

Observations on the Butt Rot of Sakhalin Fir (*Abies sachalinensis* MAST.) in the Tokyo University Forest, Hokkaido, with Special Reference to Infection and Propagation of Decay

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In the previous surveys⁸⁾¹¹⁾, in the Tokyo University Forest, Hokkaido, it was cleared up that the natural forest of Sakhalin fir (*Abies sachalinensis* MAST.) was heavily infected with butt rot caused by the attack of wood-rotting fungi among which *Fomitopsis annosa* (FR.) KARST., *Phaeolus Schweinitzii* (FR.) PAT. and *Tyromyces balsameus* (PECK) MURR. were predominant.

As for the mode of progress of butt rot, it has been considered to be done by decay ascending from roots firstly infected. Observations on natural infection of western hemlock and fir conducted by BUCKLAND et al. (1949)¹⁾, of pines by *Fomes annosus* by RISHBETH (1951)⁹⁾, of Douglas fir by *Poria Weirii* by BUCKLAND et al. (1954)²⁾, and of sugar maple by NORDIN (1954)⁷⁾, made clear the mode of propagation of butt and root rot and courts of entry and infections of fungi. A review on heart rots in living trees was published recently by WAGENER and DAVIDSON (1954)¹²⁾, in which they stated that butt rot progressed through roots adjacent to infected ones. There is, however, a scarcity of information on the mode of propagation of butt rot of Sakhalin fir in Japan.

The writer observed in detail decayed butts and roots of Sakhalin fir and a conclusion regarding to the mode of propagation of butt rot was gained.

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OBSERVATIONS

The majority of trees of Sakhalin fir on the slope facing on southeast along No. 1 stream in No. 57 division in the University Forest was heavily infected, whereupon many trees were taken for samples in the present work. Since fructifications of wood-rotting fungi causing butt rot were found scarcely, identification of causal fungi was made by observing the type of decay appeared in a transversely cut surface of trees, because decayed woods show characteristic appearances with species of causal fungi. It was found in the present survey that the observation of longitudinal surfaces of decayed stumps makes it easy to identify the species of fungi and gives advantages for the study on the progress of wood decay in butts and roots.

In general, the decay caused by only one species of fungi was rare and it was found that the bulk of decay was resulted by the attack of more than two spe-

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cies of wood-rotting fungi. The mode of infection and propagation of butt rot will be presented by providing here some examples of observations on (A) extension, contact and fusion of root systems (B) decay of butts and roots.

A. Extension, contact and fusion of root systems (Pl. X-a, -b)

Root systems of Sakhalin fir extend conspicuously and when the interval of trees is less than 4-5 m almost all the roots between them tangle and contact one another and we may consider them just as roots of the same tree. Extension of root systems, however, varies considerably with trees. In spite of the considerable contact, fusion of roots could scarcely be observed.

Root decay in a part of contact almost always could not be recognized, though damages, causes of which were unknown, were sometimes observed, and they might provide entrances for invasion of wood-rotting fungi. This fact, however, seems to mean that contact of roots can be seen only when roots are in sound conditions and that any contact of roots becomes unable to be recognized when decay in that part proceeds so that it becomes a source of next infection.

B. Dissection of decay. 1. (Pl. X-c, -d and Fig. 1-a, -b, -c)

The diameter of a heavily decayed stump at 30cm above the ground was 57×50 cm, on which the decayed part of 20×18cm caused by the attack of *Fomitopsis*

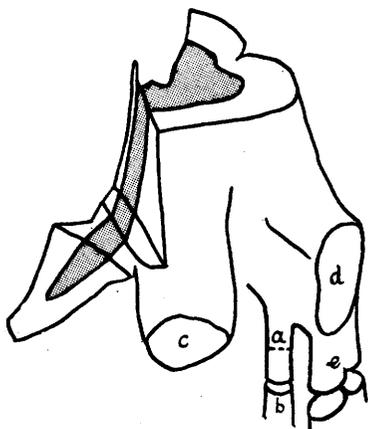


Fig. 1-a. A decayed butt.

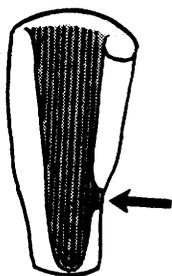


Fig. 1-c. The entrance of *Fomitopsis annosa* in a root.

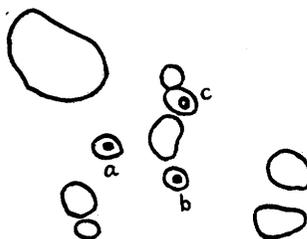


Fig. 1-b. The location of roots after removing the butt.

annosa and *Tyromyces balsameus* was observed. As shown in Pl. X-c, the decay, resulted by *Phaeolus Schweinitzii*, was observed under that by *F. annosa* on the longitudinal surface of the butt and root in one direction. This fact shows that the survey of decay at transverse surface of a stump is insufficient for judgement of causal fungi. And further, since the decay by *P. Schweinitzii* reduced gradually its grade of decay and disappeared at about 1 m under the surface of the stump, it

was supposed that this decay progressed downwards from upper part of the trunk to which the fungus invaded through a root.

According to the results of the survey on a decay in another root, a considerable decay by *P. Schweinitzii* in the root was observed (c in Fig. 1-a), and because a type of rot by *P. Schweinitzii* was not found in the transverse surface of the stump, it was supposed that the decay proceeded from the root c already infected to the adjacent one and that the time of infection of *P. Schweinitzii* to the root c would be later than that of the infection of the other two species of wood-rotting fungi. In the part a and b in Fig. 1-a (a in Fig. 1-b), the type of decay by *F. annosa* was recognized; the diameter of decay was 2×1 cm against 5.5×4.5 cm in that of the part a and 2.5×1.5 cm against 5.5×5.5 cm in b, the distance between a and b being 6 cm. But any root rot still could not be seen in the root d and e. According to these facts, it is considered that the decay caused by *F. annosa* advanced through the root a (b). So, the roots were chased downwards to discover the entrance of the causal organism. In the transverse surface at 15 cm under the part b, there was no root decay. The entrance, therefore, should exist in the fragment of 15 cm long. As shown in Fig. 1-c, a small hole was found in a longitudinal surface of the fragment. *F. annosa*, the causal fungus, surely entered from the hole. Further, b in Fig. 1-b was also decayed by this fungus and c showed the type of decay by *T. balsameus*.

By chasing the origin of the decay in the root c, a fragment of the root having three openings was gained (Pl. X-d). The entrance was at any time the part of wounds resulting from enveloping rind, swelling or destroyed parts by various causes in root systems.

Dissection of decay. 2. (Pl. XI -a, -b, -c and Fig. 2-a, -b, -c)

The diameter of the stump taken for a sample tree was 56×49 cm on which the decay caused by the attack of *Tyromyces balsameus*, *Fomitopsis annosa* and *Phaeolus Schweinitzii* was observed.

The state of decay in longitudinal surfaces of two directions shown in Fig. 2-a was surveyed after turning up the stump.

As shown clearly in Pl. XI-a, -b and Fig. 2-b, -c, decays in the surface of the stump resulted by the attack of *T. balsameus* and *F. annosa* were nearly the same in largeness, but it was found that decay by *T. balsameus* became larger and that by *F. annosa* disappeared, cleaving the stump in two different directions and

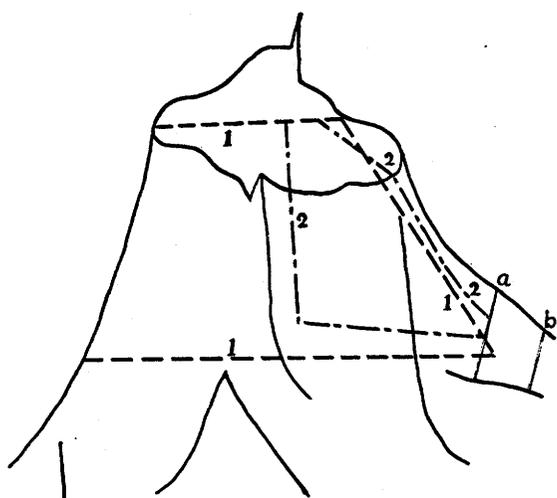


Fig. 2-a. The direction of two longitudinal sections.

chasing the decay underwards. Partially decay by *P. Schweinitzii* was found in a cleaved surface.

These may be resulting in the fact that fungi causing butt rot enter from se-

parate roots and that the time of infection is different. Since the infection of *T. balsameus* took place originally from a root and then the decay by *F. annosa* progressed from another root, it was discovered that the decay by the latter was

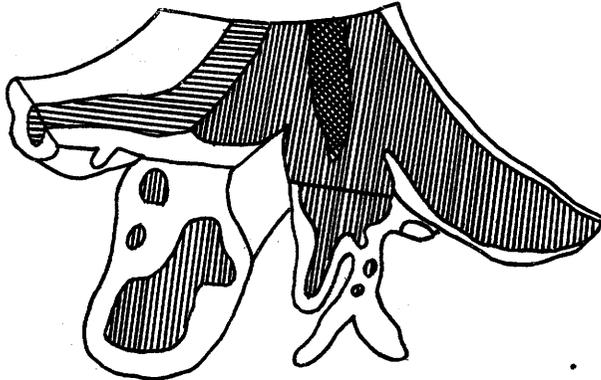


Fig. 2-b. The longitudinal section and its under surface in the section 2.

Marks in the decayed part are as follows:

-  The decayed part caused by the attack of *Fomitopsis annosa*.
-  The decayed part by *Tyromyces balsameus*.
-  The decayed part by *Phaeolus Schweinitzii*.

surrounded by that of the former (Fig. 2-b).

By removing the butt, the location of roots (Fig. 2-c) was discovered, and it was observed that many roots were attacked by *T. balsameus* and a few roots by *F. annosa*.

Among roots decayed by *T. balsameus*, of course, those may exist which are decayed downwards from butt, as this is the way in which the decay proceeds. Chasing further the roots b-e and a-e in Fig. 2-c, it was recognized that these roots had the hole favoring

the fungus infection. Pl. XI -c shows the roots from which *T. balsameus* and *F. annosa* invaded. These roots have wounds resulting from enveloping rind or cracks of swelling of the roots like the former example and these wounds may provide a good chance for infection of these organisms.

When the decay of roots proceeds extremely, decayed roots become the same state as soil and it is very difficult to find them in the soil without taking special care, but such decayed roots were often found.

CONSIDERATION

It has been known widely that the damage by butt rot in the natural forest of Sakhalin fir in Hokkaido cannot be overlooked. This fact was pointed out by IMAZEKI and AOSHIMA (1955, 1956).⁴⁾⁵⁾ During 1952-1954, they carried out the detailed observations on fungus decay of Sakhalin fir and Yezo spruce in the primeval forests in the headwaters of

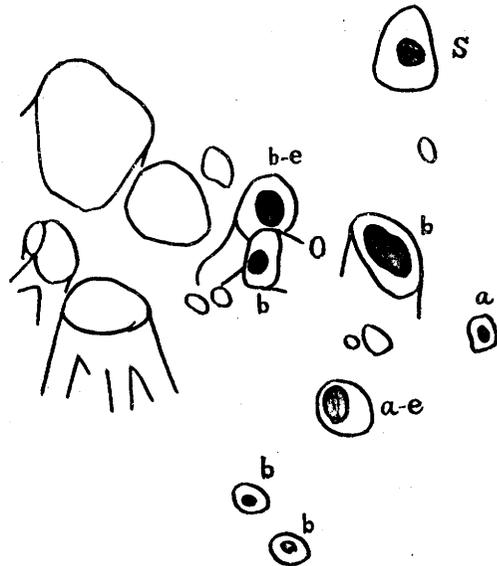


Fig. 2-c. The location of roots after removing the butt.

- a : decay by *Fomitopsis annosa*,
- b : decay by *Tyromyces balsameus*,
- S : decay by *Phaeolus Schweinitzii*.
- e shows to have an entrance.

of Sakhalin fir and Yezo spruce in the primeval forests in the headwaters of

the River Ishikari, Hokkaido. In their information (1956)⁵⁾ they stated that the maximum and minimum percentage of the occurrence of butt rot of Sakhalin fir were 90 % and 17 %, respectively, and the average was 50 %. And, in fact, it was found that 90% among the trees of Sakhalin fir of more than 40cm b. h. d. at sample plots were infected in the University Forest, Hokkaido (SASAKI and YOKOTA, 1955).¹¹⁾ Up to date, butt rot has been supposed to be resulted by invasion of wood-rotting fungi through roots already decayed by them. Technically it is, however, very difficult to survey the decay in stumps under the ground so that only a few reports on the propagation of butt rot have been published. Recently, BUCKLAND et al. (1954)²⁾ made clear the mode of propagation of decay by a wood-rotting fungus, *Poria Weirii* MURR., in their detailed investigation on the yellow laminated root rot of Douglas fir. According to their publication, they pointed out that the fungus attacks trees through the contacted or fused point of roots, which are a characteristic feature of Douglas fir. "Decayed roots are viable for inocula under the ground about a period of 50 years," they stated, "so that the decay spreads year after year from the center of infection."

According to the results in the present observation, some of which were described above, following facts were discovered :

(a) The root system of Sakhalin fir extends widely, so that it enters easily to another system and the contact of roots happens to one another. In this case, however, the fusion of roots as it has been observed by BUCKLAND et al. scarcely could be found out.

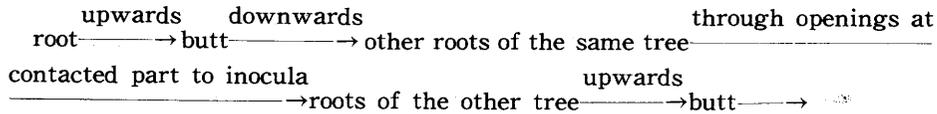
(b) By observing the cut surface of the decayed roots and butts in different directions, two ways in the progress of decay were recognized. One way is the decay ascending to butt after causal fungi entered from a root and the other way is that the decay descends to the roots after butts were heavily destroyed. These two ways in the progress of decay must have a close relation which have an important significance in interpreting the mode of propagation of decay from a center of infection to sound trees.

In detailed observations of roots which had the opening for fungus invasion, it was found that the openings always were wounds or parts which made it easy for the causal fungi to enter the root through the openings resulting from enveloping rind or cracks of swelling of roots, etc.

(c) As the decay of roots proceeds considerably, they become such a state as soil, though they are keeping the original form of roots. Such roots were often found by treating decayed roots with special care, but they collapsed immediately by touching. Though it has not been known how long these decayed roots entertain the ability to be the source of infection, it is considered that they live as pathogens for a considerably long period as stated by BUCKLAND et al. (1954)¹⁾, because better conditions will be provided under the ground to entertain the ability of infection of wood-rotting fungi than above the ground.

If a root system intrudes into another system, which contains such heavily decayed roots, and if there are such openings convenient for invasion of pathogenic fungi as wounds and cracks, soon the infection will happen through these openings.

Generalizing the results in the present work, it is almost certain that decay propagates from a root to another, as supposed formerly. Therefore, the scheme on propagation of butt rot will be proposed as follows;



Control methods of butt rot are investigated by many authors; that for pines by *Fomes amosus* (RISHBETH, 1952)⁹⁾, that for lodgepole pine in Alberta, Canada (NORDIN, 1954)⁶⁾, that for spruce in Alberta (NORDIN, 1955)⁷⁾, etc. The characteristic of the latter two is to associate the method with the management of stands. IMAZEKI and AOSHIMA (1956)⁵⁾ described the relation between decay and site conditions and suggested the importance of basic investigations regarding to the mechanism of fungus infection, the velocity of progress of decay after invasion of fungus into trees, ecology of causal fungus, the relation between the occurrence of decay and site conditions, and the establishment of methods for identification of causal fungi by means of the observation of decayed woods, etc., for the establishment of control methods.

It is, of course, necessary to associate a control method with forest management of Sakhalin fir in future works. As cited by WAGENER and DAVIDSON (1954)¹¹⁾, age, stand history, stand composition and site are the basic determinants of defects from heart rots. However, because Sakhalin fir forest in the present work is a natural forest, age and stand history are quite obscure and therefore further inspections should be done to build an advantageous method controlling butt rot of Sakhalin fir.

SUMMARY

It is natural that butt rot fungi should invade healthy trees through scars on the trunk. Besides, one of the modes of infection and propagation of butt rot was discovered by dissecting in detail decayed butts and roots of Sakhalin fir (*Abies sachalinensis* MAST.) grown in the natural forest in the Tokyo University Forest, Hokkaido.

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トドマツの根株腐れの侵入と伝染径路に関する観察 (摘要)

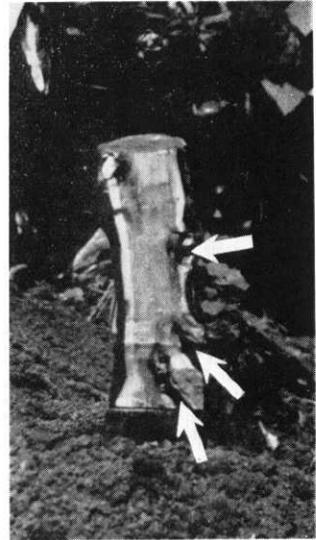
大学院研究奨学生 横 田 俊 一

東京大学農学部附属北海道演習林内のトドマツ天然林は根株腐れによって著しい被害を受けている。そこで被害木を伐倒して根株部の腐れを詳細に観察した結果、腐れの侵入径路及び伝播の様式が略々明かとなった。樹幹部の傷から腐朽菌が侵入することは勿論であるが、その他、根系を通じても伝染することが明かとなった。即ち、一つの根から入った腐朽は次第に根株に上って行き、根株部を腐朽せしむると共にこの腐れは別の根に進んで行く。斯くして根は甚だしく腐朽し、単に根としての形を留むるのみとなる。一方、トドマツの根系は横に著しく拡がるので容易に他の根系の中に侵入して根の接触が生ずる。従って甚しく腐朽した根をも一つの根系の中に他の健全な樹木の根系が入りこんだ場合に、偶々根の一部に腐朽菌の侵入に都合のよい傷が腐朽根との接触部の附近にあれば、腐朽菌は容易に侵入して健全樹木を侵しはじめる。一旦根が侵されると上述の如き過程を経て、次々と根株腐れのおこる範囲が拡大して行く。この様に根株腐れは樹木の根を通じて伝播して行くものであることが明かとなった。なほ根株腐れをおこす主要な腐朽菌は数種あるが、それらの腐朽の伝わり方は何れも同様であった。

(昭和 31 年 5 月 27 日 東京大学農学部森林植物学教室において)



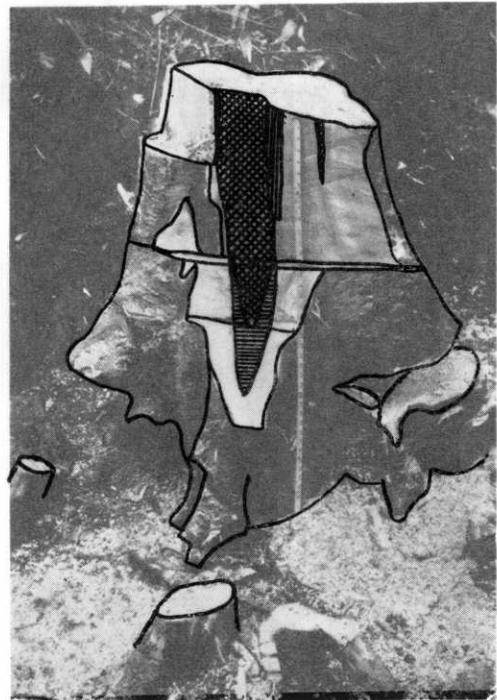
a. The extent of root systems of *Abies sachalinensis*.



d. The entrance of *Tyromyces balsameus* in a root.

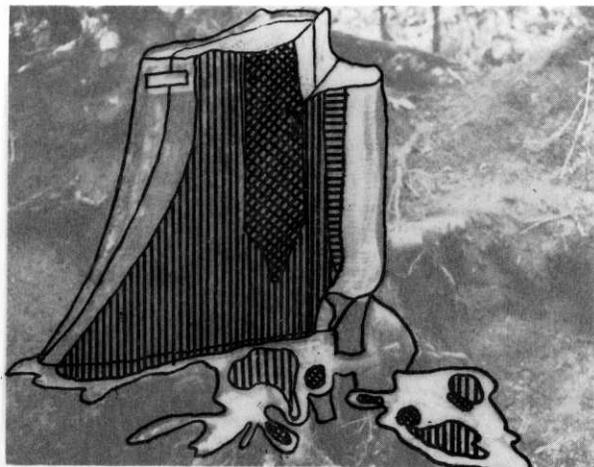


b. Root systems contacting to each other.



c. "Root and butt rot" caused by the attack of a few species of wood-rotting fungi.

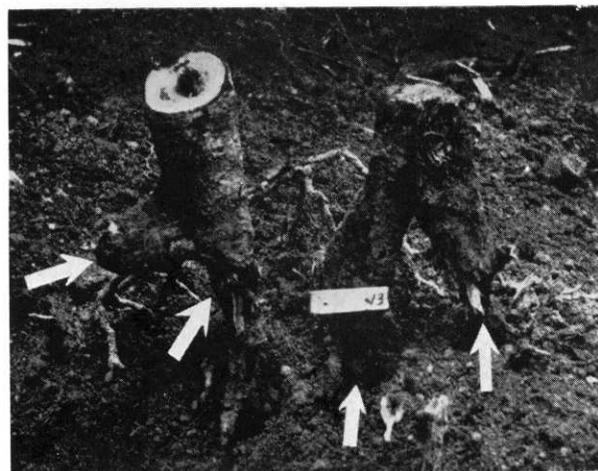
Plate. XI



a. "Root and butt rot" caused by a few species of wood-rotting fungi in a longitudinal section.



b. Ditto.



c. The entrance of the wood-rotting fungi. Left : *Tyromyces balsameus*; Right : *Fomitopsis annosa*.