greater than those caused by storage decay in pine stored under corresponding conditions, which greatly promote decay in such wood.

The brightness of the bleached sulphate pulp or rayon pulp investigated here seems to have been affected only to a very slight degree by storage decay. *Polyporus zonatus,* however, had a greater deleterious effect than *Stereum purpureum.*

## IV. *Experimental Prevention of Decay Damage in Aspen Wood by Chemical Agents*

During the past few decades, numerous experiments have been conducted on the combatting of biological storage damage by the use of chemical preparations. As regards round wood these experiments have largely concerned saw log timber of pine and spruce, which, of course, during storage and transportation is very susceptible to severe damage, mainly by blue stain and storage decay, which hitherto have not been permitted even to a limited extent in first-class timber. Even though such treatment of the raw material by certain agents has proved to be effective, the method — largely because of the expenses involved — has scarcely been adopted on any extensive scale; it has mostly been kept in reserve, to be resorted to in emergencies such as the utilization of wind-thrown or fire-damaged forest (*cf.* BUTOVITSCH & SPAAK, 1939, 1941, BUTOVITSCH & NENZELL, 1943).

In recent years, however, there has been increasing support for the idea of protecting round timber against storage damage by using chemical agents, even under normal conditions. In this connection it may primarily be a case of more valuable classes of wood such as saw timber and veneer wood, though such a grade as aspen matchwood might well come into question too — the more so in that it is only the end surfaces that need to be protected here (*cf.* KAUFFERT, 1948 and others). Indeed, attempts have previously been made to protect matchwood stored on land in a moist state with the bark on, and thus strongly exposed to storage damage by fungi. These experiments, however, have not resulted in any really effective method.

In Sweden the party most interested in adequate storage of matchwood is of course the Swedish Match Company, under whose auspices certain experiments with a series including some new chemical agents have been resumed during the past two years. These experiments, which are still proceeding and of which only a few preliminary results will be reported here, include both laboratory tests and experiments on a practical scale in a timber yard.

## A. *Laboratory Experiments with Aspen Blocks Surface-Treated with Various Chemical Agents as a Protection against Storage Decay*

The experiments, which were arranged at the Mycology Laboratory of the Royal School of Forestry, were designed to elucidate the efficacy of a number of chemical agents, conceivable in practice, against the commonest storage decay fungi occurring in aspen wood. Agents that were found to be effective against these fungi would subsequently be tested on a practical scale.

The laboratory experiments were conducted in accordance with the current standard method (*cf.* for example CARTWRIGHT & FINDLAY, 1946), aspen blocks 5.0 by 2.5 by 1.5 cm in size and treated with various agents being placed on agar cultures of the following rot fungi: *Stereum purpureum, Stereum hirsutum* and *Polyporus zonatus*. However, only a few experiments with the first-named fungus, which is incomparably the commonest in aspen wood, will be treated in the following.

In each flask (one litre) were placed two treated blocks and one untreated block. The flasks were stored in a thermostat at 22° C for four months, after which the loss of weight due to fungal attack was calculated by dry-weight determinations in dried blocks. Fresh blocks were usually employed; before being placed in the flasks their volumes were determined and the approximate dry weight calculated by comparison with a large number of blocks, similarly measured for volume, which had been dried at 100° C. At least eight blocks of the same kind were used in each experimental series. The values given in table 9 represent the means of what were very consistent figures for loss of weight.

The laboratory experiments were conducted in several stages with a number of chemical agents. In the following, however, only the results of some of the experiments will be reported (table 9), without any detailed discussion of the composition of the various agents (*cf.* SCHULZE, THEDEN & STARFINGER, 1950). The experimental blocks, which were kept moist and protected as much as possible against airborne infection, were immersed in the respective impregnation fluids for five minutes and thereafter air-dried for two hours on sterilized glass shelves before being placed in the flasks. For those blocks that were to be impregnated with a further substance, the procedure was repeated, the blocks thus being placed in the flasks after approximately a further two hours. Half of the blocks were leached for 24 hours, however, by immersion in water, after which they were placed in parallel series. In those cases in which special preparations against leaching were used (»Modocoll», »Sano», »Imbeck»; *cf.* the following) the blocks were not immersed but were brushed with those preparations.

The agents, which were employed in the prescribed concentration, consisted partly of various chlorophenols such as »Santobrite», »Permatox» (sodium pentachlorophenolate in water) and »Ambrite», partly of various chlorated naphthalines such as

TABLE 9

Effect of various chemical agents against the storage decay fungus *Stereum purpureum* in green aspen wood in laboratory experiments at 22° C, 1951—1953.

*Inverkan av olika kemiska konserveringsmedel mot lagringsrötsvampen Stereum purpureum i rått aspvirke i laboratorieförsök vid 22° C 1951—1953.*

| Duration of experiment | Agent | Test blocks not leached after treatment with preservative | | Test blocks leached in water 24 hours after treatment with preservative | |
|---|---|---|---|---|---|
| | | Loss of weight in per cent of dry weight | Surface extent of mycelium (scale 0—5) | Loss of weight in per cent of dry weight | Surface extent of mycelium (scale 0—5) |
| 1951 4 months | Permatox | 13.0 | 1 | 31.7 | 3 |
| | Hylosan P33 | 11.1 | 2 | 12.0 | 2 |
| | Fluralsil | 20.2 | 2 | 36.9 | 5 |
| | Untreated | 42.3 | 5 | 37.3 | 5 |
| 1952 4 months | Ambrite | 16.6 | 5 | 36.5 | 5 |
| | Ambrite + Modocoll I | 21.0 | 5 | 15.7 | 5 |
| | Hylosan P33 | 13.0 | 3 | 19.2 | 4 |
| | Hylosan P33 + Modocoll I | 14.6 | 5 | 16.9 | 5 |
| | Hylosan + Modocoll II | 6.0 | 3 | 1.6 | 4 |
| | Hylosan + Sano | 13.8 | 5 | 12.6 | 5 |
| | Basileum | 1.1 | 0 | 2.5 | 0 |
| | Basileum + Modocoll I | 0.5 | 0 | 0.1 | 0 |
| | Untreated | 36.4 | 5 | 36.0 | 5 |
| 1953 2 months | Timmercuprinol | 0 | 2 | 1.0 | 2 |
| | Untreated | 17.4 | 5 | 12.7 | 5 |

»Hylosan P 33» (which also contains 5 per cent pentachlorophenol) and »Basileum» (monochlornaphthaline in oil), and lastly, a few fluorite salts dissolved in water, such as »Fluralsil» and »Osmol WB 4». In addition a few tar preparations were tried which had been used for treating the ends of birch logs to prevent their sinking when floated; namely »Imbeck» (Mo & Domsjö Company) and »Sano» (The Swedish Pulp Company). Further, two watery solutions of »Modocoll» (ethyl-oxiethyl cellulose, Mo & Domsjö 1951) with varying concentrations were used in combination with »Ambrite», »Hylosan» and »Basileum» in an attempt to bring about a protective membrane over the wood surface, and hence if possible to prevent leaching of the preservative applied. Some data relative to the laboratory experiments will be found in table 9.

From table 9 it is evident that in the first experimental series all the agents tested produced a fairly substantial fall in the fungal attack provided the blocks were not subjected to leaching after impregnation. If they were, only »Hylosan» (dissolved in oil, and not in water, as with the other two substances) showed a good effect, so that this agent could be expected to be serviceable in practice too. Each of the three tested agents was investigated, however, during the storage season of 1951 with respect to its possible protective effect on fresh aspen wood intended for the production of matches and piled in the Swedish Match Company's timber yard at Jönköping (*cf.* the following).

In the second experimental series »Hylosan» was retested together with a few new agents, but in addition the possibility was examined of obtaining, besides the preservative itself, protection against leaching. For the latter purpose were used two different watery solutions of »Modocoll», one of them being considerably more diluted and of lower viscosity than the other, as well as the aforementioned agent »Sano». Table 9 shows that the American chlorophenol preparation »Ambrite», gave some protection, but none at all after leaching. The addition of »Modocoll», however, served to reduce the damage to about one half. In this experimental series too, »Hylosan» provided fairly good protection even after leaching, but not fully satisfactorily other than in the form of a watery emulsion greatly thickened by »Modocoll» (»Hylosan» plus »Modocoll II», prepared by Docent I. Jullander at the Mo & Domsjö Research Laboratory). Addition of the tar preparation »Sano» did not give appreciably greater protection than with »Hylosan» alone. The same was true of the similar preparation »Imbeck». Excellent protection was obtained with »Basileum» too, both alone and with the addition of an agent against leaching. Following treatment with this preparation, no superficial mycelia whatsoever developed in the experimental blocks. The preparation »Timmercuprinol» was also tested and found very effective (Table 9). All of the aforementioned preparations were also tested on a practical scale, as will be seen in greater detail in the following section.

B. *Experiments on the Possibility of Impregnating Aspen Wood against Storage Decay in the Timber Yard.*

Aspen timber used in the production of matches must be stored moist, and is therefore kept unbarked. If storage occurs on land, as is frequently the case, the wood will be highly exposed to attack by storage decay fungi at the ends and for at least half a metre therefrom (*cf.* section I). These parts of the aspen logs, which represent large quantities of wood from the standpoint of match production, must therefore be cut off before the wood enters the mills. If this storage decay could be prevented in the log ends, large sums of money would thus be saved.

In 1951 and 1952, as mentioned in the foregoing, experiments with various chemical agents applied to the log ends were conducted at the Swedish Match Company's timber yard at Jönköping. The experiments, which are still in progress under the immediate supervision of Forest Officer Olle Larsson, will not be described in detail here; suffice to report in brief the principal results obtained so far.

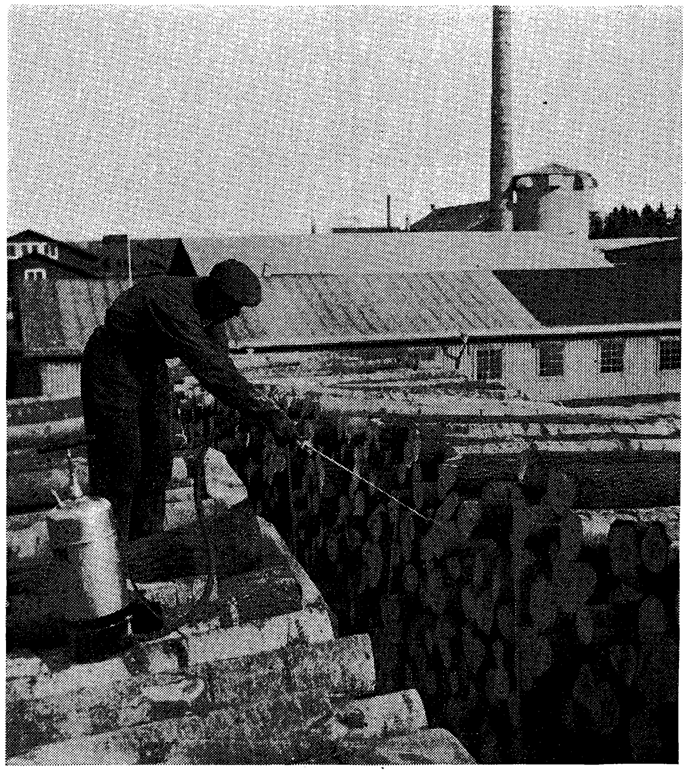

Fig. 15. Spraying against storage decay on the ends of unbarked aspen logs for match production. Swedish Match Company's timber yard at Jönköping, May 1952.

*Skyddsbesprutning mot lagringsröta på stockändar av obarkat aspvirke avsett för tändstickstillverkning. Tändsticksbolagets vedgård i Jönköping, maj 1952.*

The preparations were applied by means of a spray (*cf*. fig. 15) to the ends of the aspen logs in one section, about 3 metres long and marked by laths, on either side of a passage between two piles (approximately 50 logs on each side in each section were treated). During the spraying itself, adjacent sections of logs, often used as untreated controls, were protected by tarpaulin (fig. 15). The experimental piles were about 5 metres high, and logs were chosen with dimensions as uniform as possible — approximately 9½ inches at the middle beneath the bark.

In 1951 the following preparations were used (in a 10 per cent concentration): »Permatox», »Hylosan PE» (dissolved in water) and »Fluralsil», all of which were sprayed on the log ends. To elucidate the best time for treatment with impregnation fluid the sprayings were carried out on three different occasions — April 18, July 1 and August 1. In one series the April spraying was repeated on the same logs on August 1. Since most of the aspen wood came from northern Sweden, surface treat-

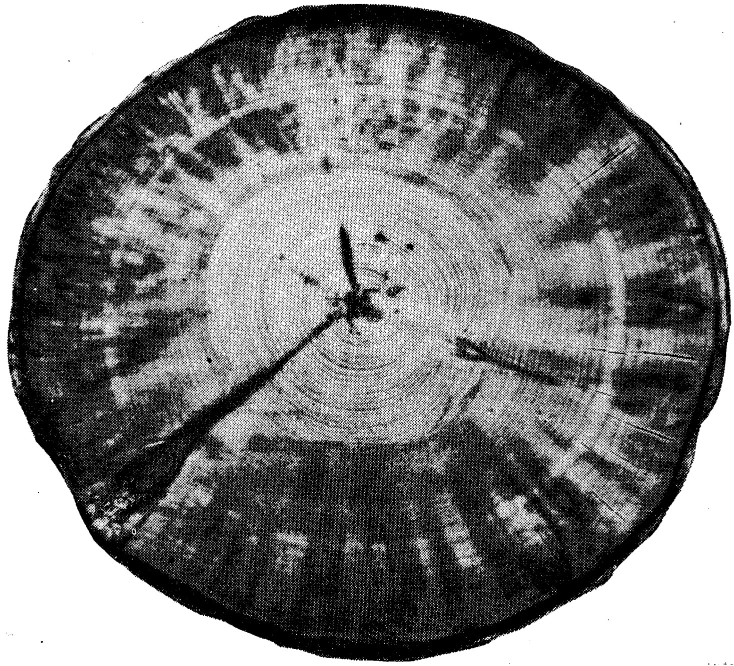

Fig. 16. Discoloration and decay (caused by *Stereum purpureum)* in an untreated aspen log at a distance of 34 cm from the ends. Timber yard for aspen in Jönköping after 1 year storage.

*Missfärgning och lagringsröta (förorsakad av S t e r e u m p u r p u r e u m) i en obehandlad aspstock 34 cm från ändytorna efter 1 års lagring. Vedgård för asp i Jönköping.*

ment was not possible immediately after cutting, but would otherwise have been of great benefit (*cf.* the so-called osmosis method).

In 1952 the experiments were repeated on the same lines but with other preparations, which were applied o n c e only (at the beginning of April) to fresh wood immediately after it had arrived at the timber yard. All the agents were applied in fine weather. »Hylosan P 33» (in oil), »Basileum» and »Ambrite» were accordingly sprayed in the same manner as in the preceding year, whereas an emulsion of »Hylosan P 33» in water, thickened with »Modocoll», was applied to the ends with a brush. The preparations were used in the prescribed concentration, and the consumption averaged about half a litre per square metre.

At inspection of the results the following winters, 1951/52 and 1952/53 respectively, there were sawn from each of a large number of logs in each experimental series one end disc 4 cm thick, and, in addition, one billet 34 cm long, which is the shortest length usable in the mill. The extent of storage decay was examined in each of these sections of trunk by estimating its area in percentage of the sapwood.

Following this initial inspection of the experimental results the general conclusion could be drawn that each of the preparations tested reduced the decay damage by about

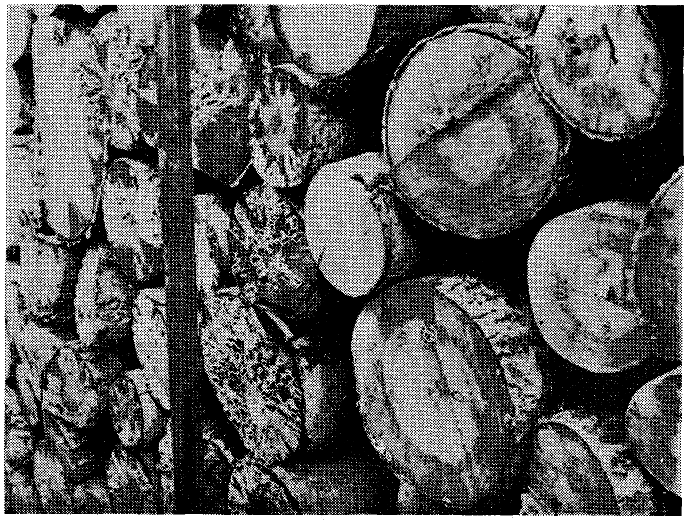

Fig. 17. Sections of aspen piles, separated by laths, at the Swedish Match Company's timber yard at Jönköping. The logs in different sections had been treated with different chemicals as a protection against storage decay. The photograph shows one section without sporophores which had been treated with »Hylosan», adjacent to an untreated section with an abundance of *Stereum purpureum* sporophores.

*Genom träribbor avgränsade sektioner av aspvältor i Tändsticksbolagets vedgård i Jönköping. Inom olika sektioner ha stockarna behandlats med olika kemikalier som skydd mot lagringsröta. På bilden en sektion utan fruktkroppar behandlad med »Hylosan» bredvid en obehandlad sektion med rikligt av fruktkroppar av Stereum purpureum.*

20 per cent at the ends (4 cm) and by about 30 per cent 34 cm in towards the middle. Storage decay — which in nearly every case was caused by *Stereum purpureum* — thus involved roughly 90 per cent of the sapwood for a distance of 4 cm in the untreated logs, but only about 75 per cent in the treated ones. At a distance of 34 cm the corresponding figures were 45 per cent and 32 per cent respectively (fig. 16). The tested agents had accordingly served to decrease considerably the extent of the rot, but not to prevent it entirely. A later inspection of the results in a part of the experiment showed that if the logs were kept in the pile for part of the following spring or summer, the decay fungi probably spread with equal rapidity in the treated and in the untreated logs. No essential difference could be detected in the extent of the rot following spraying at different times. Of great interest, however, was that the formation of sporophores on the log ends could be completely suppressed by »Hylosan» and »Permatox», particularly if the treatment had occurred at the latest of the stated times, namely August 1 (fig. 17).

Since in all probability the infection already occurs to a very large extent during the spring and early summer, it should be of considerable benefit to apply as soon as possible after felling, together with a fungicide, a pore-closing agent that may prevent invasion of the wood tissue by the mycelia. Experiments on this principle were conducted in the forest and in the same timber yard during the following year, but there has been no time as yet to analyze the results in detail. Nevertheless, a further improvement has been attained, particularly in the experiments in the forest. In logs treated with the osmosis-preparation »Antrosit SB 2» on the log ends with a brush in April 1953 immediately after felling, no discoloration at all appeared, at least after one summer's storage.

Whether methods of preservation by chemical agents (which must not be poisonous) really are economically defensible will probably be judged best when an absolutely reliable protection has been developed (*cf.* KAUFERT, 1948). In such economic calculations, however, the possibility should be taken into account of arranging the depôts of timber so that the stores of wood can be kept either wholly or partially immersed in water or, if on land, can be kept under continuous watering during the warmest part of the year — which method is of course particularly effective where feasible.

# *Summary*

Over a period of three to four years experiments were conducted in which birch and aspen pulpwood was forest-stored in different ways to make possible a study of the conditions under which storage decay occurs (figs. 1 and 2). Such damage, which previously had not received much attention, has come increasingly into the foreground in recent years due to the wider use of hardwood in the production of chemical pulp.

In forest storage of birch and aspen pulpwood for 2 years or longer the logs should preferably be clean-barked, which procedure affords good protection by greatly promoting drying more or less regardless of the time of felling and mode of piling (tables 1 and 2).

If birch and aspen pulpwood cannot be clean-barked in the forest, it may well be stored barked in strips, provided the depôt is located in a reasonably open position with good possibilities of drying (table 4). Barking in strips can also be recommended after the wood has arrived at the pulpwood yard (figs. 13 and 14). If the pulpwood piles are situated in a fairly open position, hardwood will dry well when barked in strips, in contrast to corresponding softwood, which under any conditions will be badly damaged by storage decay.

If birch and aspen pulpwood is stored unbarked — as is probably the commonest method — substantial damage will be caused by decay, notably in birch, but only up to a maximum of half a metre from the ends during the first two years (tables 2 and 3; figs. 5—12). At the middle of the logs (wood about 3.5 metres long was investigated) the moisure content remains so high (table 1; figs. 3 and 4) that storage decay usually does not develop, at least in relatively thick logs, for several years. Rotting naturally occurs faster in short than in long logs. Unbarked coniferous wood dries more rapidly than corresponding hardwood, and is therefore damaged earlier at the middle of the logs.

The commonest storage decay fungi in birch and aspen wood in Sweden are *Polyporus zonatus* (figs. 7, 10 and 11), *Stereum purpureum* (figs. 8, 12 and 16), *Stereum hirsutum, Corticium evolvens* (fig. 14) and *Daedalia unicolor,* which occur throughout the country. *Polyporus hirsutus, Polyporus versicolor* and *Schizophyllum commune* in particular mainly occur in southern Sweden. All of the aforementioned fungi cause white rot, and thus attack chiefly the lignin components of the wood. The most aggressive fungus seems to be *Polyporus zonatus* (*cf.* table 7); in aspen *Stereum purpureum* is the most common. *Corticium evolvens* forms large resupinate sporophores but is more or less innocuous.

Experimental cooking of rot-damaged birch, forest-stored for varying periods, showed that one-year storage decay is of virtually no significance (table 5), but that two-year damage may cause a decrease of about 5 per cent in the yield per unit of

volume of wood, and three-year damage a decrease of 10—20 per cent (tables 5 and 8). If the decrease in yield is calculated only per unit of weight, the significance of the rot will be substantially underestimated, so far as hardwood is concerned. Two to three years' storage decay also serves to impair markedly the strength of the pulp (tables 5 and 8). However, the brightness of bleached pulp is not appreciably affected by rot damage (tables 5 and 8). In the production of rayon pulp from rot-damaged aspen wood, the yield is similarly influenced if the rot damage is two or three years old, but not more than about half as much as the yield of sulphate pulp from birch wood with corresponding damage (tables 6 and 8).

In laboratory experiments with various chemical agents (table 9) it was found that the storage decay fungi of hardwood could be effectively arrested in their development by a number of preparations, for example »Hylosan» or »Basileum», particularly if an agent protecting against leaching (»Modocoll») was administered concurrently. — Experiments on a practical scale with aspen matchwood in a timber yard (fig. 15) have shown that chemical agents, sprayed on the log ends, hitherto have reduced the volume of decayed sapwood from about 90 per cent to 75 per cent at the log ends, and from 45 to 32 per cent, on the average, at a distance of about 34 cm from the ends (fig. 16). The sporophore formation has been found possible to prevent almost entirely (fig. 17). Preliminary experiments with the fungicides (especially »Antrosit SB 2») applied to the log ends with a brush immediately after felling have given still better results.

# *Sammanfattning*

## OM UPPKOMSTEN OCH BETYDELSEN AV LAGRINGSRÖTA I BJÖRK- OCH ASPVIRKE SAMT FÖRSÖK ATT FÖREBYGGA DYLIKA SKADOR


Under 3—4 år ha försök utförts med uppläggning av björk- och aspmassaved i skogen på olika sätt för att studera betingelserna för uppkomsten av lagringsröta (fig. 1, 2). Sådana skador, som tidigare icke mycket uppmärksammats, ha under senare år blivit alltmer aktuella i och med att lövveden i allt större utsträckning börjat användas för framställning av kemisk massa.

Vid långtidslagring av björk- och aspmassaved i skogen bör virket helst helbarkas, varvid ett gott skydd erhålles genom den kraftiga uttorkningen av sådan ved tämligen oberoende av uppläggningstiden och uppläggningssättet (tab. 1, 2).

Om björk- och aspmassaveden icke kan helbarkas i skogen, kan den med fördel lagras randbarkad, om uppläggningsplatsen väljes något sånär luftig med goda uttorkningsmöjligheter (tab. 4). Randbarkning kan även rekommenderas, sedan veden kommit fram till vedgården (fig. 13, 14). Om massavedsvältorna ligga någorlunda fritt, torkar lövveden utmärkt i randbarkat skick i motsats till randbarkat barrvirke, som under alla förhållanden blir starkt skadat genom lagringsröta.

Lagras björk- och aspmassaved obarkad, vilket torde vara det vanligaste, uppkomma betydande skador genom röta företrädesvis i björk men endast i stockändarna högst 1/2 m in i veden under de 2 första åren (tab. 2, 3, fig. 5—12). I mitten av stockarna (c:a 3,5 m lång ved undersökt) bibehåller sig fuktigheten så hög (tab. 1, fig. 3, 4), att lagringsröta i regel ej utbildas förrän efter flera års lagring, åtminstone ej i grövre dimensioner. I kortare ved sker det givetvis hastigare än i längre ved. Obarkat barrvirke torkar hastigare än motsvarande lövvirke och blir därför snabbare skadat i mitten av stockarna.

De vanligaste lagringsrötsvamparna i björk- och aspvirke i Sverige äro *Polyporus zonatus* (fig. 7, 10, 11), *Stereum purpureum* (fig. 8, 12, 16), *Stereum hirsutum, Corticium evolvens* (fig. 14) samt *Daedalia unicolor,* vilka äro utbredda över hela landet. Företrädesvis i södra Sverige tillkomma särskilt *Polyporus hirsutus* och *Schizophyllum commune.* Alla de nämnda svamparna förorsaka vitröta och angripa sålunda företrädesvis vedens ligninbeståndsdelar. Den mest aggressiva svampen synes vara *Polyporus zonatus* (jfr tab. 7); på asp är *Stereum purpureum* vanligast. *Corticium evolvens* utbildar stora resupinata fruktkroppar men är tämligen ofarlig.

Utförda provkokningar av sulfatmassa av rötskadad björk, som lagrats olika länge i skogen, visade att 1 års lagringsskador praktiskt taget sakna betydelse (tab. 5) men att 2-åriga skador kunna föranleda en minskning av utbytet per volymsenhet ved med c:a 5 % och 3-åriga skador med 10—20 % (tab. 5, 8). Om utbytesminskningen endast uttryckes per viktsenhet, kommer betydelsen av röta i lövved att kraftigt underskattas. Genom 2—3 års lagringsröta nedsättes även massans styrka högst avsevärt (tab. 5, 8). Vitheten hos blekt massa påverkas dock ej nämnvärt av rötskadorna (tab. 5, 8). Vid framställning av viskosmassa av rötskadad aspved påverkas likaledes utbytet, om rötskadan är 2—3 år gammal men ej mer än omkr. hälften så svårt som beträffande utbytet vid framställning av sulfatmassa ur björkved med motsvarande skador (tab. 6, 8).

I laboratorieförsök med olika kemiska preparat (tab. 9) visade det sig, att lövvirkets lagringsrötsvampar effektivt kunna hindras i sin utveckling genom ett flertal preparat,

t. ex. »Hylosan» eller »Basileum», särskilt om dessutom ett urlakningsskyddande medel (»Modocoll») samtidigt tillsättes. — Försök i praktisk skala i vedgård med aspvirke för tändstickstillverkning (fig. 15) ha resulterat i att lagringsrötan med kemisk bekämpning (besprutning) hittills kunnat nedbringas från c:a 90 % rötvolym i splinten i ändytorna till 75 % och på c:a 4 dm avstånd från ändyta från 45 % till 32 % i medeltal (fig. 16). Fruktkroppsbildningen har visat sig möjlig att praktiskt taget helt förhindra (fig. 17). Orienterande försök med behandling av stockytorna (bestrykning, särskilt med »Antrosit SB 2») omedelbart efter avverkningen ha givit ännu bättre resultat.

# *Literature*

BJÖRKMAN, E., 1946. Om lagringsröta i massavedgårdar och dess förebyggande. (On storage decay in pulpwood yards and its prevention). — Medd. Stat. skogsforskn.-inst., 35.

BROWN, K. J. & MCGOVERN, J. N., 1950. Production of high-yield pulps from aspen by mild treatments with sodium hydroxide. — Forest Products Lab., Forest Service, U. S. Dep. of Agr.

BUTOVITSCH, V. & SPAAK, H., 1939. Studier och försök att skydda i skogen kvarliggande timmer mot insekter och svampar jämte beräkningar av konserveringsmetodernas ekonomiska förutsättningar. (German summary). — Norrl. Skogsvårdsförb. Tidskr.

—»— 1941. Fortsatta försök att skydda i skogen sommarlagrat timmer mot insekter och svampar. (German summary). — Norrl. Skogsvårdsförb. Tidskr.

BUTOVITSCH, V. & NENZELL, G., 1943. Ytterligare bidrag till kännedom om sommarkonservering i skogen av obarkat och barkat talltimmer. (Weitere Beitrag zur Kenntnis der Konservierung des im Walde sommerlagernden geschälten und ungeschälten Schneideholzes). — Norrl. Skogsvårdsförb. Tidskr.

CARTWRIGHT, K. St. G. & FINDLAY, W. P. K., 1946. Decay of timber and its prevention. — London.

FRITZ, CLARA, W., 1951. Decay and stains in wood. — Canadian Woods, their Properties and Uses. Ottawa.

JENSEN, W., 1953. Laboratorieundersökningar av björkved som råvara för massaframställning. (English summary). — Norsk Skogindustri, 8.

KAUFERT, F. H., 1948. The preservative treatment of aspen. — Lake States Aspen Report, 19. Lake States Forest Exp. Station, Forest Service, U. S. A.

MO & DOMSJÖ, 1951. Modocoll. Vattenlösliga cellulosaetrar som förtjocknings-, emulgerings- och bindemedel. — Örnsköldsvik.

PERILÄ, O. & SEPPÄLÄ, E., 1952. Pakurikäävän vaikutuksesta koivupuuhun sekä tästä valmistetun sulfiittiselluloosan paperiteknillisiin ominaisuuksiin. (On the effect of black tinder fungus on birch wood and paper making properties of birch sulphite pulp). — Papper och Trä, 34.

SCHAFER, E. R., 1947. Aspen for pulp and paper. — Lake States Aspen Report, 14. Lake States Forest Exp. Station, Forest Service, U. S. A.

SCHANTZ-HANSEN, T., 1948. Logging methods and peeling of aspen. — Lake States Aspen Report, 3. Lake States Forest Exp. Station, Forest Service, U. S. A.

SCHULZE, B., THEDEN, GERDA & STARFINGER, KÄTHE, 1950. Ergebnisse einer vergleichenden Prüfung der pilzwidringen Wirksamkeit von Holzschutzmitteln. — Wissenschaftl. Abh. d. Deutsch. Materialprüfungsanstalten, II: 7.

ZASADA, Z. A., 1947. Aspen properties and uses. — Lake States Aspen Report, 1. Lake States Exp. Station, Forest Service, U. S. A.