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BARK AND WOOD STRUCTURE AND PROCESS OF FORMATION OF ABIOTIC  
CANKER.

Northern Forest Research Centre  
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# BARK AND WOOD STRUCTURE AND PROCESS OF FORMATION OF ABIOTIC CANKER

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## Introduction

Frost-killing of vital vascular tissues has a great potential in canker inception in exotic and native trees. If recurrent, it may reduce the food reserves at a critical time in the spring, or it may reduce the capacity to store food in the autumn. Continuous devitalization often leads to mortality. The genus Populus and Pinus, both having a wide geographic distribution, were chosen for anatomical study because of the prevalence of canker, dieback, loss of leader and stem deformation in young and pole-sized trees. In order to obtain a full picture of host response to winter injury a study of temperature records and of structure of rejuvenated bark and wood in injured stems seems indispensable.

## Incidence of Frost

In many parts of the North Temperate zone, fall frost signifies the approach of winter and occurs during an autumn transition. In the northern Rocky Mountains, foothills and boreal forest, autumn transition begins in the latter part of August in many isolated valleys where air drainage is poor. It lasts longer in the high foothills and Rockies in the lower latitudes where winters are shorter but the frequency of warm spells and cold spells also increases. In the plains country east of the Rockies, a similar pattern exists, except the autumn transition is shorter and the frequency of warm spells and cold spells decreases in

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the winter months. The latter anomalies are confined almost entirely to November and March in the northern latitudes and eastern longitudes of the Canadian Plains.

The spring transition covers a period from the middle of March to the end of June in the Rockies and high foothills and during April and May in the Plains area. In general, the frequency of temperature fluctuation increases partly because of chinooks and partly because of warming trends throughout the Prairies with the onset of summer. Chinooks along the Rockies and foothills country produce a rise in temperature, occasionally 30° to 40°F within an hour and terminate by the arrival of strong cold arctic winds. A drop in temperature from +40° to -30° is not uncommon. In some winters, Arctic winds push the chinook with sudden rises of 20°F well to the south and east of the normal chinook belt into the Plains area.

#### Bark and Wood Structure of Canker

##### Bark Structure

In radial sections of initial canker, damaged parenchymata in the cambium, cortex and phloem become physically disorganized by crushing, collapse and honeycombing. Disintegration of cellular contents results in inter- and intra-cellular occlusions with gummy resin and pitch, respectively in poplar and pine. On the living side of the stem adjacent to the canker, new periderm and phloem tend to unfold the edge of current sapwood resulting in a raised ridge-like band.

Radial sections of scabby bark in 2-year-old poplar and 3-year-old pine show essentially the same sequences of necrosis in the cortex and phloem. Discoloration in poplar scabby bark is yellowish brown and that of

pine a reddish or purplish brown as described by Mullick (1972). Below the upper scabby bark of poplar, a second periderm forms in the phloem and cortex with exfoliation of the original. In pine small but not the large patches of scabby bark flake off after a second periderm is formed. In large patches, phloem rays proliferate to develop horizontal resin canals that coalesce into a single pitch pocket. Periderm sequences in later years consist of the same number of cork cell layers or several times more than the original one. Accompanying them are wedges of rejuvenation tissue contributed the phloem ray and cortex. As new excrescences develop unevenly, they tend to push necrotic phloem layers into oblique alignment. In older wood, enlargement of the lesion in area and thickness of scabby bark follows each freeze-killing of the phloem alternating with sequences of periderm enclosing lens-like laminations. Longitudinal fissures characterize poplar scabby bark and pitch pockets characterize pine scabby bark which often is raised along one side.

The combium ray initials at the interface of the phloem and xylem bordering the canker proliferate to produce ray excrescences consisting of isodiametric parenchymatous cells that result in a thick layer of occlusion tissues intergrading laterally with normal phloem. Sieve elements and cambial initials are absent. Ray parenchyma, retaining their normal orientation throughout the excrescence are less conspicuous and shorter than the normal cells. Diagonal sequences of periderm often develop in this tissue.

## Wood Structure

Frost ring is the first to form in sapwood of stems with scabby bark but it may be absent if the bark and sapwood are killed outright in young trees. The first tissues to be formed have their origin in the xylem ray of the summerwood which proliferate in the springwood to form aggregate, multiseriate and uniseriate rays in poplar and ray excrescences in pine. Callosed reticulate wall thickenings are common in parenchyma of the former and in reticulate tracheids of the latter. All cells tend to retain isodiametric form of ray initials and frequently they are angular and globose. Interspersed among them are cells of cambial origin, all of which become dominant as soon as the cambium is reestablished. Tracheids frequently have fine to broad bands of spiral thickenings and are variously bent, forked, attenuated at apices or one end angular and blunt or rounded and clavate. Vessels of poplar also stand out because of their lateral proliferations, forking and scalariform and reticulate pitting. Presence of attenuated border pits and callose distinguishes these conducting elements from normal ones.

Another extreme variation of wood structure occurs at the margins of the canker where ray cells develop weaker isodiametric tissues similar to the ones occurring in the p loem. Reestablishment of the cambium at the frost ring and at the margin of the canker shows a wide range of development and maturation in the sequences of multiple growth layers. As in the frost ring, alignment of tissues becomes quite complex involving some overlapping twisting and turning of the elements and resulting in interlocking grain of the wood. Observations show that even

after four months, reorientation of the elements does not occur. Ray proliferation diminishes somewhat but it continues to dominate the multiple growth layer. Spiral tracheids are numerous except for the gelatinous fibers.

#### Process of Development of Canker

Phloem and xylem are most vulnerable to freeze-killing during the developmental and maturation cycles. Development of the phloem in April exposes this tissue at bud and needle traces to frost injury earlier by four to six weeks than that of the xylem which begins to develop in May. Similarly phloem and xylem are vulnerable during the autumn transition because their late maturation coincides with the killing frost; the most common loci are leaf and bud traces. Damage to the bark may occur during the winter months when very warm day temperature is succeeded by cold night temperature.

Bark and sapwood in current shoots show no visible difference in susceptibility to freeze-killing particularly if wood and buds are immature and leaves are green as in poplar. In older wood, sapwood is less susceptible to killing as long as it is nourished and protected by undamaged bark. Once the storage capacity of the bark is reduced, the phloem and xylem no longer are able to rejuvenate readily at the margin of the canker. In decreasing order of sensitivity to frost-killing, the tissues are phloem rays, cortex, cambial region rays, pith, and phloem and xylem parenchyma in the cambial region. Frost-killing has the greatest impact on tissues most active in storage and rejuvenation occurring in

the zone between the cortex and the phloem. The impact of the damage on subsequent development of new phloem and xylem is, therefore, in inverse proportion.

Initiation of canker starts with phloem discoloration and sequences of periderm separating dead tissues from living ones. The resultant raised lesion of bark becomes scabby and very much laminated. In pine it may flake off in the first year but it soon becomes resin soaked and unable to separate readily. A pitch pocket develops with the enlargement and fusion of horizontal resin canals. New resin canals from proliferation of phloem ray cells provide a continuous flow into the pitch pocket. When pitch flow becomes profuse, the scabby bark lifts to one side. In poplar, scabby bark remains in tact for several weeks before it ruptures and allows some of the water soluble gummy resins to drain from the impregnated dead tissues. Cracks develop in the wood below if the cambium and parenchyma ray have been killed. Phloem ray excrescences become prominent along the edge of the canker resulting in terracing of scabby bark in poplar.

Once an ungulate segment of wood becomes exposed to and impregnated with pitch and gummy resin from the bark, it discolors in an arc, the width of the canker. But pitch impregnated wood does not weather and cross-check as does poplar wood impregnated with gummy resins.

#### Discussion and Summary

Decreasing order of susceptibility of rejuvenating tissues has been from that of the most actively proliferating cortex parenchyma

and phloem rays to the proliferating xylem ray. These tissues have been found to be poorly developed and differentiated. However, tissues developed by the reestablished cambium have also been found to be defective and poorly differentiated, resulting particularly in weaker fibers, smaller vessels, and in a tendency toward spiral tracheids and reticulate and scalariform vessel elements. Long after the reestablishment of the cambium, ray initials continued to play an increased role in the development of vascular tissues. They were observed as massive excrescences in the phloem and as aggregates of multiseriate and defused cells in the xylem.

Thus, winter injury has had two types of impact on living tissues: necrosis of storage parenchymata and the inability of the cambium to survive. Ultimately reestablishment has resulted in insufficient development and maturation of vascular occlusion tissues. The storage and vascular tissues have always been interdependent. In view of the evidence, the ability of the host to survive the impact has depended on growth factors first and on species and clones second.

This report has been compiled from personal research notes and previous publications (Zalasky 1970 and Zalasky 1972). Some of the useful Canadian references for weather records and reports are Ashwell (1971), Canada Department of Transport (1965-1971) and Kendrew and Currie (1955). For readings on frost ring, the American authors Rhoads (1923), Harris (1934) and Glock et al (1960) are highly recommended. For original work on scabby bark, German author, Joachim 1957 and 1963 would be the starting point.

### Application of Results

Low temperature effects are of two kinds, complete disorganization and necrosis of developing and maturing parenchymata and the change in the pattern of development of specialized differentiated cells. The foregoing information has great significance in hardening off of seedlings, in all forms of amenity plantings and establishment of trees, in performance tests for winter survival, and in the use of pulp.

- (1) In hardening off of seedlings, the method presently in use in high risk areas may in fact lead to defects in seedlings by suppression of the terminal bud resulting in forking and weak stem form. A combination of low temperature and freezing water spray is of questionable value in preparing seedlings for growth under field conditions. Retardation of plant development during the normal growth cycle may in fact lead to more damage later. Lateral buds usually break in July and new shoots developing in August become vulnerable to autumn freeze-killing. This leads to a question, is hardening off by low temperature necessary or can it be dispensed with entirely if seedlings were planted or set out after the danger of frost. The advantage of the latter is that plants put on additional growth sufficient to nourish new buds and store food before the frost season starts.
- (2) In tree establishment, low temperature damage to the stem in the form of branch or leader dieback and canker leads to deformation of the crown and stem in young and pole-sized trees.

It results in shortened life span of trees used in recreational amenity plantings. On the other hand, these trees have the advantage of the broad crown being more amenable for use as shade. In performance tests for survival under winter conditions, current shoots and sapwood in general endure better when the growth cycle occurs well in advance of autumn freeze-killing.

- (3) Growth factors readily affect rejuvenation. Soil fertility often accounts for patchy growth and failure of survival of weaker plants regardless of species or clone.
- (4) In harvesting of trees for pulp, the high risk areas can be readily mapped from the existing damaged stands. A high per cent of short fibers in pulp often requires mixing longer fiber obtained from more valuable species as spruce. It also adds to the cost of filtering and marketing cheaper fiber separately. 'Schlereid-like' cells are an obsession in paper making because they will not absorb ink, thus leaving white spots on dense paper. They also have window-like openings on all sides. In light weight paper, their inclusion leads to a weakness of mottling characteristic or 'light spots' in an area that should be uniformly opaque.

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