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Common Fungal Diseases of Russian Forests

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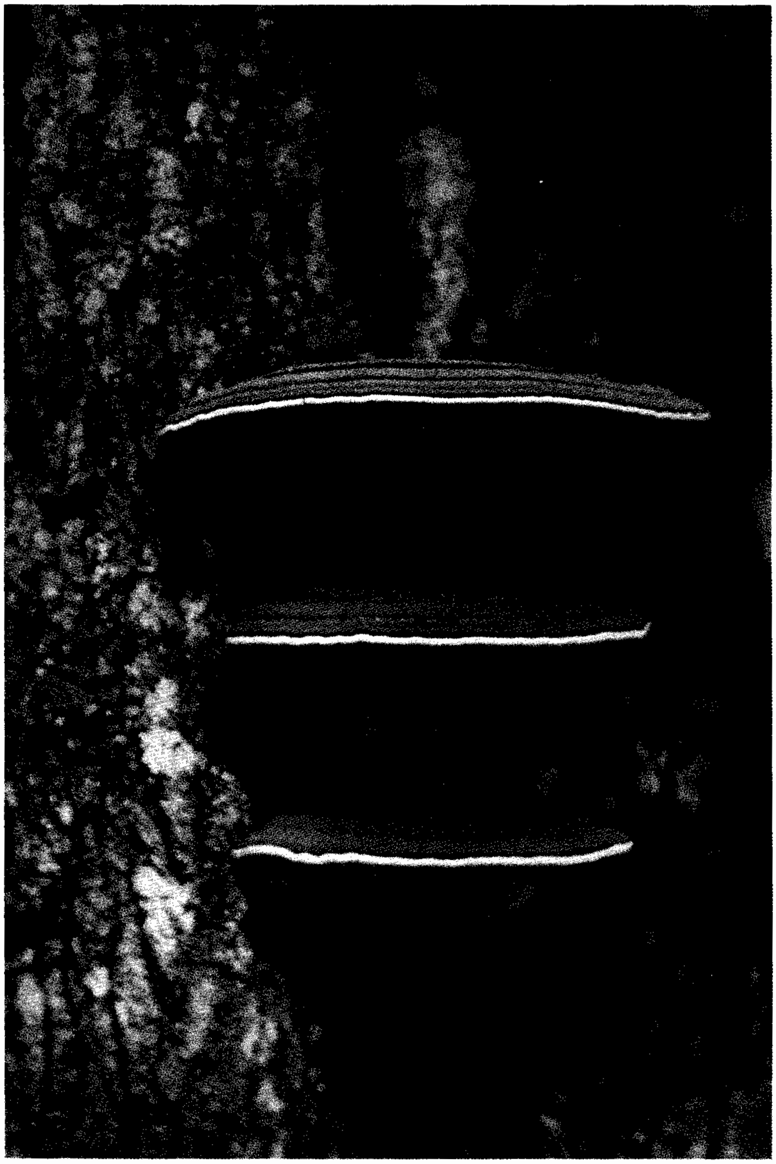

Abstract

Describes common fungal diseases of Russian forests, including diagnostic signs and symptoms, pathogen biology, damage caused by the disease, and methods of control. The fungal diseases are divided into two groups: those that are the most common in Russian forests and those that are found only in Russia. Within each group, diseases are subdivided by plant organ attacked, i.e. fruit, seeds, leaves, needles, roots, stems, and branches.

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Cover Photo

Basidiocarps of *Ganoderma applanatum* on the trunk of an aspen (*Populus tremula*).

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Introduction

Contacts in forestry between Russia and the United States range from programs that exchange information and/or scientists to those associated with bilateral economic relations. Forest products and raw materials routinely cross the borders of the two countries, and a variety of phytopathogenic microorganisms can accompany them. Accidental introductions of forest insects and diseases can be unpredictable and result in serious damage to forested ecosystems. In the United States, the devastation caused by epiphytotics such as Dutch elm disease and Endothia cankers of chestnut has been well documented. These pathogens were introduced to North America from Europe. Less well known is the damage caused by blister rust of cork pine (*Pinus strobus*) caused by *Cronartium ribicola* Ditr., which was transported across Russia on host-plants. Today, this disease affects many five-needle pine species (e.g., *P. sibirica* and *P. strobus*), including endemic species of pine.

This publication is part of an effort to determine whether there are differences between pathogenic microflora of Russian and U.S. forests. Accordingly, we present descriptions of the most common fungal diseases of forest plants in Russia, including pathogenic fungi that are found only in Russian forests. Because there was no list of pathogenic fungi that affect forest plants in Russia, we had to summarize data from numerous, albeit highly regarded, sources. Also, not all fungi are fully described because some species have not been investigated completely. Nor is the area of distribution for certain fungi precise, as many species have been reported only in a single publication. Still other fungi are scattered throughout Russia. Among the fungal species not found in the United States are dangerous pathogens that could pose a serious threat to U.S. forest ecosystems as well as species whose role in Russia is insignificant.

Although many of the major fungi of Russia described in this report are familiar to the American forestry community, U.S. scientists and research foresters can gain an awareness of the current situation in Russian forests (most research papers on fungal diseases of forest trees are not available to forestry groups outside of Russia). Because the distribution of some diseases differs in different countries, causes can range from resistance of host-plants and environmental peculiarities to intraspecific, strain diversity of fungi and their properties.

Most Common Fungal Diseases of Russian Forests

Diseases of Fruits and Seeds

Seed quality exerts considerable influence on the health of seedlings in both artificial and natural forest regeneration. Fungal diseases reduce the quality and yield of fruits and thus seedling production in different regions of Russia. Fruit and seed pathogens differ significantly with respect to virulence and host specialization, development characteristics, and symptoms. Some diseases that develop during the summer change the shape, color, structure, or size of seeds and fruits. They are easily recognized when the latter are harvested. In the case of seed infection that occurs after maturity and dispersal, it is impossible to determine external disease symptoms during harvest. As a result, diseased seeds that are stored with healthy ones can serve as the source of inoculum for infection of healthy seeds.

Fungal infection of fruits and seeds can be internal, damaging the embryo and cotyledons, or external on the seedcoat. In the latter case, the seeds are not infected but the superficial mycelium can infect the germinating seedling. Fungal diseases cause partial losses of fruits and seeds. Sometimes an entire crop is lost. Most of these diseases reduce a seed's ability to germinate. Some diseases reduce germination power during storage or cause heavy damage and seed loss on growing trees. Other diseases delay the growth and development of seedlings.

Birch Seed Mummification

Class/Order: Ascomycetes, Helotiales

Pathogen
Sclerotinia betulae Woron.

Hosts
Species of birch (*Betula*)

Diagnosis
Sclerotia form as a black, horseshoe-shaped rim on the boundary between the seed's achene and wing. Affected achenes are dark. Germinating sclerotia produce funnel-shaped apothecia 1-4 mm in diameter, with tiny stalks 3-15 mm long. The outside surface of the apothecia is brown and the base of the stalk is covered with dark-brown hairs. A dirty-white or brown-yellow asci layer (hymenium) forms on the inside surface of the apothecia. Asci are cylindrical, 130 x 5-6 μ. Ascospores are oval, colorless, with a verrucose cover, 10-12 x 4.5 μ.

Biology
During the flowering period in spring, ascospores mature in apothecia on autumn-infected seeds. Ascospores are windborne to catkins and infect young seeds. Mycelium penetrates the seed tissues and then the wing; sclerotia are formed here. Apothecia form on sclerotia the following spring. The disease occurs primarily in birch stands. Single trees and groups of birches growing in open areas are rarely affected significantly, an important factor when harvesting seeds.

Damage
Reduces germination power, sometimes reducing seedling yields by 90-100 percent

Distribution
European part of Russia, Urals, Siberia, Far East

Fruit Deformation

The form, color, and anatomical structure of fruits are affected. Seeds of affected fruits fail to develop or remain underdeveloped.

Class/Order: Ascomycetes, Taphrinales

Pathogen
Taphrina alni-incanae (Kuhn.) Magn.

Hosts
Species of alder *(Alnus),* including European *(A. glutinosa),* speckled *(A. incana),* and Manchurian *(A. hirsuta)*

Diagnosis
Flowers and seed scales of young fruits become elongate, about 2 cm long, and vary in form. Asci with ascospores develop on these deformed parts.

Damage
Reduces seed production

Distribution
European part of Russia, Urals, Siberia, Far East

♦♦♦

Pathogen
Taphrina johansonii Sad.

Hosts
Species of poplar (*Populus),* including gray *(P. canescens),* and Bolle's *(P. pyramidalis),* and European aspen *(P. tremula)*

Diagnosis
Seeds enlarge to several times normal size. A yellow-orange layer of asci forms on the surface of affected seeds. Every ascus has 8 spores, but sometimes ascospores form buds and fill the sac.

Damage
Reduces seed production

Distribution
European part of Russia, Urals, Siberia, Far East

♦♦♦

Pathogen
Taphrina rhisophorus Sad.

Host
White poplar (*Populus alba*)

Diagnosis
The seeds enlarge to several times normal size. A waxy, golden-yellow layer of asci with ascospores forms on the surface of affected seeds. Asci are elongate, clavate, thin on the base, 120-160 x 22 μ. Ascospores are globose, colorless, 4 μ.

Damage
Reduces seed production

Distribution
Middle and southern areas of European part of Russia, southwestern Siberia

♦♦♦

Pathogen
Taphrina pruni Fckl.

Hosts
Species of cherry (*Padus, Prunus*)

Diagnosis
The wall of the ovary enlarges but the embryo fails to develop, and an elongate, sac-like or pocket-like, hollow fruit develops. A waxy, gray layer of asci with ascospores forms on the surface of affected fruits. Asci are cylindrical, 40-60 x 8-15 μ.

Damage
Reduces seed production

Distribution
European part of Russia, Urals, Siberia, Far East

Fruit Spots

Spots occur primarily on seed wings of maple (*Acer*) and ash (*Fraxinus*), and on fruits of nut-bearing trees (*Juglans*). They rarely form on the seeds and fruits of other species. Some affect other plant organs, including leaves. Under favorable conditions for fungal development, these diseases can significantly reduce the germination power of seeds and infect germinating seeds and seedlings. The following are the most common spot diseases of seeds and fruits.

Class/Order: Deuteromycetes, Hyphomycetales

Pathogen
Cercospora acerina Hart.

Hosts
Species of maple (*Acer*)

Diagnosis
Dark-brown or dark-red, small, coalesced spots form on the seed wings. Clusters of conidiophores with conidia form on the spots. Conidia are reversely clavate, pointed on top, brown-olive, 45-180 x 5-8 μ.

Damage
Reduces germination power of seeds and kills leaves

Distribution
European part of Russia

♦♦♦

Pathogen
Heterosporium fraxini Ferd. et Winde.

Hosts
Species of ash (*Fraxinus*)

Diagnosis
Gray spots form on the seed wings. Conidiophores form on spots as small, black tufts. Conidia are elliptic-elongate, thorny, 2- or 4-celled, yellow, 5-6 x 1.7 μ.

Damage
Reduces germination power of seeds

Distribution
European part of Russia

Class/Order: Deuteromycetes, Melanconiales

Pathogen
Cylindrosporium platanoides (Allesch.) Died.

Host
Norway maple (*Acer platanoides*)

Diagnosis
Dark-brown, elongate spots form on the seed wings. Sporodochia form on the spots. Conidia are thread-like, 4-celled, pale green, 28-80 x 5-3 μ.

Damage
Reduces germination power of seeds and affects seedling leaves

Distribution
European part of Russia

♦♦♦

Pathogen
Gloeosporium fagi West.

Host
European beech (*Fagus sylvatica)*

Diagnosis
Circular or irregular, brown or green spots with dark borders and light centers form on the nuts. Sporodochia are brown and appear as concentric circles. Conidia are 1-celled, colorless. There are two types of conidia: macroconidia are oval or widely spindle-like, 10-16 x 4-5 μ; microconidia are elongate-oval, 4-6 x 1.5-2.0 μ.

Damage
Reduces germination power of seeds; seedlings are infected and killed

Distribution
Southeastern area of European part of Russia

♦♦♦

Pathogen
Marssonina juglandis (Lib.) P. Magn.

Host
Persian walnut (*Juglans regia*)

Diagnosis
Brown or gray-brown spots of various shapes and dimensions form on the fruits. Black, dotted, convex sporodochia form on the spots as concentric circles. There are two types of conidia: macroconidia are stick-like with one opaque septa 16-30x 3-4.5 μ; microconidia are stick-like, straight or slightly curved, 6-12 x 1-1.5 μ.

Damage
Immature fruits drop; leaves, petioles, and young shoots are infected.

Distribution
Southern area of European part of Russia

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Phyllosticta aceris Sacc.

Host
English field maple (*Acer campestre*)

Diagnosis
Small, round, yellow (later white) spots with a dark border form on seed wings. Pycnidia are globose, black, about 120 μ in diameter, and imbedded in wing tissue but later break through tissues. Conidia are egg-shaped, elongate, colorless, 5-7 x 2.5-3 μ.

Damage
Reduces germination power of seeds; leaves also are infected.

Distribution
European part of Russia

Pathogen
Phoma samarorum Desm.

Hosts
Species of maple (*Acer*)

Diagnosis
Pycnidia form on the surface of seed wings and are imbedded in the tissue. Pycnidia tops form on the wing as small, brown hillocks. Conidia are oval-elongate, colorless, 1-celled, 5-7 x 2-3 µ.

Damage
Immature seeds drop

Distribution
European part of Russia

Molds

Seed molds are caused by saprophytic fungi and rarely by facultative parasites. Seeds and fruits of nearly all tree and shrub species are affected. A characteristic external symptom of molds is superficial mycelium on infected tissues of seeds and fruits. Infection occurs during storage under high moisture conditions. Initially, the mycelium of mold fungi develops superficially and does not influence seed germination power. However, it can destroy the seedcoat and penetrate interior tissues. Infection of interior tissue reduces germination power and often destroys the embryo. Affected seeds rot and are useless for sowing.

Class/Order: Deuteromycetes, Hyphomycetales

Pathogen
Penicillium expansum (Link.) Thom., and *P. italicum* Pers.

Hosts
Primarily species of birch (*Betula*), oak (*Quercus*), beech (*Fagus*), and chestnut (*Castanea sativa*)

Diagnosis
Bright-brown or red, sharply outlined, and gradually coalesced spots form on the surface of seeds. Green or blue powdery mycelium forms on the spots. The seed tissue becomes friable and brown. Conidiophores form coremia. The upper part of the coremia resembles a brush. Conidia are elliptical, green, connected in chains, 3 x 3.4 µ.

Damage
Reduces germination power and kills seeds

Distribution
Throughout Russia

♦♦♦

Pathogen
Trichothecium roseum Link.

Hosts
Primarily species of maple (*Acer*), birch (*Betula*), ash (*Fraxinus*), oak (*Quercus*), spruce (*Picea*), pine (*Pinus*), and larch (*Larix*)

Diagnosis
Dark-brown or nearly black, sharply outlined spots form on the surface of infected seeds. Pink (rosy) powdery mycelium with conidia develops on the spots. Conidia are pear-like, 2-celled, 12-18 x 8-10 µ.

Damage
Reduces germination power

Distribution
Throughout Russia

♦♦♦

Pathogen
Fusarium *spp.*

Hosts
Primarily species of fir (*Abies*), larch (*Larix*), spruce (*Picea*), pine (*Pinus*), and oak (*Quercus*)

Diagnosis
Rosy or crimson mycelium forms on the seed surface. Infected tissues of pulpy seeds tum red. The embryo can die. There are two types of conidia: microconidia are oval, cylindrical-oval or ellipsoid, usually 1-celled, sometimes 2-celled, colorless, numerous, 4-12 x 3-8 μ; macroconidia are multicelled, fusiform and slightly curved, 10-60 x 2-5 μ.

Damage
Reduces germination power and causes seed and seedling rot and damping-off

Distribution
Throughout Russia

♦♦♦

Pathogen
Botrytis cinerea Pers.

Hosts
Primarily species of fir (*Abies*), larch (*Larix*), spruce (*Picea*), pine (*Pinus*), elm (*Ulmus*), rose (*Rosa*), oak (*Quercus*), and chestnut (*Castanea)*

Diagnosis
A thin, downy, dark-gray web of mycelium that consists of hyphae and conidiophores forms on the seeds. Seeds eventually decay, and compact black sclerotia form on them. The conidiophores produce clusters of conidia which are egg-shaped or round, 1-celled, colorless or smoky, 9-12 x 5-10 μ.

Damage
Reduces germination power and causes seed and seedling rot and damping-off

Distribution
Throughout Russia

♦♦♦

Pathogen
Alternaria tenuis Nees.

Hosts
Primarily species of fir (*Abies*), larch (*Larix*), spruce (*Picea*), pine (*Pinus*), birch (*Betula*), elm (*Ulmus*), oak (*Quercus*), chestnut (*Castanea*), and Siberian pear tree (*Caragana arborescens*)

Diagnosis
A dark-brown or olive-black thin mycelium and conidia form on seeds and fruits. Conidia are single or connected in clusters or chains, reversely clavate, with 1-9 transverse septa and 1 or more longitudinal septa, and dark-olive or olive-brown, 7-130 x 6-22.5 μ.

Damage
Reduces germination power and causes seed and seedling rot and damping-off

Distribution
Throughout Russia

♦♦♦

Pathogen
Cladosporium herbarum Link.

Hosts
Primarily species of fir (*Abies*), spruce (*Picea*), pine (*Pinus*), oak (*Quercus*), and ash (*Fraxinus*)

Diagnosis
A dark-olive, velvety, turf-like mycelial web forms on seeds and fruits. Conidiophores are single or in clusters, with septa. Egg-shaped or elliptical conidia are 1-celled; cylindrical conidia are 2- or 3-celled, olive-brown, 12-28 x 6-7 μ.

Damage
Reduces germination power of seeds and causes mold of needles and leaves

Distribution
Throughout Russia

♦♦♦

Pathogen
Aspergillus niger Link.

Hosts
Primarily species of beech (*Fagus*), oak (*Quercus*), spruce (*Picea*), and pine (*Pinus*)

Diagnosis
Round spots with a black, turf-like mycelial web form on seeds and fruits. Conidiophores are numerous, straight, brown. Conidial heads are round, 20-50 μ in diameter. Conidia are oval, 1-celled, olive-brown, 2.5-5 μ, connected in chains.

Damage
Reduces germination power

Distribution
Throughout Russia

Class/Order: Zygomycetes, Mucorales

Pathogen
Mucor spp.

Hosts
Species of oak (*Quercus*), beech (*Fagus*), and Persian walnut (*Juglans regia*)

Diagnosis
Gray or gray-white, downy mycelium forms on seeds and fruits. The surface of mycelium is covered with distinct, dark-brown, spherical sporangia heads.

Damage
Delays seed germination

Distribution
Throughout Russia

♦♦♦

Pathogen
Rhizopus nigricans Ehr.

Hosts
Primarily species of oak (*Quercus*), apple (*Malus*), mulberry,(*Morus alba*), blackberry *(Rubus),* and Persian walnut *(Juglans regia)*

Diagnosis
White or gray, downy, mycelium forms on seeds and fruits. Numerous bead-like black sporangia form on the mycelium. Spores are ellipsoid, angular, dark, 8-14 x 6-11 μ.

Damage
Delays seed germination

Distribution
Throughout Russia

♦ ♦ ♦

Pathogen
Thamnidium elegans Link.

Hosts
Primarily Siberian pea tree *(Caragana arborescens)*, spindle tree (*Euonymus*), elderberry (*Sambucus)*, lime (*Tilia*), and honeysuckle (*Lonicera*)

Diagnosis
Sparse, white, yellow, or gray mycelium forms on seeds and fruits. Sporangia are spherical, with a colorless cover. Spores are colorless, elliptical, 8-10 x 6-8 μ.

Damage
Delays seed germination

Distribution
Throughout Russia

Seed and Fruit Rots

The rots most often damage fruits with excess moisture and nutrients. They distort seeds and fruit tissue structure and later decompose the tissue. Seed and fruit infection occurs during their harvest, transport, and especially, storage under high moisture and poor ventilation conditions.

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Phomopsis quercella (Sacc.) Died.

Hosts
Species of oak (*Quercus*)

Diagnosis
Dark, initially gray, spots form on cotyledon surfaces. Later, the spots enlarge and spread over the entire cotyledon. In high humidity, luxurious white pellicles develop on the cotyledons. Black pycnidia, 1.5 mm in diameter, develop within the mycelial mat. The seedcoat becomes erumpent and then bursts. Mature pycnidia produce orange conidial masses. There are two kinds of conidia: fusiform, with sharp ends and 2 oil drops, colorless, 7-11 x 1.5 -2 μ, and thread-like, curved, hook-like, colorless, 22-66 x 0.2-0.7 μ.

Damage
Kills acorns in storage and withers germinating seedlings.

Distribution
European part of Russia, southern Urals, Far East

♦ ♦ ♦

Pathogen
Cytospora intermedia Sacc.

Hosts
Species of oak (*Quercus*)

Diagnosis
Dark-brown, sharply outlined spots with white pellicles form on cotyledons. Later, the pellicles turn dark, enlarge, and cover the entire cotyledon. Black stromata with pycnidia form on the mycelium and

arise on the surfaces of acorns through cracks in the seedcoat. Pycnidia produce horn-like conidial masses. Conidia are cylindrical, slightly curved, colorless, 1-celled, 5-6 x 1.5 μ.

Damage
Reduces germination power and causes seedling mortality.

Distribution
European part of Russia, southern Urals, Far East

Control
Observation
- Monitor seed production plantations for appearance and distribution of seed and fruit disease to determine species, levels of damage, and dynamics of disease development.
- Collect and analyze seeds and fruits twice a year according to periods of pathogen development.
- Inspect seeds and fruits before sowing, check for fungal or bacterial infection, and apply seed treatments.

Cultural
- Harvest seeds and fruits only from special seed plantations to maintain healthy seeds with high genetic and germination qualities.
- Select quality healthy stands for seed plantations to maintain tree species ecotypes and forms that are the most resistant to diseases and abiotic factors.
- Avoid seed and fruit injury during harvest, transport, extraction, and storage of seeds.
- Store seeds and fruit at optimal temperature, moisture, and ventilation conditions.

Chemical
- Disinfect instruments and scales before and after every seedlot harvest.
- Disinfect storage areas with sulfur fumigation before storing new harvests of seeds and fruits.
- Use specific chemicals for specific diseases.

Class/Order: Deuteromycetes, Melanconiales

Pathogen
Gloeosporium quercinum West.

Hosts
Species of oak (*Quercus*)

Diagnosis
Gray-brown, dark-brown or nearly black, irregularly shaped, sharply outlined spots form on cotyledons. The spots become thicker and enlarged. Affected cotyledons are covered by black spots and become dry. Under humid conditions, yellow pellicles form on affected parts of acorns. Small yellow-brown cushion-like sporodochia develop on them in concentric circles. The conidial mass is white and slimy. There are two kinds of conidia: elongate-oval, colorless, 8-17 x 3.5-7.5 μ, and cylindrical or wedge-like, colorless, 4-8 x 1.5-2 μ.

Damage
Reduces acorn germination power and causes leaf spot

Distribution
European part of Russia, southern Urals, Far East

Class/Order: Basidiomycetes, Aphyllophorales

Pathogen
Schizophyllum commune Fr.

Hosts
Species of oak (*Quercus*)

Contents

Diagnosis
Brown spots covered by compact, yellow mycelium form on cotyledons. The seedcoat bursts from mycelial growth and fungal fruiting bodies form that have a lateral stalk, a pale-gray, wavy surface, and a pale-brown, gill-bearing hymenophore. The tissues of affected acorns are destroyed.

Damage
Reduces germination power

Distribution
European part of Russia, southern Urals, Far East

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Pathogen
Stereum hirsutum (Willd: Fr) S.F. Gray

Hosts
Species of oak (*Quercus*)

Diagnosis
Cotyledons turn brown and lose their structure. Yellow, chamois-like pellicles develop between the seedcoat and cotyledon surface. Fruiting bodies form on the outer seed surface as thin, hairy, leather-like pileuses with a gray upper part and a smooth, yellow hymenophore.

Damage
Reduces germination power

Distribution
European part of Russia, southern Urals, Far East

Class/Order: Ascomycetes, Microascales

Pathogen
Ceratocystis roboris Georg. et Teod. and *C. valachicum* Georg. et Teod.

Hosts
Species of oak (*Quercus*)

Diagnosis
Black spots develop near the base of acorns; cotyledons become soft and the outer seedcoat turns black. Conidia form, more often in coremia, on affected acorns. Perithecia develop after the acorns die. Perithecia are pear-like, black, with long necks.

Damage
Reduces germination power and withers seedlings

Distribution
Southern area of European part of Russia

Diseases of Needles and Leaves

Needle Diseases

Lophodermium Needle Casts

Class/Order: Ascomycetes, Phacidales

Pathogen
Lophodermium seditiosum Mint., Stal., et Mill. and L. *pinastri* Chev.

Hosts
Primarily species of pine, including Scots (*P. sylvestris*), white *(P. strobus)*, jack *(P. banksiana)*, Siberian *(P. sibirica)*, and mountain *(P. pumila)*

Diagnosis

The first symptoms of *L. seditiosum* infection appear in late October and early November. Yellow spots form on infected parts of needles, usually in the lower part of the crown in early stages of disease development. The first external symptoms of disease in seedling nurseries are found 3-9 days after snowmelt. Infected needles die and turn red-brown (**Fig. 1**). Lophodermium needle casts usually have uniform distribution over the forest areas. On a single tree, the disease spreads from bottom to top. Killed needles on 1-year-old plants remain attached to the stem for a year before they are cast. Damaged needles of 3-year-old plants usually are cast during the first growing season. Pycnidia develop on diseased needles from mid-April until mid-May. Apothecia are formed in June-July.

Pycnidia on single needles are oval-elongate, but on twin needles are round to elongate and are 300-500 μ, often linked. Conidia are 1-celled, colorless, cylindrical, 6-8 μ. Apothecia that develop beneath the epidermal layer are gray, often connected, elongate, sharpened. Apothecia are 901-1281 x 435-554 μ. They open longitudinally during maturation; the color of the split margins is blue-gray or dirty-green. Epidermal cells are absent under the base of apothecia when viewed on a transverse cutting. Transverse lines on the needles are absent or rare. Asci are colorless and wide, 126-184 x 11-14 μ. Ascospores are thread-like, 90-115 x 3 μ.

The first visible symptoms of *L. pinastri* infection of pine seedlings appear usually in May, approximately 1 month after snowmelt during storage of seedlings in the heeling beds or soon after seedling planting. Needles die and turn red in the lower part of plants. Pycnidia form on affected needles in June and July or are absent. As a rule, fruit bodies form only on cast needles. Transverse lines on the needles develop usually at the end of summer or beginning of the next year after infection, shortly before apothecia develop. Transverse lines and apothecia do not form on needles of growing seedlings.

Pycnidia are dark-gray or black, round, 300-400 μ. When mature, they open as a longitudinal split; conidia are 1-celled, colorless, cylindrical, 4.5 x 6.25 μ. The base of apothecia is immersed in the epidermis; apothecia are black, oval or ellipse-elongate, 825-1099 x 432-563 μ. Fruit bodies open during maturation as longitudinal splits. The split margins are red- or dark-brown. There are usually 5 or more epidermal cells under the base of the apothecium on transverse cutting. Transverse lines on needles (especially paired) are black, numerous, and distinct. Asci are colorless, wide, 90-148 x 10-12 μ. Ascospores are thread-like, 90-115 x 3 μ.

Figure 1.—Pine (*Pinus sibirica*) needles affected by *Lophodermium seditiosum.*

Biology
Lophodermium needle casts of seedlings in nurseries and green-houses, saplings, understory trees, and forest plantations less than 5 years old are caused primarily by *L. seditiosum.* Occasionally, *L. pinastri* is found on seedlings in nurseries and greenhouses. Understory trees and forest plantations 6-14 years old are damaged by both species of fungi at the same time. Pines more than 15 years old are infected only by *L. pinastri.*

Sources of *L. seditiosum* inoculum are diseased plants in nurseries, pine plantations, and understory trees. Both healthy and weak plants are affected. Ascospores mature and spread in June and July. Needle penetration occurs from late July to late September or early October. Intensity of disease development depends on the quantity of precipitation from June to August and air temperature during July and August; however, moisture is the primary factor in disease development.

Pine plantations and understory 15 years old and older are the sources of *L. pinastri* inoculum. Apothecia form on dead needles on the ground during the year after they drop. The most active period for ascospore release and needle penetration is July and August, but these can occur in May. Seedlings subjected to infection may have been weakened by unfavorable growing conditions, infection by other diseases, and mechanical injuries.

Damage
Nursery seedlings and forest plantations less than 5 years old sustain the greatest damage. Damage to pine seedlings in Russian nurseries ranges from 30-100 percent. Needle casts reduce productivity of pine plantations as well as the health of standard planting material in the nursery.

Distribution
Throughout Russia

Control
Observation
Survey for the appearance and distribution of disease in spring just after snowmelt and again during the second half of summer and early autumn.

Cultural
- Choose location of new nurseries carefully, e.g., at least 200 m from existing pine forests or plantations.
- Rotate pine with other conifers in nursery beds at intervals of 2 years or more.
- Select seed sources from resistant plantations.
- Use appropriate and agrotechnical methods for establishing and maintaining seedlings.

Chemical
- Protect 1-3-year-old seedlings with systemic fungicides (BAYMEB, Benomyl, Bavistin, Daconil, Benlate, Topsin M) or protective fungicides (Zineb, sulphur).

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Pathogen
Lophodermium macrosporum (Hart.) Rehm.

Host
Norway spruce (*Picea abies*)

Diagnosis
Needles on previous-year shoots turn brown in May. Long, black apothecia form on lower surface of needles during summer. Asci are mace-shaped, 100 x 15-21 μ.

Damage
Weakens and can kill seedlings in understory and forest plantations

Distribution
European part of Russia, Urals, Siberia

Pathogen
Lophodermium juniperinum (Fr.) De Not.

Host
Ground cedar (*Juniperus communis*)

Diagnosis
Previous-year needles turn yellow or red-brown at the beginning of summer (**Fig. 2**). Prominent, black apothecia about 2 mm long form on the upper surface of needles in midsummer. Asci are mace-shaped, wide, 70-90 x 9-12 μ. Ascospores are thread-like, colorless, 65-75 x 1-2 μ.

Damage
Weakens trees and sometimes causes dieback

Distribution
European part of Russia, Urals

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Pathogen
Lophodermium nervisequium (D.C.) Rehm.

Hosts
Species of fir (*Abies*), including Nordmann (*A. nordmanniana*), silver (*A. alba*), and Siberian (*A. sibirica*).

Figure 2.—Ground cedar (*Juniperus communis*) affected by *Lophodermium juniperinum*.

Diagnosis
Needles turn brown at the end of summer. Pycnidia form on the lower surface of needles as tiny black marks. Elliptical black apothecia, 1-1.5 mm long, form in needles later. Asci are mace-shaped, 70-100 x 15-20 μ. Ascospores are oblong-clavate, slightly curved, colorless, 1-celled, 50-60 x 2-2.5 μ.

Damage
Weakens trees in young stands and can cause partial dieback

Distribution
Southeastern area of European part of Russia, Urals, Siberia

Snow Blight

Pathogen
Phacidium infestans Karst.

Hosts
Scotch pine (*Pinus sylvestris*), Siberian stone pine (*P. sibirica*), mountain pine (*P. pumila*), Norway spruce (*Picea abies*), Siberian black spruce (*P. obovata*), and ground cedar (*Juniperus communis*)

Diagnosis
The first symptoms of disease appear in January when temperature inside the snow layer ranges from 0-5°C. The foliage is pale-green, and an ephemeral and cobwebby mycelium forms on the needles at this time. In February, needles have a marbled appearance with specific alternation of green, yellow, and brown spots. Active development of exterior mycelium begins in March when the temperature inside the snow layer reaches to +0.5°C. Needles beneath the snow are killed.

Mycelium spreads from diseased needles and during the period of snowmelt develops into white and gray pellicles, which are important diagnostic features. The pellicles are short-lived and only dirty-white pieces of mycelium remain on the seedlings and soil. Diseased needles die during the first several days after snowmelt and become bright-red or orange. At this time groups of infected seedlings are clearly noticeable in comparison with the green color of healthy plants. Soon after snowmelt, diseased needle color lightens and primordia of apothecia develop on them. The apothecia are small, dark blurred spots. During summer, infected needles become gray, and apothecia resemble dark hillocks. At the beginning of autumn, needles turn a distinct ashy color. Fragile apothecia open and burst through the needle epidermis, forming star-shaped openings. The gray-pink round hymenial layer is visible at this time. Asci are widely clavate with a distinct thick cover and they contain ellipsoid, rarely egg-shaped ascospores. Asci are 72-140 x 12-25 μ; spores are 11-28 x 5-9 μ.

Biology
Ascospores mature and spread after the apothecia open. The most active period occurs under warm, moist conditions after heavy precipitation and higher than mean annual air temperature. Spore dispersal usually is from late September through October. Major spore dissemination occurs in mid-October. The most favorable conditions for this process and needle infection are periods of snow followed by snow melt. Spore spread ends before permanent snow cover is established. Typical mid-October weather patterns, alternating rain and snowfall, result in heavy precipitation and high humidity. Spore loading on the needles is well established when snow cover is permanent. Ascospores germinate on and penetrate needles. Fungal development inside leaf tissue begins after snow cover is established. The most important factor in this process is the temperature under the snow cover. Conditions for pathogen development are most favorable when high snow cover lies on unfrozen soil that remains slushy during the winter and the temperature inside the snow layer is 0° and above.

The saprophytic phase of fungus development begins after snowmelt and continues through the vegetative growth period. Fungal fruit bodies form and mature throughout the year. The parasitic phase of the fungus begins with apothecia opening and continues up to snowmelt. In Russia, depending on climate conditions, there are three types of fungal development during the parasitic phase: European, Siberian, and Intermediate. In the European type, the spores spread in autumn and disease develops during the winter. The European type develops in regions with wet autumns, relatively mild winters, and high snow cover. With the Siberian type, sporulation, penetration, and infection of healthy needles occur simultaneously in the snow layer cavities and in the snow "greenhouses" that have relatively high humidity and temperature during spring snowmelt. The

Figure 3.—Pine (*Pinus sylvestris*) understory in cutting area showing symptoms of snow blight (*Phacidium infestans*).

Siberian type occurs under conditions of continental climate with cold dry autumns, harsh winters, and warm springs. The Intermediate type is similar to the other types depending on weather changes.

Damage
Damages seedlings in nurseries, forest plantations, and pine understory. Snow blight is most prevalent on planted and natural seedlings, and on pine plantation understory during winters with a deep snow layer. Annual mortality of nursery seedlings ranges from 25-40 percent. Snow blight also hinders successful artificial regeneration in clearcut areas where annual mortality ranges from 50-60 percent (**Fig. 3**).

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Observation
- Survey for snow-blight loci during the first 2 - 3 days after snowmelt; mycelial patches are visible at this time; repeat observations in September-October.

Prevention and Cultural
- Establish new tree nurseries at least 200 meters from adjacent forest stands and plantations.
- During spring, collect and burn all diseased seedlings.
- Do not use snow blight-infected seedlings for reforestation.

Chemical
- In nurseries and pine plantations, apply protective fungicides (colloid sulfur) and systemic fungicides (Benomyl, Benlate, Daconil, Bavistin, Derosal, BAYMEB).

Meria Needle Blight

Class/Order: Deuteromycetes, Hyphomycetales

Pathogen
Meria laricis Vuill.

Hosts
Species of larch (*Larix*), including European or common (*L. decidua*), Siberian (*L. sibirica*), Sukachev (*L. sukaczewii*), and Dahurian (*L. dahurica*)

Diagnosis
The first symptoms of infection occur 10-14 days after new needles emerge. Small brown spots develop on the upper surface of the needle and enlarge to include the entire needle. Damaged needles are red-brown and slightly twisted (**Fig. 4**). At this time, the pathogen produces colorless conidia in clusters along stomata lines on the lower surface of the needle. Conidia develop on conidiophores that emerge from stomata, and spore clusters appear as sand on the needle.

Biology
Mycelium of the pathogen overwinters in cast needles, which are the source of infection in spring. Damage is most prominent on seedlings growing in one location for 2 years. The disease spreads and kills needles in the lower, middle, and finally upper part of the plants. The time between conidia penetration into needles and new spore formation is 10-14 days.

Disease development depends on the summer weather. Temperature does not significantly influence pathogen development; mycelium growth occurs at 5°-30°C; the optimum temperature is 18°-20°C. Intensity of spore dispersal depends on moisture or quantity of precipitation; dry weather suppresses disease development while damp weather during the first part of the growth period favors the disease.

Control
Observation
- Survey for disease appearance and spread within 10-14 days after needles have expanded; repeat observations in midsummer.

Cultural
- Establish new nurseries at least 100 m from forest stands or plantations.
- Establish current-year seedling beds some distance from beds where seedlings from previous years are growing.
- Collect and burn cast damaged needles in autumn and early spring to remove potential sources of overwintering fungus.

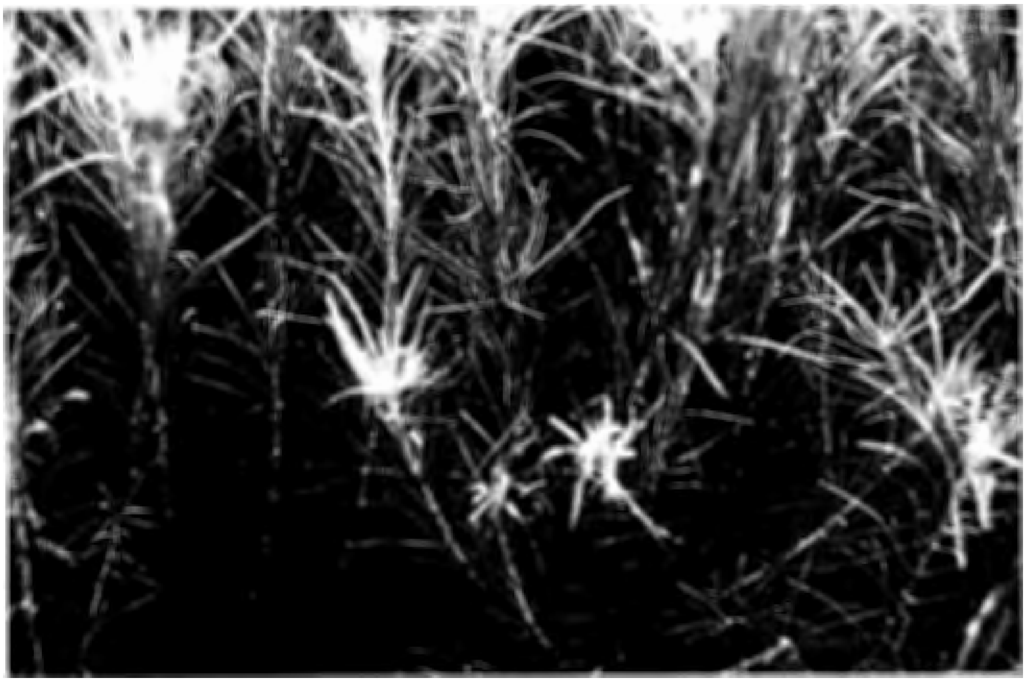

Figure 4.—Current-year larch (*Larix decidua*) seedlings affected by larch needle cast (*Meria laricis*).

• Use greenhouses to protect seedlings from primary infection.

Chemical
• Apply fungicides to fallen needles (e.g., colloid sulfur) to exterminate the inoculum source.
• Apply preventive fungicides on foliage of seedlings and young plantations during the growing season.
• Use systemic fungicides (BAYMEB, Topsin M, Daconil, Bavistin, and Derosal) and protective fungicides (colloid sulfur, Zineb, Poliram, Policarbacin, Metiram).

Brown Felt Blight

Class/Order: Ascomycetes, Sphaeriales

Pathogen
Herpotrichia juniperi (Duby) Petr.

Hosts
Species of pine (*Pinus*), spruce (*Picea*), fir (*Abies*), and cedar (*Juniperus*)

Diagnosis
Needles are encased in thick, dark-brown mycelium after snowmelt. Felt-like mats of mycelium overgrow needles and twigs (**Fig. 5**). Felts develop while branches are beneath the snow. Perithecia are formed at the beginning of autumn. They are nearly globose or pear-shaped, 200-300 µ in diameter, and covered with long brown hairs at the base. Asci are elongate, 72-100 x 10-12 µ. Ascospores are spindle-shaped, colorless, 1- to 4-celled, 15-30 x 6-12 µ.

Damage
Kills seedlings in nurseries, weakens understory in forest plantations, and promotes branch breakage by snow

Distribution
Northwestern area of European part of Russia, middle Urals, Siberia

Rhizosphaera Needle Casts

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Rhizosphaera pini (Corda.) Maubl.

Hosts
Species of fir (*Abies*), including Nordmann (*A. nordmanniana*), silver (*A. alba*), and Siberian (*A. sibirica*)

Diagnosis
Single yellow spots develop on infected needles, which turn brown by the end of summer (**Fig. 6**). Pycnidia chains develop on infected needles along the midrib, appearing as minute black spheres about 100 µ in diameter. Conidia are egg-shaped, colorless, 1-celled, 16-23 x 7.5 µ.

Damage
Weakens and can kill young trees and fir plantations under forest canopy

Distribution
Southeastern area of European part of Russia, Urals, Siberia

♦ ♦ ♦

Pathogen
Rhizosphaera kalkhoffii Bubak.

Host
Norway spruce (*Picea abies*)

Figure 5.—Fir (*Abies sibirica*) understory tree affected by *Herpotrichia juniperi.*

Diagnosis
Yellow spots on 1-year-old needles develop in summer or autumn. Spots merge gradually. Infected needles turn brown. After overwintering, round, black pycnidia, 80-150 μ in diameter, form on lower surfaces of needles. Conidia are oval, colorless, 1-celled, 7-10 x 3-5 μ.

Damage
Causes weakening and dieback of seedlings and young plantations

Distribution
Northwestern area of European part of Russia

Control
- Control is required in nurseries and plantations only in cases of significant injury.

Cultural
- Cull and burn infected plants in nurseries and plantations in the spring.
- Remove forest logging residues (near nurseries and plantations) that may serve as a source of inoculum.

Chemical
- Protect nurseries and plantations with Bordeaux mixture.

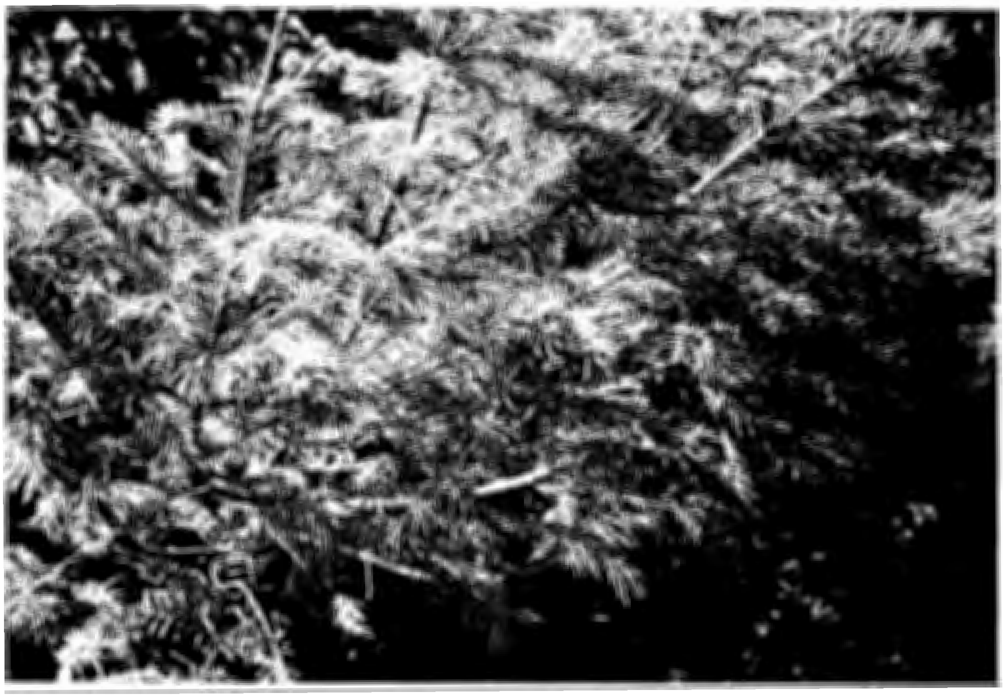

Figure 6.—Fir (*Abies sibirica*) needles affected by *Rhizosphaera pini*.

Needle Rusts of Pine

Class/Order: Basidiomycetes, Uredinales

Pathogen
Coleosporium spp.

Hosts
Species of pine (*Pinus*), including Scots *(P. sylvestris),* Swiss mountain *(P. montana),* and Austrian *(P. nigra)*

Diagnosis
Aecia develop on the needles in late spring or beginning of summer. Aecia form as lines on the both sides of needles. Aecial blisters are orange, later white, about 3 mm long. Aeciospores, connected inside aecia like chains, are orange, oval or elongate, with thorny spore walls, 16-26 x 26-57 μ. After aeciospore dispersion, aecia covers remain on needles for some time but eventually disappear, leaving brown spots on the needles.

Biology
The pathogen is a macrocyclic rust. In summer, aeciospores are produced within aecia on needles. Aeciospores infect the leaves of alternate hosts, primarily herbaceous plants such as *Tussilago farfara*, *Senecio nemorensis, S. jacaea, Sonchus arvensis*, and species from the genus *Inula*. The uredinial stage develops in yellow pustules during summer on leaves of these plants. Urediniospores from the pustules cause repeating cycles of infection on leaves of the same herbaceous species. The telial stage develops on the same leaves and telia overwinter on the dead leaves. Teliospores germinate in the spring, producing basidia with basidiospores that infect needles. Infection is heaviest on well-lighted portions of the crown and in warmer areas within stands.

Damage
Weakens plant and causes growth loss

Distribution
European part of Russia, Urals, Siberia, Far East

Control

Prevention

- Remove alternate host plants.

Chemical

- Apply Bordeaux mixture to foliage.

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Pathogen

Chrysomyxa ledi (Alb. et Schw.) de Bary.

Hosts

Norway spruce *(Picea abies)* and Siberian black spruce *(P. obovata)*

Diagnosis

Aecia develop on the lower surface of needles as 2 lines. They are orange, blister-like, and no more than 2 mm long and 3 mm high (**Fig. 7**). Aeciospores are elliptical, yellow, 19-30 x 15-21 μ.

Biology

Aecia produce chains of aeciospores that are disseminated by wind and infect leaves of the alternate host, *Ledum palustre*. The uredinial and telial stages develop on the leaves of *L. palustre*. Telia overwinter and germinate in the spring, producing basidia with basidiospores that infect needles. The rate of infection increases in stands where crowns are open and well insolated e.g., low-density stands or along forest edges and roads.

Damage

Affects spruce needles in young and mature stands and can cause massive needle loss, resulting in weakening and death of understory trees. Needle damage can reach 100 percent in an epiphytotic year.

Distribution

Northwestern area of European part of Russia, Urals, Siberia, Far East

Control

- Application of Bordeaux mixture is recommended in nurseries when seedling infection is heavy.

Figure 7.—Needle rust of spruce (*Picea abies*) caused by *Chrysomyxa ledi*.

Powdery Mildews

Class/Order: Ascomycetes/Erysiphales

Many deciduous trees and shrubs are affected. The most common powdery mildews and hosts in Russia are listed in Table 1.

Diagnosis
The primary symptom of infection is the formation in late spring and early summer of a powdery growth on the upper surfaces of leaves or other tender plant parts **(Fig. 8).** The powdery growth is white, gray, or brown, and consists of superficial mycelium and conidial sporulation. Appearance

Table 1.—Species of fungi causing powdery mildew, their hosts, and distribution of disease occurrence

Pathogen	Hosts	Distribution
Microsphaera alphitoides Griff. et Maubl.	*Quercus*	European part of Russia, Urals, Siberia, Far East
M. betulae Magn.	*Betula*	European part of Russia, Urals, Siberia, Far East
M. berberidis Lev.	*Berberis*	European part of Russia
M. penicillata (Wallr.) Lev.	*Alnus, Rhamnus, Syringa, Viburnum*	European part of Russia
M. lonicera Wint.	*Lonicera*	European part of Russia, Southern and Middle Urals, Far East
M. syringae (Schwein.)Magnus	*Syringa*	European part of Russia
M. vanbruntiana Gerard.	*Sambucus*	European part of Russia, Urals, Siberia, Far East
M. viburni (Duby) Blum.	*Viburnum*	European part of Russia
M. grossulariae (Wallr.) Lev.	*Ribes*	European part of Russia
Uncinula aceris Sacc.	*Acer*	European part of Russia, Southern and Middle Urals, Siberia, Far East
U. salicis Wint.	*Populus, Salix*	European part of Russia, Urals, Siberia, Far East
U. fraxini Miyake	*Fraxinus*	Far East
U. clandestina Schroet.	*Ulmus*	European part of Russia, Far East
Phyllactinia suffulta (Rabh.) Sacc.	*Alnus, Betulae, Corylus, Fraxinus, Sorbus, Fagus, Ulmus*	European part of Russia, Urals, Siberia, Far East
Podosphaera oxyacanthae de Bary	*Crataegus, Padus, Sorbus*	European part of Russia, Urals, Siberia, Far East
Trichocladia caraganae Magn.	*Caragana arborescens*	European part of Russia
T. euonymi Neger.	*Euonymus*	European part of Russia, Urals
Sphaerotheca pannosa (Wallr.) Lev	*Rosa*	European part of Russia, Urals, Far East

Figure 8.—Floodplain oak stands (*Quercus robur*) affected by *Microsphaera alphitoides.*

differs considerably with the pathogen species. It can be inconspicuous and cobwebby, well-developed and mealy, compact and wadding-like, or felt-like. In late summer, numerous cleistothecia are produced on or in the mycelial mat. They are yellow-brown or black spheres with special appendages that differ in position, form, structure, and length depending on the fungal species. This is a diagnostic feature. The number of asci that develop in the cleistothecia also depends on the pathogen.

Biology
As obligate parasitic fungi, some species are restricted to certain plant species, e.g., *Microsphaera alphitoides,* and *M. palczenskii*, while others can infect plants from different botanical families, e.g., *Phyllactinia suffulta,* and *Podosphaera oxyacanthae* (Table 1). Species from the genera *Microsphaera, Phyllactinia, Podosphaera,* and *Uncinula* are sensitive to humidity but tolerate a wide range of temperatures.

Damage
In forest nurseries, these diseases cause premature defoliation and weaken seedlings. Affected seedlings become misshapen and are not used for standard planting material. Both plant growth in young plantations and plantation productivity are reduced, as are the decorative and protective properties of trees and shrubs in urban settings.

Control
Cultural
- Sow seeds in nurseries as early as possible.
- Eliminate stump sprouts (source of inoculum) near nurseries.
- Fertilize (NPK complex), especially with phosphorus, to speed leaf maturation and shorten the period of disease susceptibility.
- Create plantations of mixed tree species to reduce disease spread.

Chemical
- Apply BAYMEB and colloid sulfur.

Leaf Spots

Class/Order: Ascomycetes, Phacidiales

Pathogen
Rhytisma acerinum (Pers.) Fr. (anamorph: *Melasmia acerina* Zev.)

Hosts
Species of maple (*Acer*)

Diagnosis
Spots develop on leaves in summer. The infected tissue turns yellow and numerous small, black stromata develop within the spots on upper leaf surfaces. Large convex, black, shiny, stromata coalesce with small ones within the spot. Stromata are surrounded by yellow-green margins. Conidia are produced on the stromata. After overwintering, apothecia develop in the stromata and asci with ascospores mature during the summer. Asci are mace-shaped on a pedicle, 120-130 x 9-10 μ. Ascospores are sticky, thread-like, 52 x 80 x 1.5-3 μ.

Distribution
European part of Russia, Urals, Far East

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Pathogen
Rhytisma punctatum (Pers.) Fr. (anamorph: *Melasmia punctata* Sacc.)

Hosts
Species of maple (*Acer*)

Diagnosis
Small, yellow spots develop on leaves in summer, and conidophores and spores develop on them. Later, small, dotted, shiny stromata develop within the spots. Apothecia form within the stroma. Asci are wide, 120-130 x 9-10 μ. Ascospores are thread-like, colorless, 60-80 x 1.5-3 μ.

Distribution
European part of Russia, Urals, Far East

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Pathogen
Rhytisma salicinum (Pers.) Fr. (anamorph: *Melasmia salicina* Lev.)

Hosts
Species of willow (*Salix*)

Diagnosis
Yellow spots develop on leaves in summer. Later, a convex, black, shiny stroma, 0.5-2 cm in diameter, forms (**Fig. 9**). Apothecia form, ripen during spring, and emerge from the stroma. The hymenium is yellow. Asci are wide, 120-150 x 10-15 μ. Ascospores are colorless, thread-like, 60-100 x 1.5-3 μ.

Distribution
European part of Russia, Urals, Siberia, Far East

Class/Order: Ascomycetes, Dothideales

Pathogen
Dothidella betulina (Fr.) Sacc.

Hosts
Species of birch (*Betula*)

Diagnosis
In summer, numerous small, black, convex stromata develop on the upper leaf surfaces (**Fig. 10**). They are round or irregular. Spherical pseudothecia with several loculi form after the leaves drop. Asci in loculi are cylindrical, 38-70 x 10-12.5 μ. Ascospores are elliptical, 2-celled with unequal cells, greenish, 10-14 x 5 μ.

Distribution
European part of Russia, Urals, Far East

Figure 9.—Tar spot of willow (*Salix caprea*) caused by *Rhytisma salicinum.*

Figure 10.—Leaf spot of birch (*Betula pendula*) caused by *Dothidella betulina.*

Pathogen
Dothidella ulmi (Duv.) Wint. (anamorph: *Piggotia astroidea* Berk. et Br.)

Hosts
Species of elm (*Ulmus*)

Diagnosis
Grayish-black, roundish, convex stromata, 2-3 mm in diameter, develop on leaves in summer. Spherical pseudothecia form inside the stroma with the outlet opening on the stroma surface. Asci are cylindrical, on short pedicles, 60-70 x 8-9 µ. Ascospores are elongate, egg-shaped, greenish, 2-celled, with unequal cells, 10-12.5 x 4.5 µ.

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Pathogen
Venturia tremulae Aderh. (anamorph: *Pollacia radiosa* (Lib.) Bald. et Cif.)

Host
Species of poplar (*Populus*), including white *(P. alba)* and black *(P. nigra)*

Diagnosis
The first infections occur in early summer on leaf blades, and round violet-brown spots of various sizes form. Later, the brown surface turns olive and velvety with the formation of a layer of conidiophores and conidia. Infected young shoots turn black and wither bending like a hook. Conidia are oval-elliptical, light-olive, with 2 unequal sized cells, 17-26 x 7-11 µ.

Biology
Overwinters as mycelium on fallen leaves and shoots blighted the previous season. Conidiophores and conidia develop from mycelium; conidia are the primary inocula. Incubation period is 10-14 days; thus, several generations of conidia can form during the summer and cause secondary infections of leaves and young shoots. Disease development depends on the weather conditions, primarily humidity. Wet weather and timely rains promote conidia germination and infection. Infection can occur over a temperature range of 13-35°C. The most favorable conditions for the pathogen are created during the first part of the vegetative growth period when the quantity of precipitation (and humidity) is high and young foliage is most susceptible to infection.

Damage
Causes leaf and terminal shoot blight (and sometimes dieback) and reduces height growth. Damage occurs primarily in nurseries but weakening and dieback of young poplar can occur in natural stands. Poplar stands in urban areas lose aesthetic quality. Seedling infection in nurseries often reaches 100 percent. Defoliation on infected seedlings can reach 30-50 percent by mid-August.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Isolate mother tree plantations and transplant beds of *P. alba* from mature stands.
- Plow under fallen leaves and shoots during autumn or early spring.

Chemical
- Apply (DNOC) fungicide before new foliage expands.
- Apply several fungicides (sulfur and Thiram) during the vegetative growth period

Class/Order: Ascomycetes, Taphrinales

Pathogen
Taphrina aurea Fr.

Hosts
Species of poplar (*Populus),* including black *(P. nigra)* and Bolle's *(P. pyramidalis)*

Diagnosis
Large spots form on leaves as round swellings in summer. A golden-yellow hymenium develops on the lower surface. The cells under the asci are elongate. Asci are cylindrical or widened at the base, 50-98 x 15-25 µ. Ascospores are spherical, 4 µ.

Distribution
European part of Russia

Pathogen
Taphrina polyspora Johans.

Host
Tartarian maple (*Acer tatarica*)

Diagnosis
Infected areas on the leaf are swollen and become irregularly shaped brown spots. Later, they turn black and burst. The hymenium develops on the upper surface of spots. There are no cells under the asci. Asci are wide, cylindrical, rounded at the top, 33-47 x 12-17 μ. Ascospores are spherical, 3-4 μ.

Distribution
European part of Russia

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Pathogen
Taphrina ulmi Johans.

Host
European white elm (*Ulmus laevis*)

Diagnosis
Infected areas on leaves are slightly swollen, irregularly shaped spots. They are initially yellow and later turn gray-brown or black. The hymeniun develops on the upper surface of spots. The cells under asci are wide. Asci vary from cylindrical to egg-shaped, rounded at the top, 12-20 x 8-10 μ. Ascospores are spherical, 3.5 μ.

Distribution
European part of Russia

Class/Order: Deuteromycetes, Hyphomycetales

Pathogen
Cercospora coryli Mont.

Hosts
Species of hazel (*Corylus*)

Diagnosis
Small, irregularly shaped, red-brown spots with a light center form on leaves. They may coalesce. The pathogen sporulates on the spots. Conidia are cylindrical, light-olive, 2- to 3-celled, 30-45 x 3-4.5 μ.

Distribution
European part of Russia

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Pathogen
Cercospora fraxini Sacc.

Hosts
Species of ash (*Fraxinus),* including European *(F. excelsior)* and green *(F. viridis)*

Diagnosis
Irregularly shaped or angular, brown or nearly black spots, 2-4 mm in diameter, form on leaves. Clusters of conidiophores develop on the lower surface of leaves. Conidia are spindle-shaped, pale olive, and 1-celled at the beginning of development; later, they become 2- to 6-celled, 26-65 x 4.4-6.5 μ.

Distribution
European part of Russia

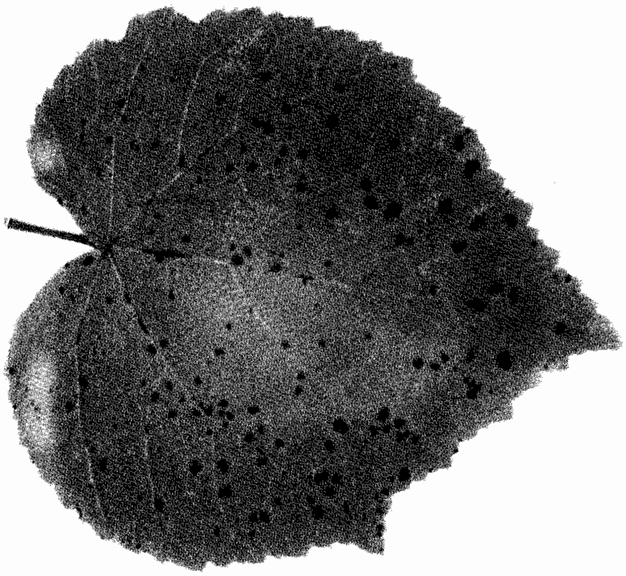

Figure 11.—Leaf spot of lime (*Tilia cordata*) caused by *Cercospora microsora*.

Pathogen
Cercospora microsora Sacc.

Hosts
Species of lime (*Tilia* spp.)

Diagnosis
Dark-brown spots with light centers form on leaves in early July **(Fig. 11)**. They are round or irregularly shaped, 2-3 mm in diameter. Conidiophores and conidia develop on the surface of the spots. Conidia are spindle-shaped, slightly curved, pale olive, 4- to 9-celled, 20-100 x 3-4 µ.

Distribution
European part of Russia, Urals, Siberia, Far East

♦ ♦ ♦

Pathogen
Cercospora salicina Ell. et Ev.

Hosts
Species of willow (*Salix*)

Diagnosis
Irregularly shaped, nearly black, often coalesced spots form on leaves, making the foliage seem dirty-black. Sporodochia form on both surfaces of the spots. Conidia are clavate shaped, slender, colorless or brown, 25-40 x 2-2.5 µ.

Distribution
European part of Russia, Urals, Siberia

Class/Order: Deuteromycetes, Melanconiales

Pathogen
Colletotrichella periclymeni (Desm.) v. Hoehn.

Hosts
Species of honeysuckle (*Lonicera*)

Diagnosis
Spots are round, often coalesced, olive-brown with light centers, often with a dark narrow border. Sporodochia are formed on the upper surface of spots. Conidia are elongate spindle- or sickle-shaped, colorless, 17-31 x 6.5-10 μ.

Distribution
European part of Russia, Urals, Siberia

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Pathogen
Coryneum foliicola Fckl.

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Spots are round or irregularly shaped when coalesced, and red-brown or brown. Sporodochia are formed on upper surface of spots. Conidia, formed on slender pedicles, are elongate-elliptical, 4-celled, olive, 12-18 x 5.5-7 μ.

Distribution
European part of Russia, Urals, Siberia

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Pathogen
Cylindrosporium ulmi (Fr.) Vassil.

Hosts
Species of elm (*Ulmus*)

Diagnosis
Spots are small, round or irregularly shaped, and may be coalesced. They are yellow initially and then turn brown. Sporodochia form on lower surface of spots and are slightly convex and yellow-brown. Conidia are colorless, cylindrical, widened at the top or spindle-shaped, curved or straight, 2- to 5-celled, 28-60 x 3.5-8 μ.

Distribution
European part of Russia, Urals, Siberia, Far East

♦♦♦

Pathogen
Gloeosporium coryli (Desm.) Sacc.

Hosts
Species of hazel (*Corylus*)

Diagnosis
Spots are round, red- to dark-brown. Small, dark, flat, cushion-like sporodochia (acervuli) are formed on both surfaces of spots. Conidia are cylindrical, with spherical ends, colorless, 1-celled, 7-15 x 5-7 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Gloeosporium betulinum West. (syn. *Discula betulina* West. Arx)

Hosts
Species of birch (*Betula*)

Figure 12.—Leaf spot of oak (*Quercus robur*) caused by *Gloeosporium quercinum*.

Diagnosis
Spots are round, about 10 mm in diameter, olive- to red-brown, with indefinite margins. Flat, yellow acervuli form on the underside of spots. Conidia are cylindrical, sometimes spindle-shaped, colorless, 1-celled, 7-15 x 0.5-2 μ.

Distribution
European part of Russia, Urals, Siberia, Far East

♦ ♦ ♦

Pathogen
Gloeosporium quercinum West. (teliomorph: *Gnomonia quercina* Kleb.) (syn. *Discula umbrinella* (Berk. & Broome) Sutton)

Host
Pedunculate oak (*Quercus robur*)

Diagnosis
Round or irregular shaped spots, 2-4 mm in diameter, develop on infected leaves in early July. Spots often occur on shoots. They are yellow-green and later turn brown (**Fig. 12**). Yellow-brown, cushion-like acervuli form on the lower surface of spots. There are two types of conidia: macroconidia are oval, egg-shaped, colorless, 1-celled, 10-18 x 4-6 μ; microsporidia are stick-like, 4-8.5 x 1-1.5 μ.

Distribution
European part of Russia, Urals

Pathogen
Gloeosporium tiliae Oudem.

Host
Little leaf lime (*Tilia cordata*)

Diagnosis
Spots form on leaves and sometimes shoots and flower perianth. They are creamy or rusty, with a dark-brown edge, 4-8 mm in diameter. Spots often occur on shoots and perianths. Small, dark-brown or brown sporodochia form on both leaf surfaces. There are two types of conidia: macroconidia are oval, egg-shaped, colorless, 1-celled, 10-18 x 4-6 µ; microconidia are stick-like, 4-8.5 x 1-1.5 µ.

Distribution
European part of Russia, Urals

♦♦♦

Pathogen
Gloeosporium tremulae (Lib.) Pass.

Hosts
Species of poplar (*Populus*), including European aspen *(P. tremula)* and white poplar *(P. alba*)

Diagnosis
Spots are large, gray-brown or gray-green surrounded by brown tissue, and lighter at the center (**Fig. 13**). Numerous small, black, flat, cushion-like acervuli, often coalesced, form on the upper surface of leaves. Conidia are cylindrical, curved, colorless, 1-celled, 10-15 x 1.5-2 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Pestalotia breviseta Sacc.

Figure 13.—Leaf spot of trembling aspen (*Populus tremula*) caused by *Gloeosporium tremulae* showing numerous, black sporodochia of fungus.

Hosts
Species of apple *(Malus)* and pear *(Pyrus)*

Diagnosis
Leaf spots are gray and vary in shape and size. Cushion-like sporodochia form on the upper surfaces of black spots in clusters. Conidia are spindle-shaped, 5 celled, with 3 appendages, 8-10 x 1 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Marssonina populi Kleb.

Hosts
Species of poplar (*Populus*), especially balsam poplar hybrid (*P. tacamahaca*)

Diagnosis
Spots appear on leaves from late May to early June. Spots are brown, round, about 4-5 mm in diameter, and gradually coalesce. They can cover the entire leaf surface. The central part of the spot is dotted with yellow-white sporodochia. Conidia are egg-shaped, elongate to pear-shaped, sometime curved. They are 1-celled initially but later 2-celled with the upper cell wider than the basal cell, colorless, 15-29 x 5-10 μ.

Biology
Source of inoculum in the spring is fallen infected leaves. Conidia from sporodochia initiate the repeating cycle of disease during summer. Pathogen incubation is about 3-5 days, so incidence of infected trees and degree of crown damage increase quickly. Primary infection occurs on lower branches nearest the conidia on overwintering fallen leaves. Infection spreads to the middle and upper branches of the crown. Wet weather (or high humidity) and moderate temperatures (13-18°C) intensify disease development.

Damage
Causes premature defoliation. By midsummer, susceptible species of poplar lose 50-80 percent of their foliage. Successive seasons of infection and leaf loss can cause a decrease in growth and vigor. Damage is most severe in nurseries.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Isolate newly created poplar nurseries and plantations from mature stands.
- Gather and burn infected fallen leaves in autumn.

Chemical
- Apply fungicide (DNOC) to fallen leaves in spring before or soon after new leaves emerge.
- Apply Bordeaux mixture to foliage during growth stages.

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Asteroma padi Grev.

Host
Bird cherry (*Padus avium*)

Diagnosis
Large spots form on both surfaces of leaf. Brown-violet spots form among branching, fan-like hyphae. Brown pycnidia are inconspicuous, embedded in the leaf tissue in groups. Conidia are elongate, egg-shaped, colorless, 1-celled, 12-18 x 3-4 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Asteroma tiliae Rud.

Host
Little leaf lime (*Tilia cordata*)

Diagnosis
Large spots, brown-violet or nearly black, form on the upper surface of leaf. Heavily branched mycelial fans form on the surface of the spot.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Phyllosticta coryli West.

Hosts
Species of hazel (*Corylus*)

Diagnosis
Spots are large, irregular shaped, brown with lighter brown center. Pycnidia form on both surfaces of spots embedded in leaf tissue. They later break through the tissue. Pycnidia are spherical with a flat top, 100-150 μ in diameter. Conidia are colorless, ellipsoidal, with 2 drops of oil, 1-celled, 7-8 x 2-3.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta fraxini Ell. et Mart.

Host
European ash (*Fraxinus excelsior*)

Diagnosis
Spots are round, 5-10 mm in diameter, brown, surrounded by dark-red margins. Brown pycnidia about 150 μ in diameter form on the upper surface of leaf. Conidia are elongate, elliptical, colorless, with 1-2 drops of oil, 7-9 x 2.5-3 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta populina Sacc.

Hosts
Species of poplar (*Populus*)

Diagnosis
Leaf spots are angular, white, with a black border, 1-3 mm in diameter. Pycnidia form on the upper surface of spots, are spherical, and black. Conidia are egg-shaped or elliptical, 1-celled, olive, 6-8 x 3-3.5 μ.

Distribution
European part of Russia, Urals, Siberia

Pathogen
Septoria betulae Pass. non (Lib.) West.

Hosts
Species of birch (*Betula*)

Diagnosis
Spots form on both surfaces of leaf. They are irregularly-shaped or round, brown or light-brown, and coalesce. Pycnidia about 100 μ in diameter form on the lower surface of leaf. Conidia are thread-like, colorless, with 1 to several septa, 30-60 x 1.5-2 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Septoria populi Desm.

Hosts
Species of poplar (*Populus*)

Diagnosis
White necrotic spots are 2-3 mm in diameter, surrounded by dark margins. Pycnidia develop on dead tissues as black dots, 112-240 μ in diameter. Conidia are cylindrical, curved, colorless, 2-celled, 30-45 x 3 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Septoria quercicola (Desm.) Sacc.

Hosts
Species of oak (*Quercus*)

Diagnosis
Small white spots, 1-3 mm in diameter, form on both surfaces of leaves, and are surrounded by wide dark margins. Pycnidia are scattered and black. Conidia are thread-like, curved, colorless, 40-60 x 1.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Septoria xylostei Sacc. et West.

Host
Honeysuckle (*Lonicera tatarica*)

Diagnosis
Spots form on both surfaces of leaves. They are gray-white, surrounded by black margins. Black pycnidia, about 130 μ in diameter, are embedded in the leaf tissue. Conidia are thread-like, curved, colorless, 40-60 x 1.5 μ.

Distribution
European part of Russia, Urals, Siberia

Damage
Heavy infection causes premature yellowing of foliage and defoliation. Infections in successive years weaken trees. Leaf spots cause considerably more damage in nurseries. Damage can reach 40-100 percent. In urban areas, decorative properties of trees and stands can be reduced.

Table 2.—Leaf rust pathogens, host tree species, alternate host, and distribution of disease

Pathogen	Host	Alternate host plant	Distribution
Melampsora allii-populina Kleb.	*Populus nigra*	*Allium, Arum elongatum*	European part of Russia, Urals, Siberia, Far East
M. pinitorqua Rostr.	*Populus tremulae, P.alba*	*Pinus sylvestris*	European part of Russia, Far East, Siberia
Melampsoridium betulae Arth.	*Betula* (sometimes alternate host plant is absent)	*Larix*	European part of Russia, Urals, Siberia, Far East

Control

Cultural

- Establish new nurseries as far as possible from forest stands with the same woody species.
- Remove fallen leaves as a source of inoculum in nurseries and urban stands during autumn.

Chemical

- Apply fungicide (DNOC) in early spring.
- Apply Bordeaux mixture during vegetative growth period.

Leaf Rusts

Class/Order: Basidiomycetes/Uredinales

Rust fungi infect numerous deciduous woody species. The most common pathogens, hosts, and areas of distribution in Russia are listed in Table 2.

Diagnosis

Uredinia are formed in summer on the leaves of the deciduous woody species as yellow-orange pustules that rupture the epidermal layer. Initially single and then numerous, they coalesce and often cover the entire leaf surface (**Fig. 14**). Urediniospores are oval, oblong, or spherical, with a wart-like sporewall. Size of urediniospore depends on the pathogen species and ranges from 11-30 x 11-18 µ. In late summer, telia form on leaves of the same woody species between cuticle and epidermis. They are crust-like, 1-1.5 mm diam, initially yellow-brown and later dark-brown. Telia can be single or in groups but often are coalesced and cover the entire leaf. Teliospores are prismatic or irregularly prismatic, round at both ends, 30-60 x 6-14 µ. Teliospore walls are light-brown, 1-1.5 µ thick.

Biology

Basidiospores form on telia in spring and infect alternate hosts for heteroecious macrocyclic rusts. Aecia form on the alternate host. Aecia produce aeciospores at the beginning of summer and infect the primary host. Uredinia containing urediniospores develop on infected leaves of the primary host and cause repeating (secondary) infection cycles during summer. Optimal conditions for uredinia formation are high humidity and moderate or high temperatures. Teliospores form on the leaves in late summer. They overwinter on fallen leaves then produce basidia with basidiospores in spring. Basidiospores infect emerging leaves or needles of alternate host plants. Teliospore germination and basidiospore production is most intense during warm and humid springs.

Damage

Rusts cause leaves to wither and prematurely drop, reducing tree growth. The infection of young shoots delays their development and results in damage from early autumn frosts. Most damage occurs in nurseries, particularly where seedlings are overstocked. Severe infection in urban stands significantly decreases aesthetics and protective functions of trees.

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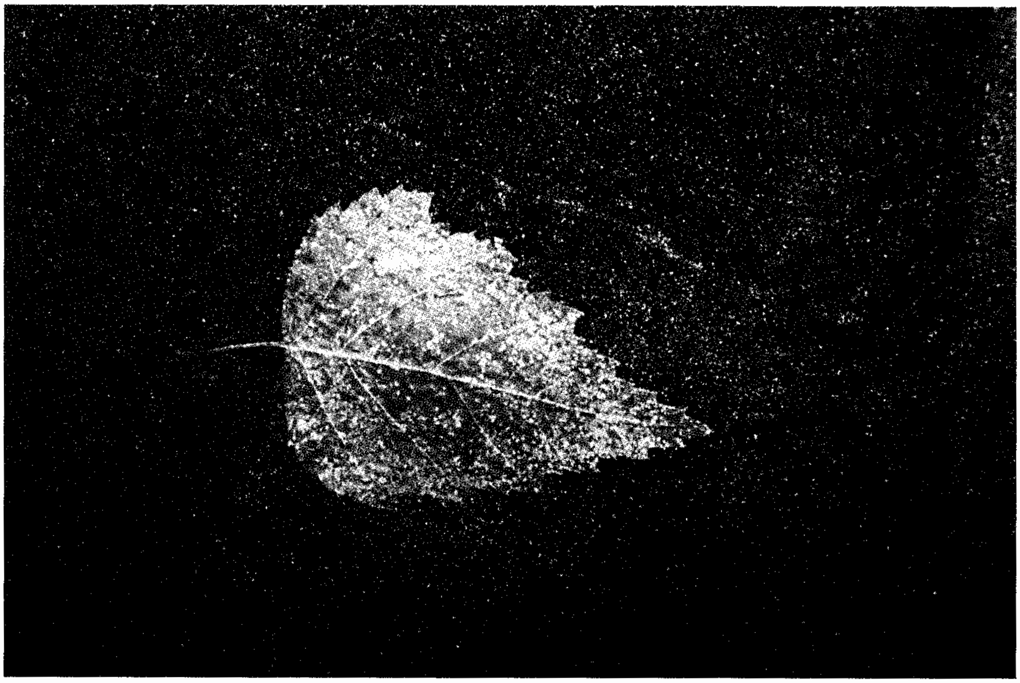

Figure 14.—Rust on birch (*Betula pendula*) caused by *Melampsoridium betulae*. Uredinia occur on the under surface of the leaf.

Control

Observation

- Survey for disease appearance and dispersion in nurseries and young plantations in early July (period of uredinia pustule formation).

Cultural

- Use plant material selected for resistance to leaf rusts.
- Eradicate possible alternate hosts near nurseries or plantations.
- Collect or burn fallen leaves.

Chemical

- Before leaves emerge in spring, apply fungicide (DNOC or Thiram) to fallen leaves and the lower parts of plants.
- Apply fungicide (Zineb, Metiram and copper hydroxide) to foliage in summer.

Diseases Of Roots, Stems, And Branches

Diseases in Tree Nurseries and Young Forests

Damping - off

Class/Order: Deuteromycetes/Hyphomycetales

Pathogens

Primarily species from *Fusarium, Alternaria, Botrytis*, and *Verticillium* genera, but also by *Rhizoctonia,* spp., *Mycelia sterilia,* and *Pythuim* spp.

Hosts

Species of pine (*Pinus*), including Scots *(P. sylvestris)*; spruce (*Picea),* including Norway *(P. abies),* Siberian black *(P. obovata),* and blue *(P. pungens);* and larch *(Larix),* including European *(L. decidua),* Siberian *(L. siberica),* Sukachev *(L. sukaczewii)*, and Kurilian *(L. kurilensis);* also species of beech *(Fagus),* elm *(Ulmus)* and birch *(Betula)*

Figure 15.—Current-year pine seedlings (*Pinus sylvestris*) severely affected by Fusarium root rot. Localized areas in beds of pine affected by Fusarium root rot.

Diagnosis

There are two forms of disease: pre- and post-emergence damping-off. Pre-emergence symptoms include lack of germination or emergence in seedling beds and rotten seeds and seedlings in the soil. Post-emergence symptoms include small areas of diseased seedlings **(Fig. 15)** that under favorable conditions for the fungus quickly merge and affect the entire planting area. A dark-brown constriction forms at the stem base, and seedlings fall to the soil and wither. Occasionally, fungal mycelium develops near the soil line in the zone of constriction, particularly during wet weather. Some diseased seedlings do not shed their seed cover. Lateral rootlets often die and rot. Diseased plants are easily pulled from the soil; the main root has no bark. The constriction at the stem base does not form in seedlings more than 4 weeks old. Another symptom is top withering caused by hyphal-induced embolisms in xylem vessels. Infected plants lose their turgor and wither but their root systems do not rot; they die 3 to 4 weeks after emergence.

Biology

Sources of inoculum are previously diseased seeds, seedlings, and soil. Pathogens, including *Fusarium* species, can exist as saprophytes on decaying plant tissues for long periods. *Fusarium* species can produce chlamydospores that remain in the soil for long periods and are highly resistant to unfavorable environmental factors and pesticides. The disease spreads by conidia carried or brought into the soil on seeds. The rate of mycelium spread in the soil is about 2-5 cm/day.

Disease development is most active in heavy, acidic, and waterlogged soils, though conditions for development can be favorable on dry and sandy soils. Weather conditions considerably influence disease development and distribution; mortality increases with low temperature and high humidity as well as high temperature and moisture deficit.

Damage

Kills seedlings; when conditions for disease development are favorable (high humidity and soil moisture), can affect up to 100 percent of the seedlings.

Distribution

Throughout Russia

Control
Cultural
- Select flat areas with light soils when establishing nurseries.
- Avoid sites formerly used to grow agricultural plants, e.g., potatoes, corn, or melons, due to the potential for previous *Fusarium* infection.
- Sow seeds at optimal time, observe rules of sowing, and use only certified seeds.
- Care for seeding beds after seedlings emerge and prevent weed growth and drying of soils.

Chemical
- Use chemical seed dressing where necessary. Dust seeds with fungicides (Bavistin, Benomyl, BAYMEB, Topsin-M, Daconil, Vitavax, Thiram, and Tersan). Fungicide treatment combined with micronutrient fertilizer ($ZnSO_4$, $CoSO_4$, $CuSO_4$, $KMnO_4$) is the most effective treatment.
- Apply fungicides (Thiram, Tersan, Karbation, or Vapam) to the soil where infection is heavy.
- Use fungicides in irrigation water in disease loci in nursery beds.

Biological
- Apply antagonistic antibiotics (Trichothecin, Phytobacteriomycin, or Phytolavin).

Diseases of Forest Stands

Wilts

Verticillium Wilt

Class/Order: Deuteromycetes/Hyphomycetales

Pathogen
Verticillium dahliae Kleb. and *V. albo- atrum* Rke. et Berth.

Hosts
Species of maple (*Acer*), particularly Norway (*Acer platanoides*), and birch (*Betula*), poplar (*Populus*), lime (*Tilia*), and elm (*Ulmus*)

Diagnosis
Affected trees fail to foliate in spring or die suddenly in midsummer **(Fig. 16)** in the acute form of disease development. In the chronic form, several branches die and then later the entire crown dies. Numerous epicormic shoots form on the stem but they soon die. Bark sloughs from dead trees. The wood of infected roots and stem initially has green stripes but later turns dark-green. An important diagnostic feature in the conidial stage is the conidiophores, which typically are branched vertically with colorless, ellipsoid conidia, 2-5 µ, on them. Microsclerotia and chlamydospores develop later. In natural conditions, the fungus sporulates rarely, however, spores develop rapidly in the laboratory (in moisture chambers).

Biology
Infection is initiated by conidia at the base of the stem or branch. Occasionally, trees are infected through damaged stems and branches. The mycelium penetrates the tree and spreads in the vascular system. From the lower part of the stem, mycelium grows upward and penetrates branches. When the fungus attacks, most of the roots (or the entire root system) are infected. The tree usually dies before mycelium reaches the stem. Sources of inoculum are infected wood, bark residues, and dead roots. The pathogen survives by forming microsclerotia and chlamydospores. These structures survive in the soil on dead debris for several years. Inoculum potential increases in soils where agricultural species such as potato (*Solanum tuberosum*), tomato (*Lycopersicum esculentum*), and sunflower (*Helianthus annuus*) have grown.

Damage
Kills seedlings in nurseries and artificially and naturally regenerated maple stands 1 to 2 years old. Dieback of trees in forest plantations and natural stands is possible during first 4 years of growth.

Distribution
European part of Russia, particularly the southwestern region

Figure 16.—Dieback of naturally regenerated maple (*Acer platanoides*) caused by *Verticillium dahliae.*

Control

<u>Cultural</u>

- Do not establish forest nurseries and plantations in areas where *S. tuberosum, L. esculentum,* and *H. annuus* have grown.
- In nurseries, remove diseased plants and their entire root system.
- Selectively remove infected trees or clearcut in disease loci in affected natural stands.
- Remove and destroy all felling residue.

Dutch Elm Disease

Class/Order: Ascomycetes, Microsporales

Pathogen

Ophiostoma ulmi (Buism.) Nannf. (Syn. *Ceratocystis ulmi* (Buism.) Mor. (anamorph: *Graphium ulmi* Schwarz.)

Hosts

Species of elm (*Ulmus*), including table top (*U. glabra),* Ohyo *(U. laciniata),* European white *(U. laevis),* smooth leaf *(U. carpinifolia),* Japanese *(U. japonica),* Siberian *(U. pumila),* and Androssowi *(U. androssowii)*

Figure 17.—Elm (*Ulmus laevis*) affected by *Ceratocystis ulmi* (=*Ophiostoma ulmi*).

Diagnosis
Wilting foliage is the major symptom (**Fig. 17**). The most typical and distinctive feature of the disease is leaf roll along the primary rib. However, other symptoms are evident e.g., pigmentation and dropping of leaves. Unlike the asexual reproduction stage (conidia), the sexual ascus stage (black perithecia) occurs rarely. Most Russian strains belong to an aggressive pathogen race.

Biology
The pathogen can be distributed by air, water, and animals as a result of root grafting or by shoot infestation. Inoculation results from mechanical injury to trunks and branches by elm bark beetles, which play the major role in the disease distribution. *Scolytus scolytus* Fabr., *S. multistriatis* Marsch., and *S. pygmaeus* Fabr. are common in infected areas in Russia. The fungus is present on eggs and in larval galleries of the bark beetles. Spores were observed on 83.3 percent of beetles captured from infected trees. Beetles damage 1- and 2-year-old shoots in spring when they feed in twig crotches. Initially, necrotic zones develop in the current-year annual ring of any thin twig. In the chronic form of the disease, usually in trees more than 50 years old, the fungus remains in the upper part of the tree in the older sapwood elements. Symptoms usually arise annually with wilting of individual shoots in the crown; the disease continues to develop over several years until the tree dies. In the acute form, the pathogen not only spreads in the crown but also reaches the stem base and roots. Tree death is sudden and occurs in one growing season.

Damage
Causes massive dieback of elm species in forest and urban ecosystems. During epiphytotics, mortality of mature trees can approach 100 percent.

Distribution
Ukraine, Moldova, Volga River, Baltic Sea, central regions and European and Middle Asia parts of Russia (in the former U.S.S.R., the disease was first observed in the city of Odessa in 1935)

Control
Control of Dutch elm disease entails the suppressing both the pathogen and vector population.

Observation

• Survey elm stands in June and July for tree condition, presence of symptoms, and abundance of elm bark beetles.

Cultural

• Create mixed stands with a variety of deciduous species.
• Use disease-resistant planting material.
• Conduct selective and clear sanitation cutting and remove trees with disease symptoms (October through April) to reduce the abundance of overwintering bark beetles.
• Destroy infected wood and debark healthy portions of cut trees and branches.

Oak Wilt

Class/Order: Ascoymycetes, Microascales

Pathogen

Species of *Ceratocystis* (*C. roboris* Georg. et Teod., *C. valachicum* Georg. et Teod.) and species of *Fusarium* and *Verticillium*

Hosts

Species of oak *(Quercus)*

Diagnosis

The disease has both rapid and chronic development forms. The rapid form is characterized by leaves wilting at the top of the tree and branches. The disease quickly spreads to the entire crown. In this case, leaves curl, turn yellow or bronze, and fall 3 to 6 weeks after the first symptoms appear. If infection occurs at the end of summer, leaves turn tan and some fall while others remain on branches throughout the winter. Mycelial masses form under the bark of dead trees and arise from bark cracks. In the chronic form, wilting begins on several separate branches. Leaves are smaller than normal, turn yellow or tan, and drop. Often, buds on diseased branches fail to grow in spring, and/or leaves do not reach normal size and fall prematurely. Affected trees are characterized by sparse foliage and top dieback. Heavily weakened and dying trees produce adventitious sprouts. Morphological changes in the crown are not specific for the chronic form. Similar symptoms can be caused by other diseases as well as chemical, weather, and other adverse environmental factors.

The pathogen develops within the water-conducting xylem vessels, and causes dieback of adjacent parenchyma and extensive tyloses formation. Characteristic symptoms of this disease are evident when branches and trunks are cut; tan or dark-olive spots and streaks and dots form in the sapwood or the entire sapwood turns brown.

Biology

Infection usually occurs by spores, though infection by mycelium can occur through grafted roots. Spores are distributed by water, wind, and on seeds and tools, but most commonly by insects. The most active vectors are insects such as *Scolitus intricatus, Plagionotus detritis, P. arcuatus,* and *Agrilus angustulus.* Oak wilt usually develops in previously weakened stands. The percentage of diseased trees increases with tree age. The disease is prevalent in low-density stands. Oak dieback occurs in both mountain and floodplain stands but is more severe in the latter.

Damage

Weakens and kills oak stands **(Fig. 18).** Depending on age, nearly 75 percent of the stands can be affected. The death rate can reach 70 percent.

Distribution

European part of Russia

Control

Cultural

• Conduct sanitation cuts to remove and destroy infected trees, including trees infested by oak bark beetles; spray stumps with Fundasol or Nitraphen.
• Establish seed plantations in healthy and disease-resistant stands.
• Examine acorns for infection before seeding.

Figure 18.—Dead and dying trees of oak (*Quercus robur*) stands that were attacked by oak wilt – *(Ceratocystis roboris).*

Chemical
- Treat tree with contact insecticides during the feeding period of bark beetles.
- Use systemic fungicides to suppress the pathogen (injection into the trunk is the most effective method).
- Treat acorns with fungicide (Fundusol and TMTD).

Dieback and Canker Diseases

Cenangium Dieback of Pine

Class/Order: Ascomycetes, Helotiales

Pathogen
Cenangium abietis (Pers.) Rehm. (anamorph: *Dothichiza ferruginosa* Sacc.)

Hosts
Species of pine (*Pinus*), particularly Scots *(Pinus sylvestris)*, and fir (*Abies*) and spruce (*Picea*)

Diagnosis
Symptoms first appear in the leader of current-year or the previous-year shoots. The bark turns red but necrotic areas do not have clear boundaries. Infected needles die and remain on the branches through

the growing season (**Fig. 19**). The conidial stage develops on infected branches and needles during the entire growing season. Small, black pycnidia-like tubercles develop in bark splits. Apothecia develop on dead branches and stems 1 or 2 years after infection. In wet conditions, apothecia are saucer-like with a green-yellow hymenial layer. In dry weather, apothecia resemble dark-brown, nearly black rough tubercles, 1-3 mm in diameter, raised from the bark splits. Conidia are colorless, oval or ovoid, 8-12 x 4 μ. Asci are clavate, 60-80 x 10-12 μ. Ascospores are colorless, ellipsoid or ovoid, with 1 or 2 oil drops, 10-12 x 5-7 μ.

Biology

The sources of inoculum are diseased plants and fallen needles. New infections on healthy treees are initiated by conidia and ascospores. High humidity promotes sporulation and infection. The fungus penetrates tissues of needles and bark injured by various agents, including insects. Many factors that result in poor growing conditions and weakened plants promote disease development. These include unfavorable climate conditions (drought and others), changes in water regime, insect injury (from *Aradus cinnamomeus* Panz. and *Ellopia fasciaria* L.), and industrial pollution.

Damage

The fungus usually occurs as a saprotroph on pine trees killed by various agents. More rarely, the disease develops as a epiphytotic in nurseries and pine plantations, causing dieback. Plant damage can range from 50-60 percent. In nurseries, seedlings can die if the epiphytotic continues for several years.

Distribution

European part of Russia, Siberia, Far East

Control

Cultural

- Remove infected trees to prevent disease spread.
- Remove and burn dead trees and branches as sources of inoculum.
- Create mixed hardwood/pine plantations as more biologically sustainable; hardwood species reduce the possibility of pine infection.

Figure 19.—Cenangium dieback of pine (*Pinus sylvestris*) caused by *Cenangium abietis.*

Figure 20.—Canker on poplar (*Populus nigra*) caused by *Nectria cinnabarina*. Sporodochia of the fungus are visible.

Nectria Canker and Dieback

Class/Order: Ascomycetes, Hypocreales

Pathogen
Nectria cinnabarina (Tode.) Fr. (anamorph: *Tubercularia vulgaris* Tode.)

Hosts
Numerous deciduous tree genera are affected, including species of maple (*Acer*), birch *(Betula)*, beech *(Fagus)*, ash *(Fraxinus)*, alder *(Alnus)*, poplar *(Populus)*, lime *(Tilia)*, elm *(Ulmus)*, oak *(Quercus)*, dogwood *(Cornus)*, and mountain-ash *(Sorbus)*, as well as barberry *(Berberis)* and currant *(Ribes)*. Bosnian maple (*Acer platanoides*) is the most severely affected species.

Diagnosis
Bright-pink cushions of conidial stromata develop as longitudinal lines in bark cracks on the infected branches and trunks. Later, they darken and turn tan, and perithecia form on the same stromata (**Fig. 20**). Conidiophores are slightly branched. Conidia are elongate-ellipsoid, slightly curved, colorless, 5.5-8 x 3 µ. Asci are cylindrical or clavate, 60-90 x 9-12 µ. Ascospores are colorless, widely fusiform, 2-celled, 12-20 x 4-7 µ. Infected wood is blue gray.

Biology
In spring, infection occurs from ascospores that overwinter. During the growing season, infection occurs from conidia. Spores penetrate tree tissues at various bark injuries, including broken branches.

The mycelium spreads in the bark, cambium, and sapwood, and penetrates the trachids where it plugs vessels and causes rapid dieback.

Damage
The fungus often is reported as a saprophyte but it can be pathogenic in nurseries and young forest plantations. Infected seedlings in nurseries can reach 20 percent. Severe disease reduces vigor and causes dieback in nurseries. The canker significantly reduces productivity of mature trees.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Observation
- Survey stands during the summer when conidial sporodochia are visible.

Cultural
- Protect trees from environmental factors that can weaken them.
- Remove infected, dying, and dead trees in forest nurseries and urban stands; prune infected branches.
- Prevent or reduce mechanical injuries that serve as entry points for the pathogen.

Cytospora Canker

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Cytospora chrysosperma (Pers.) Fr. (teliomorph: *Valsa sordida* Nits.)

Hosts
Species of poplar (*Populus*) and willow (*Salix*)

Diagnosis
The pathogen develops in bark tissue and kills it. Thin, smooth bark that is affected is red-brown; the color of thick bark does not change. Dark-gray or brown conidial stromata form in the bark. Numerous pycnida develop in the stromata and raise the bark surface as small tubercles. Mass sporulation occurs in May and early June, as well as in late August and September. Spore masses exude from pycnidia and congeal as golden-yellow or orange horns (cirris). Pycnidia can be 1.8 mm in diameter, chambered with a common opening. Conidia are colorless, allantoid, 3-5 x 1 μ.

Biology
Sources of inoculum are infected cuttings, seedlings, and infected trees in stands. Conidia are spread by rainwater or insects and infect healthy trees. The pathogen penetrates tree tissues though mechanical injuries and cracks at the base of branches. As the fungus grows, it secretes toxins that kills the bark. Mycelium then develops in dead bark. Pockets (loci) of the disease develop usually in stands predisposed to infection by unfavorable environmental conditions, e.g., droughts, flooding, winter damage, and unfavorable soil. Disease develops just after foliation and later in midsummer. Death may occur during one growing season or over several years. In the case of rapid disease development, affected trees do not foliate in the spring or die shortly after foliating. In chronic disease development, single branches die gradually in the crown; epicormic shoots develop on the stems but also are infected and die.

Damage
Kills weakened trees. Damage is most severe in nurseries, stool-beds, and forest plantations.

Distribution
Throughout Russia

Control
Cultural
- Cull diseased plant material in nurseries, forest plantations, and stands.
- Select resistant species and clones.

Figure 21.—Dothichiza canker of poplar (*Populus balsamifera*). Pycnidia with emerging mass of spores are visible.

<u>Chemical</u>

- Apply fungicides (Zineb and TMTD) as a drench before planting.

Dothichiza Canker of Poplar

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Dothichiza populea Sacc. et Briard.

Hosts
Species of poplar (*Populus*) and their hybrids, particularly from the groups of black (*Aegeiros*) and balsam (*Tacamahaca*) poplar

Diagnosis
Initially, sunken, necrotic, oval areas several centimeters in diameter form on the bark of trunks and branches. Cankers form along the entire length of the main stem and branches, but more often where branches attach to the main stem and shoots attach to branches. Affected areas on the living stem and branches appear dark, but the bark yellows after death. Callus ridges several millimeters thick develop at the margins of the necrotic area. Gradually, cankers coalesce and girdle the stem or branch. In a large infected stem, mycelium spreads in the tissues over a 2- to 3-year-period, causing a perennial canker. Infected trees are sparsely leafed and there are numerous epicormic shoots on the stems. In spring, pycnidia up to 2 mm in diameter develop on dying and dead areas of the bark. Pycnidia usually form as longitudinal rows but can be distributed randomly (**Fig. 21**). Spores are black

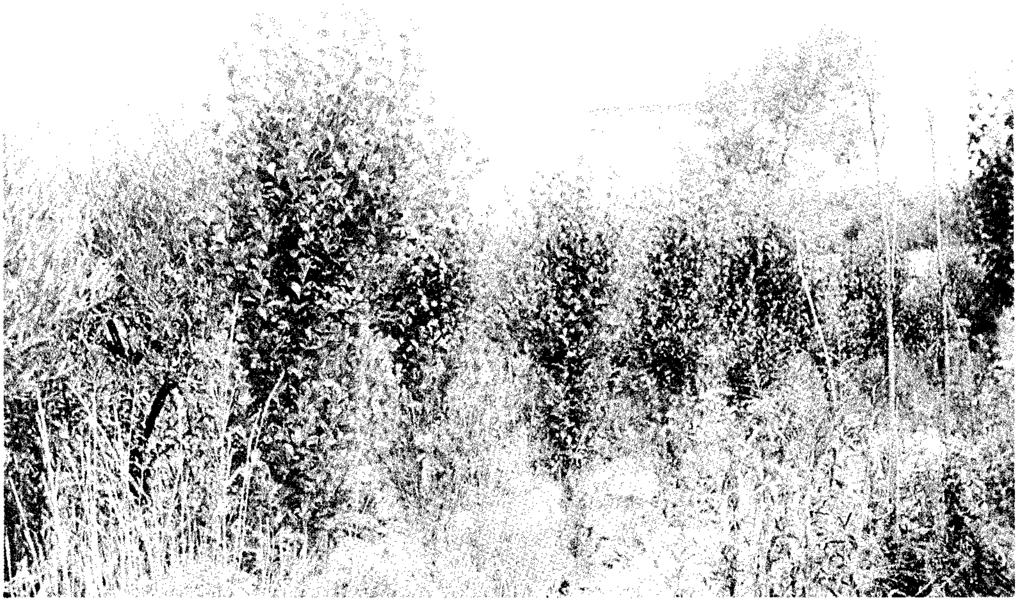

Figure 22.—Poplar (*Populus nigra*) dieback in ornamental nursery caused by *Dothichiza populea*.

or light-olive; when exuded they resemble small horns or strips, 2-4 mm in length. Conidia are colorless, ovoid, narrowed on the ends, rarely globose or ellipsoid, 1-celled, 8-13 x 6-12 µ.

Biology
Sources of inoculum are infected cuttings, transplants and diseased trees in forest plantations and stands. Infection occurs by conidia which mature early in the growing season. Mature spores can survive in pycnidia for nearly a year and are dispersed by rainwater and insects. Infection occurs from April until September. Trees are infected through mechanical injuries but also through natural openings such as lenticels, base of buds, shoot junctions, and cracks at the base of branches. Disease development occurs when conditions are unfavorable for poplar growth (poor aeration, soil compaction, waterlogging, overstocked stands).

Damage
Causes weakening and often mass dieback of poplar in nurseries, plantations, and stands of various types (**Fig. 22**).

Distribution
European part of Russia, south Urals, Siberia, Far East

Control
Observation
- Survey stands in early summer for disease symptoms.

Cultural
- Establish stool-bed plantations, nurseries, and forest plantations on sites where conditions are optimal for tree growth and development.
- Plant only healthy plant material.
- Minimize mechanical injuries when planting and cultivating.
- Select resistant species and clones that are adapted to the site conditions.

Chemical
- Apply fungicide (TMTD) to seedling roots as a drench before planting.

Clithris Canker and Dieback of Oaks

Class/Order: Ascomycetes, Phacidiales

Pathogen
Clithris quercina (Pers.) Rehm. (anamorph: *Cytospora quercella* Sacc.)

Hosts
Species of oak (*Quercus*), particularly peduncate *(Q. robur)*

Diagnosis
The bark of infected stems and branches tums red and later yellow-white upon death. Necrotic areas are sharply delimited from healthy bark. Necrosis can be elongate or circumferential. Pycnidia develop initially on the dead bark as small gray-white tubercles (hillocks). Later, numerous apothecia 5 mm long form in the dead bark. They are gray-white or dark-gray and curved. In humid conditions, apothecia open as relatively wide longitudinal splits uncovering a gray, jelly-like hymenial layer. Asci are clavate, with a stalk, 125-150 x 9-10 µ. The ascospores are thread-like, colorless, initially 1-celled but later multicelled, 90 x 1-1.5 µ.

Biology
Healthy branches and stems are infected from ascospores in early summer through injuries to bark. Trees weakened by poor growing conditions, e.g., repeated droughts, changing water regimes, or frost injury, are highly susceptible.

Damage
In the forest the fungus acts as a saprophyte, occurring on the lower dying branches and promoting the process of branch shedding. However, in the steppe zone it acts as a pathogen affecting plantations under 25 years, reducing vigor, and sometimes killing trees. Damaged plants range from 10-40 percent. The fungus causes sapwood decay as well as bark necrosis.

Distribution
European part of Russia

Control
Cultural
- Create optimal conditions for growth (soil moisture, fertilization, spacing) in nurseries and plantations.
- Remove damaged trees and felling debris after thinning.
- Minimize mechanical injury during tending operations.

Nummularia Canker

Class/Order: Ascomycetes, Sphaeriales

Pathogen
Nummularia bulliardii Tul.

Hosts
Species of oak (*Quercus*) and beech (*Fagus*)

Diagnosis
Symptoms are visible several years after infection. Thick, up to 3 mm, oval, cushion-like stromata form in infected bark and over entire length of the stem. Stromata are 1-6 cm wide and 2-40 cm long. Often, stromata are coalesced, girdling and extending up stems to a length of 1 m. Initially, stromata are brown but later turn black and coal-like. Numerous perithecia develop within the stroma. Perithecia openings appear as pointed hillocks on the entire stroma surface. Perithecia in stromata occur as a single layer; they are ovoid or sack-like, 0.5 mm high. Asci are elongate, cylindrical, on a short stalk, 100-210 x 10 µ. Ascospores are dark-brown, ellipsoid or globose, 1-celled, 12-14 x 6-10 µ. Decayed sapwood appears light-yellow in the main stem and branches.

Biology
The source of inoculum is diseased trees and felling residues with well-developed stromata. Tree infection occurs from ascospores that penetrate into tree tissues through bark cracks or mechanical

Figure 23.—Canker of oak (*Quercus robur*) caused by *Naemospora croceola*. Sporodochia with red drops of spore masses are visible.

injuries. Disease outbreaks occur most frequently in weakened stands. Predisposing stresses are severe droughts, frosts, water deficits, open-growing trees or overstocking, and bark injury from tending activities.

Damage
Affects 20- to 30-year-old trees in natural stands and forest plantations. Reduces tree vigor and causes some crown dieback. Some trees are killed.

Distribution
Steppe (southeastern) zone of European part of Russia

Control
Observation
- Survey stands for symptoms in summer and after leaf drop in autumn.

Cultural
- Create optimal conditions for the growth and development of plantations.
- Maintain proper spacing in closed plantations.
- Minimize mechanical injury of stems during tending activities.

Black Naemospora Canker

Class/Order: Deuteromycetes, Melanconiales

Pathogen
Naemospora croceola Sacc. (teliomorph: *Diatrype stigma* (Hoffm.) Wint.)

Hosts
Species of oak (*Quercus* spp.), particularly English (*Q. robur*), and birch (*Betula*).

Diagnosis
Initially, infected bark turns red, but symptoms are not conspicuous (**Fig. 23**). Later, sporodochia form on the infected bark. They are round, yellow spots with dark margins, up to 3 mm in diameter. Red

drops or horns of congealed conidial masses usually are visible at the center of the spots. In 2 or 3 years, infections often girdle small stems and branches, and a stroma develops in dead bark. Stromata are flat, up to 2 mm thick, dark-brown, and covered with numerous longitudinal and transverse cracks. Numerous pointed hillocks that develop on the stroma surface can be seen with a hand lens. These are the openings of the perithecia, which are closely aggregated, bottle-shaped, with short nipple-like openings. Asci are clavate, cylindrical, on a lengthened stalk, 30-60 x 4-3 μ. Ascospores are light-brown, cylindrical, straight or curved, with 2 oil drops, 4-12 x 0.6-1.5 μ.

Biology
The sources of inoculum are diseased and dead trees and felling residues. Trees are infected by conidia and ascospores. Spores are dispersed by rainwater, insects, and other vectors. Weakened trees in forest plantations are affected.

Damage
Affects fine branches in the lower part of the crown, as well as the larger branches of severely weakened trees. During droughts in the steppe and forest-steppe zones, the disease affects forest plantations under 25 years of age and can cause tree mortality. Damage to oak plantations in the steppe zones can exceed 70 percent.

Distribution
Middle and southern areas of European part of Russia

Control
Observation
- Survey for symptoms and spread of disease in spring and summer.

Cultural
- Create optimal conditions for plantation growth and development.
- Timely remove diseased trees and their felling residues as sources of inoculum.

Thyrostroma Canker and Dieback

Class/Order: Deuteromycetes, Melanconiales

Pathogen
Thyrostroma compactum (Sacc.) Hoehn (syn.: *Stigmina compacta* (Sacc.) M.B. Ellis

Hosts
Species of lime (Tilia) and elm (Ulmus)

Diagnosis
The first symptom of infection is dieback of the previous-year growth (**Fig. 24**). In spring, buds on these branches do not open; by the end of summer or during the next growing season, fungal stromata form on them. Dead branches often drop off, but the fungus grows into larger branches of the previous-year growth. These branches have a thin and smooth bark. Oval, pitching, necrotic depressions are formed along branches. Infected bark is darker than healthy bark. During the dormant season, necrosis spreads longtitudinally and tangentally, killing bark and outer sapwood tissues and causing the rapid death of branches. Stromata form on dead branches, initially in the zone of original necrosis, and then on the entire branch (**Fig. 25**). Necrotic spots form on stems and branches with thin bark and around the base of small, infected twigs. During wound development, bark splits longtitudinally and opens gradually. Later, bark sloughs and wood is exposed. Open cankers are elongate, often spindle-like, without changes in wood color, and have one ridge of callus (**Fig. 25**). Stromata are black, velvety, and cushion-like, and break through the bark surface. Spores have 1-3 vertical and 1-5 horizontal septa, usually 46-63 x 15.3-17.2 μ. Clusters of adventitious shoots with large leaves often develop at the base of dead branches and on limbs and trunks. These shoots are infected and killed, causing more intensive formation of clusters of adventitious shoots.

Biology
Infections by conidia occur in midsummer. Spores are disseminated by wind up to 10 m, though most fall within a radius of 3 m from their source, infecting new branches and twigs of the same tree as well as neighboring trees. Infection occurs through the buds. Rain and high humidity favor infection. The

Figure 24.—Elm (*Ulmus pumila*) dieback caused by *Thyrostroma compactum* (=*Stigmina compacta*).

Figure 25.—Lesion on branches of lime (*Tilia cordata*) caused by *Thyrostroma compactum.*

pathogen cannot colonize actively growing tissues in the tree; colonization occurs only during the dormant season. The pathogen tolerates low temperatures as growth occurs even at -2°C. Spores deposited on vulnerable twigs and branches remain viable for up to 7 months.

Damage

Causes cankers, resulting in branch dieback (**Figs. 24-25**).

Distribution

European part of Russia

Control

Cultural

- Use canker-free, healthy plant material to establish plantations.
- Prune infected branches at early stages of disease development to reduce inoculum.
- Establish quarantine areas to prevent the spread of diseased plant material to regions where the disease does not occur.

Ascocalyx Scleroderris Shoot Canker

Class/Order: Ascomycetes, Helotiales

Pathogen
Ascocalyx abietina (Lagerb.) Schläpfer. (*Gremmeniella abietina* (Lagerb.) Moretel., *Crumenula abietina* Lagerbe., *Scleroderris lagerbergii* Gremm.) (anamorph: *Brunchorstia pinea* (Karst.) Hohnk.)

Hosts
Species of pine (*Pinus*), spruce, (*Picea*), fir (*Abies*) and larch (*Larix*)

Diagnosis
Pinus species are affected more often than other species. Symptoms of the disease vary with plant age. Initial symptoms of pine infection in nurseries occur several days after snowmelt. The fungus penetrates into the needles and upper buds and affects the cambium of young branches and stems. Initially, needles are green but turn red at the base where they attach to the stem. Paired needles of the 2 to 3-year-old seedlings hang like an umbrella and fall at the slightest touch. In the nurseries this disease is called the "umbrella disease." Following snowmelt, needles of affected seedling in nurseries are flattened along the stem. They turn brown but remain attached to the stem for a long time. The upper bud and stem cambium die and bark sloughs away easily if the seedling is pulled from the soil. In disease centers in young pine stands more than 5 years old, needles hang flaglike. Upper shoots are short and thick, with shortened or thickened needles. Necrotic and sometimes girdling lesions develop on the stem and branches and kill upper shoots on plants with a stem diameter larger than 1 cm. Canker wounds sometimes form.

During summer, mature pycnidia form on needle bases and in the bark of dying and dead seedlings. Pycnidia resemble rough black warts, about 2 mm in diameter. Spores are colorless, curved, usually 3- or 4-celled, but can be 4- or 6-celled, 16-32 x 2-3.5 m. The sexual stage occurs rarely. Apothecia are black-brown, 1-1.8 mm in diameter (**Fig. 26**). Asci are colorless, clavate, 95-110 x 7.5-10 m. The ascospores are oval, with 2 or 3 septa, 15-24 x 4-4.8 m. In pine stands 15 to 20 years old, the tips of upper shoots usually die with characteristic symptoms of needles thinning and falling off. Pycnidia often form on these shoots. Similar symptoms can occur in middle-age, mature, and overmature stands.

Biology
Infection occurs by conidia and ascospores that are spread by wind or insects. Conidia dispersal occurs throughout summer; ascospore dispersal occurs from mid-July to September. Various factors cause tree weakening and reduced resistance to this disease, resulting in canker development. Unfavorable climate and soil conditions, hard frosts, and cold and rainy vegetative periods delay shoot development and disturb nutrient balance. Severe disease development occurs in low-lying areas where frequent fogs and autumn and spring frosts occur. Resistance to the disease is reduced in seedling beds and high-density plantings. Pine species planted offsite are highly susceptible to this disease.

Damage
Primarily kills seedlings in nurseries; mortality ranges from 10-60 percent. Mature trees are noticeably weakened and many are killed.

Distribution
European part of Russia, and Siberia

Control
Observation
- Survey nurseries for 10-14 days after snowmelt.
- Survey forest plantations during the summer.

Cultural
- Use indigenous seeds sources to increase seedling resistance to the disease.
- Remove infected plants from bordering forest plantations or stands.
- Select sites with flat topography for forest plantations; avoid cold, wet, shady areas.
- Use healthy indigenous planting material.
- Control the condition and density of plantings during the first 2 or 3 years after planting.

Figure 26.—Fruiting bodies of *Ascocalyx abietina* on a stem of fir (*Abies sibirica*).

<u>Chemical</u>

- In nurseries apply systemic fungicides such as BAYMEB, Benomyl (Benalate), and Daconil.

European Larch Canker

Class/Order: Ascomycetes, Helotiales

Pathogen

Dasyscyphus willkommii (Hart.) Rehm. (syn. *Lachnellula willkommii* (Hart.) Dennis).

Hosts

Species of larch (*Larix*), including European (*L. decidua*) and Siberian (*L. sibirica*); also fir (*Abies*) and Siberian stone pine (*Pinus sibirica*)

Diagnosis

Annual radial growth ceases in affected twigs and stem areas. Oval, pitching depressions form in the bark. Dead bark sloughs and cankers become open. Several cankers may form on the same stem. Cup-shaped apothecia on short stalks, 2-6 mm in diameter, form on the margins of cankers and on the dead branches. The outside surface of the apothecia is white and hairy and the hymenium is orange. Asci are oblong, 90-120 x 8-12 µ. Ascospores are colorless, oval or spindle-like, 1-celled, 16-25 x 6-9 µ. In young larch plantations, twigs and small stems die before the characteristic canker wound is formed. Resin exudes and apothecia form on the dead branches and stems.

Biology
Trees are infected by ascospores that mature in spring and autumn. The pathogen initially affects lower branches in areas of frost pockets or other bark injuries. It then penetrates into the main stem and develops for several decades. Mycelium develops in the tree tissues when the air temperature range is 3°-5°C. These conditions occur in spring and autumn, or in winter in regions with a mild climate. Epiphytotics may develop in milder winter regions. Where winters are severe, the fungus occurs usually as a saprophyte on dead branches. Larch plantations are affected severely under unfavorable conditions, e.g., waterlogged soils, overstocked stands, and unsatisfactory tending.

Damage
Causes gradual weakening of mature trees. Trees are killed in young stands (3-5 years old). Damage in larch plantations can reach 25 percent.

Distribution
Northwestern area of European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Create mixed larch plantations with optimal density on optimal sites.
- Select and use resistant species of larch.
- Conduct timely sanitation cuttings and thinnings and remove and destroy slash.

Lachnellula Canker of Siberian Pine Understory

Class/Order: Ascomycetes, Helotiales

Pathogen
Lachnellula pini (Brunch.) Dennis

Hosts
Species of pine (*Pinus*), including Siberian stone (*P. sibirica*), mountain (*P. pumila*), and Scots (*P. sylvestris*)

Diagnosis
Disease development is perennial. The first symptom is significant pitching on stems and branches. Beneath the pitch are small shallow splits in the bark. The wounds deepen but remain covered by pitch (**Fig. 27a**). Dead bark and pitch sloughs, forming open target-like cankers. Cankers occur along the entire length of main stem, but are more common in the middle and lower portion. Cankers also occur on branches. Apothecia, which are cup-like, on short stalks, form aggregately during all stages of canker development. They are covered with short brown hairs. The disks are bright-orange, 2-5 mm in diameter (**Fig. 27b**). Asci are cylindrical, 105 x 20 µ. Ascospores are colorless and ellipsoidal or egg-shaped. Young ascospores are 1-celled; mature ascospores are 2-celled, 10-13 x 5-6 µ. In dry conditions, apothecia are closed and appear as small, brown triangles on the bark of the same color. In moist conditions, apothecia open; they are bright-orange and highly visible.

Biology
Infection occurs by ascospores penetrating woody tissues through natural openings in the bark as well as mechanical injuries, including attacks by insects. The disease occurs over a range of site conditions, but understory plants are affected less than fully insolated trees. The level of disease ranges from 11-56 percent on shaded trees and from 76-85 percent on fully exposed (to the sun) trees. Needles weakened by this canker fungus often are infected by Lophodermium needle cast (*Lophodermium pinastri* Chev.), which affects both cedar and mountain pine.

Damage
Causes decline and death of stone pine undergrowth and mountain pine. Affected mountain pine range from 15-85 percent. In undergrowth, about 50 percent of the plants are weakened and up to 40 percent are killed. Infected stone and mountain pine are susceptible to bark beetle and borer attacks, which accelerate decline and mortality and increases the susceptibility of branches to snow breakage.

Distribution
Northwestern part of Europe, Southern area of Siberia, Kamchatka

Figure 27a,b.—Canker on *Pinus pumila* caused by *Lachnellula pini*:
a) initial stage of development; b) fruiting bodies on dead tree.

Control

• No control methods have been developed.

Stem Rust of Pine

Class/Order: Basidiomycetes, Uredinales

Pathogen

Cronartium ribicola Ditr.

Hosts

Species of pine (*Pinus*) including Siberian stone (*Pinus sibirica*), white (*P. strobus*); occasionally, Austrian (*P. nigra*), Swiss stone *(P. cembra)*, and Korean *(P. koraiensis)*

Diagnosis

Initially, the pathogen develops on needles and causes yellow spots to develop. Later, the base of the needle swells and turns orange-yellow. Brown spermogonia form at the base of needles; aecia later develop at the same site. Distinct blister-like aecia are yellow-orange, about 10 mm long and 0.5-0.7 mm high. They release smooth, round or angular aeciospores with colorless walls and orange contents, 22-29 x 18-22 μ. Hypertrophied areas form on the stems and branches (**Fig. 28**) and gradually become open cankers.

Figure 28.—Blister rust on pine (*P. sibirica*) caused by *Cronartium ribicola*. Blister-like asci on the stem are visible.

Biology
Aecia develop on pine in spring or early summer. Mature aeciospores are released and infect species of *Ribes*. Numerous orange, cushion-like uredinia form on the undersides of *Ribes* leaves and produce urediniospores that reinfect *Ribes* leaves during the summer. In late summer, telia form on the same leaves. Telia have a columnar structure, about 3-4 mm high, and cover the entire lower surface of the leaf. After a short resting period, teliospores germinate and produce basidia with basidiospores from the end of summer to late autumn. Basidiospores infect the pine species.

Damage
Causes weakening and dieback of seedlings in nurseries, young forest plantations, understory trees, and trees in parks, squares, and botanical gardens. Lower branches die back rapidly. Damage of seedlings in nurseries can reach 60 percent.

Distribution
European part of Russia and Siberia

Control
Observation
- Survey in early summer for aecia on stems and twigs.

Cultural
- Create mixed-species pine plantations.
- Choose sites for new nurseries and pine plantations in areas without *Ribes* species and eliminate *Ribes* species near pine nurseries and plantations.
- Prune diseased branches (twigs) on plants when rust cankers first appear.

Broom Rust of Fir

Class/Order: Basidiomycetes, Uredinales

Pathogen
Melampsorella cerastii Wint.

Figure 29.—Broom rust of fir (*Abies alba*), caused by *Melampsorella cerastii*. Stem swelling is visible.

Hosts

Species of fir (*Abies*) including silver *(A. alba),* Siberian *(A. sibirica),* balsam *(A. balsamea),* concolor *(A. concolor),* Nordmann *(A. nordmanniana)* and Sachalin (*A. sachalinensis*).

Diagnosis

The pathogen causes galls or spindle-shaped swellings to form on branches (**Fig. 29**). Longitudinal cracks develop on these swellings and gradually widen and deepen. Damaged bark later sloughs off. Several galls may form along the stem. Numerous "witches'-brooms" are produced (**Fig. 30**). Spermogonia and aecia develop along the primary rib on needles of the broom. Aecia are round or cylindrical, orange, small, cushion-like. Aeciospores are globose or elliptical, orange, with colorless walls, 16-30 x 14-20 µ. Damaged needles of witches'-brooms usually drop in winter.

Biology

In spring, needles are infected by basidiospores formed from telia produced on the previous-year leaves of chickweed species *Stelliaria* and *Cerastium*. Initially, the fungus damages young shoots and twigs and causes slight spindle-shaped swellings. The next-year buds on the diseased twig produce numerous short shoots called witches'-brooms. From the infected twigs, mycelium penetrates into the stele, develops for several years, and causes galls to develop. The galls grow slowly, can become large, and encircle the stem. Depending on the region, in mid- to late summer, aecia develop on the needles or on short shoots of witches'-brooms. The orange aeciospores are wind dispersed to the leaves of the alternate host plant, where uredinia and telia develop. Telia overwinter on the dead leaves of the alternate host and teliospores germinate in spring, producing basidia and basidiospores.

Figure 30.—Broom, caused by *Melampsorella cerastii* on a young fir (*Abies nordmanniana*).

Most rust infection occurs in clean, low-density fir stands, in stands where the alternate host predominates as ground vegetation, in small woodlots near housing settlements, and in gardens near the forest edge.

Damage
Infected understory trees have stunted growth and branch breakage is significant. Infected mature trees do not show symptoms for several decades. Diseased trees can have a dry crown or dry top. Cankers can be colonized by decay fungi such as *Phellinus hartigii* (Allesch.. et Schnabl.) Pat., *Pholiota adiposa* (Fr.) P. Kumm., and *Hericium corolloides* (Scop. Fr.) Gray. Wounds from cankers and decay development can cause considerable losses of merchantable wood. Infection also promotes colonization of the stem by insects (bark beetles, borers, and weevils). The most serious insect pest is the bark weevil *Pissodes piceae* Tll. Insects attack living tissue near dead margins of cankers and increases the susceptibility of branches to wind breakage.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
• Conduct salvage cuttings in disease centers and remove dead, suppressed, and infected trees.

Perennial Nectria Canker

Class/Order: Ascomycetes, Hypocreales

Figure 31.—Cankers caused by *Nectria galligena* on the trunk of a maple (*Acer platanoides*).

Pathogen
Nectria species, including *N. galligena* Bres., *N. ditissima* Tul., and *N. coccinea* (Pers.: Fr) Fr.

Hosts
Species of maple (*Acer*), beech (*Fagus*), oak (*Quercus*), apple (*Malus*), pear (*Pyrus*), hornbeam (*Carpinus*), poplar (*Populus*), and plum (*Prunus*)

Diagnosis
Cankers form on stems and branches; several may occur on the same tree. Initially, cankers are closed but later the bark cracks and sloughs off, exposing the wood. Infection occurs annually, giving the wood a "target-like" appearance (**Fig. 31**). White, cushion-like sporodochia of the conidial stage form between the bark cracks. Dark-red perithecia develop singly or in groups at the same site. Conidia are colorless, cylindrical, straight, with several septa, 54-62 x 5-6 µ. Asci are clavate. Ascospores are colorless, ellipsoid, 2-celled, 15-21 x 6-8 µ.

Biology
Conidia develop in spring and autumn during moist periods. Maturation and dispersion of ascospores may occur throughout the year. Ascospores overwinter and do not lose germinative power and viability. Ascospore discharge occurs after rain and fog. Spores penetrate into tree tissues at the juncture of dead branches with the stem or in cracks in dead bark. Sunscald, frost, mechanical damage, and insect injury can kill the bark. Long summers and mild winters with high levels of precipitation favor disease development.

Damage
Weakens but rarely kills trees. Fruit orchards suffer extensive damage. In beech understory, weakness and stem breakage occur near the canker. In addition, the cankers are colonized by wood-decay fungi.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
<u>Cultural</u>
- Conduct timely sanitation cuttings and thinnings and remove and destroy felling residues.
- Create mixed stands and maintain optimal stand density.
- Minimize mechanical injuries during tending activities.

Black Hypoxylon Canker

Class/Order: Ascomycetes, Sphaeropsidales

Pathogen
Hypoxylon pruinatum (Kl.) Cke.

Hosts
European aspen (*Populus tremula*), white poplar (*P. alba*), and poplar hybrids from the Aegeiros and Tacamahaca selections

Diagnosis
Affects the bark, cambium, and wood of stems and branches. Initially, bark in lesion areas is slightly red. Later, it becomes blistered and cracked, and white liquid flows from the cracks. Cankers form gradually. They are irregularly elongate and extend along trunks and branches a length of 1-1.5 m. The conidial structures develops in bark in 1-1.5 years. They are dark-brown, blister-like pillars, up to 1 mm tall. Conidiophores with conidia form on them. In about 3 years after infection, black, smeared stromata develop inside the bark. Stromata, which are gray-black, multiangular, and up to 1 cm in diameter, contain groups of perithecia (**Fig. 32**). Perithecia are globose or bottle-like, completely immersed in the stromata. Asci are oblong, with stalks, 50-62 x 4-6 μ. Ascospores are elliptic, black, 1-celled, 10 x 6 μ.

Biology
Infection is initiated by both conidia and ascospores. Conidia form from May to August. Ascospores mature and actively discharge in high humidity during late autumn and early spring. The fungus infects tree tissues through injuries to the bark, including those from insects. Poplar species and hybrids differ in degree of resistance, which depends on bark moisture, chemical composition of cell sap, and physical properties of the bark. Disease outbreaks occur in a range of forest site conditions.

Damage
Weakens trees and causes dieback in natural stands, plantations, and urban street plantings. Diseased trees in stands can reach 40 percent. The disease also promotes extensive wind breakage of branches.

Distribution
European part of Russia, Urals, Siberia

Control
<u>Cultural</u>
- Conduct timely sanitation cuttings and remove and destroy felling residue.

Cytophoma Canker of Ash

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Cytophoma pulchella (Sacc.) Guthn.

Figure 32.—Hypoxylon canker of trembling aspen (*Populus tremula*) caused by *Hypoxylon pruinatum.*

Host
European ash (*Fraxinus excelsior*)

Diagnosis
Mycelium develops in trunks in the bark tissues, including cambium, but does not colonize the wood. Initially, oval, sunken, dark areas of bark form on the trunks. Later, the margins of the infected area split and boundaries are sharply defined. Dead bark in the center of the wound remains attached to the wood and does not slough off. As many as 8 cankers can form on one trunk. Stromata with numerous pycnidia develop in the dead bark and appear as dark tubercles. Spore masses that exude from the pycnidia resemble dirty-green ribbons. Spores are alantoid, colorless, 4-6 x 1-2 µ.

Biology
The disease is most severe in weakened stands. Conidia are dispersed by wind, rainwater, and insects. Infection occurs through old dead branches, leaf scars, and bark injuries.

Damage
Weakens and occasionally causes dieback of trees 7-15 years old. Coppice stands are damaged severely; up to 80 percent of the trees may be affected.

Distribution
Southeastern area of the European part of Russia

Contents

Control

Observation

- Survey stands during summer to locate new and developing disease centers.

Cultural

- Timely remove affected dying and dead trees.
- Destroy felling residue as a source of inoculum.
- Create optimal conditions for plantation growth.

Wood-Decaying Diseases

Annosum Root and Butt Rot

Class/Order: Basidiomycetes, Aphyllophorales

Pathogen

Heterobasidion annosum (Fr.) Bref. (syn. *Fomitopsis annosa* (Fr.) Karst.)

Hosts

Species of fir (*Abies*), spruce (*Picea*), pine (*Pinus*), larch (*Larix*), arborvitae (*Thuja*), beech (*Fagus*), and birch (*Betula*)

Diagnosis

In pine stands, existing disease centers are characterized by weakened and dying trees, previous-year dead trees, and tipped and windthrown trees. Group mortality and blowdown occur and grassy glades develop in the opening (**Fig. 33**). Disease centers in grassy glades have relatively distinctive boundaries. These boundaries enlarge each year and new dying trees appear on the edges. Individual grassy glades coalesce and the stand becomes an open forest. By contrast, infected fir and spruce remain alive for a long time even though considerable decay develops in their roots and stems. Symptoms of infection are visible and include a reduction in radial and terminal growth, thin-crowned trees with dull green and brown shade-needles, and shoot deformities. In spruce stands, the disease often is concealed until tree mortality occurs as a result of blowdown. Conspicuous disease centers and grassy glades do not form in spruce stands as they do in pine stands (**Fig. 34**).

Disease characteristics and symptoms vary with different hosts. In pine, decay develops in the root system. In the first stage of infection, abundant resin exudes from the affected resin vessels in the roots. Resin-soaked root wood is a red-orange, sometimes lilac, becomes crystalline, and has a turpentine order. Resin accumulates under the bark on roots of diseased trees, then exudes to the surface where soil and other debris become entrapped, forming hard resin galls on the roots. As decay develops, the resin gradually disappears and the infected wood turns uniformally yellow. Small, white flecks of cellulose may be scattered throughout the wood. The final stage is characterized by the formation of numerous small pockets, and the wood becomes bastlike, stringy, and crumbles.

In fir and spruce, the fungus initially spreads in roots and then extends up the stem causing heart rot, which is bordered by a lilac-gray ring. The fungus grows about 3 to 4 m up the trunk but can reach 10 m. Initial decay is characterized by the gray-violet color of the wood, which later turns red-brown. In the final stage, wood is typically mottled, with relatively large white cellulose pockets and typical black specks. The decayed wood has a pocket-laminated structure and crumbles easily when dry.
The most reliable sign is the presence of the basidiocarps on the roots and root-stem base. They form usually in shady places, on the lower surfaces of decaying roots of windthrown trees, sometimes at the base of dead tree stumps, and on the partially decayed butts. Basidiocarps differ in shape and size. They are thin and perennial (**Figs. 35-36**). The surface is brown, with a light-brown margin and concentric furrows. The hymenophore is initially white and later yellow with a silky shine. Pores are tiny, round or angular, sometimes sloped.

Biology

Initial infection occurs by basidiospores and conidia of the fungus. Basidiospores develop in basidiocarps; conidia develop on the mycelium on the surface of decaying parts of infected stumps or roots. The spores are dispersed by air, water, and animals (primarily insects). Spores are transported to roots and, especially on mechanically wounded roots, infect them. Mycelium develops in roots and decay begins. The pathogen develops in both living and dead wood on colonized roots, stumps, and

Figure 33.—Annosum root rot (*Heterobasidion annosum*). Dead and dying trees are in a 25-year-old plantation of pine (*Pinus sylvestris*).

Figure 34.—Disease gap caused by *Heterobasidion annosum* in a spruce (*Picea abies*) stand.

woody debris in forest litter. If spores settle on freshly cut stumps (e.g., after thinnings), they germinate and mycelium spreads in stump wood and extends to the roots. The disease also spreads by secondary infection of living-tree roots by direct mycelial transfer at contacts of healthy and diseased roots. Tree infection also is initiated through dead rootlets or dead ends of deep roots.

The disease occurs in nearly every forest site except swamps; bog (sphagnum) and lichen (cladina) pine stands are rarely infected. Stands of various age are affected. Initial symptoms may be visible in 15- to 20-year-old stands. Seedlings of conifers that develop in disease centers also are subjected to potential infection and death. Homogenious conifer stands suffer the most damage, especially forest plantations established on former agricultural soil, waste grounds, or areas previously affected by the fungus. The disease is rare in natural pine stands. However, spruce and fir are damaged severely both in forest plantations and in natural stands. Mixed coniferous-hardwood stands are more resistant to the disease. Excessive stand density with closely interlaced and grafted roots promotes rapid infection, development, and fungal spread. In suburban forests and parks, recreation use causes root injury, soil compaction, and poor soil aeration, predisposing trees to infection and disease development.

Damage

Causes massive decline and death of stands and significant changes in stocking. In spruce and fir, significant decay may extend up the trunk from the roots and the value of the butt log is significantly reduced. Losses of merchantable volume may reach 50 percent in spruce and 75 percent in fir. Weakening and decline of infected trees usually results in bark beetle and wood-borer infestations.

Figure 35.—Young basidiocarps of *Heterobasidion annosum* on the trunk of a young pine (*Pinus sylvestris*) tree.

Figure 36.—Basidiocarps of *Heterobasidion annosum* on an old spruce (*Picea abies*) stump.

Consequently, disease centers also become outbreak centers for destructive insects. This intensifies stand decline.

Distribution
Throughout Russia

Control
<u>Observation</u>
• Survey for disease centers during normal stand assessments.
<u>Cultural</u>
• Conduct thinnings and sanitation cuttings in diseased stands or those predisposed to the disease.
• Perform reforestation after clear or partially clear sanitation cutting and following agricultural activities using homogenious hardwood and mixed plantations according to forest type, cutting character (features), infection level, and level of young growth. Conifers should not represent more then 30 percent of species composition and the number of planting points should not exceed 5,000/ha. Select species and mixture according to site conditions.
• Plant high quality plant material with well-developed root systems and mycorrhizae.
• Apply fertilizer (chemical) and manure (organics) on poor sandy soils for improving plantation growth and resistance.
• Regulate recreational use in suburban forests.

Figure 37.—*Armillaria mellea* (sensu lato) rhizomorphs under the bark on a spruce (*Picea abies*).

Figure 38.—A mycelial fan of *Armillaria mellea* (sensu lato) on the trunk of a dead spruce tree (*Picea abies*).

<u>Chemical</u>
- Treat stumps after sanitation cuttings with Carbamid, Nitrathen, (NH3)2SO4, ZnCl, and KMnO4.
- Treat the soil with Fundasol simultaneously with sanitation cutting.

<u>Biological</u>
- Treat seedling roots with antagonistic fungi.

Armillaria Root Rot

Class/Order: Basidiomycetes, Agaricales

Pathogen
Armillaria species – *Armillaria mellea* (Vahl.:Fr.) Kummer is the type species

Hosts
Species of fir (*Abies*), spruce (*Picea*), pine (*Pinus*), larch (*Larix*), beech (*Betula*), ash (*Fraxinus*), poplar (*Populus*), oak (*Quercus*), and elm (*Ulmus*)

Diagnosis
The primary signs of disease are the presence of branched, black rhizomorphs (**Fig. 37**) and white leathery mycelial fans that form beneath the bark (**Fig. 38**) in roots and stems. Basidiocarps develop usually in August-October in clusters on dead trees and stumps but can occur on the roots and base of

Figure 39.—Basidiocarps of *Armillaria mellea* (sensu lato) on the trunk of a birch (*Betula pendula*).

trunks of affected live trees (**Fig. 39**). The basidiocarp, which can reach 15 cm in diameter depending on species, is initially convex and later flat with a hillock in the center, yellow-brown or gray-brown, with numerous dark (or the same color) scales. The internal tissue is white and friable, with a pleasant odor. The hymenophore gills are slightly descending and initially white, later darkening. The stipe is central, cylindrical, 10-15 cm long and 1-1.5 cm in diameter, with small scales, white or light-brown and darker on the base, and a white thick fluffy-silk ring (annulus) under the cap. Decayed wood is white or light-yellow, fiberous, with characteristic sinuous black lines. Decay can extend 1-1.5 m up the trunk.

Biology
Basidiospores are dispersed by wind, rainfall, and animals, and germinate and infect stumps and roots of trees. Infection also occurs from root contact with rhizomorphs of the fungus or direct mycelial transfer from diseased to healthy roots. Stands are predisposed to this disease by abiotic and biotic stressors of temperature and moisture extremes, wind, soil compaction, air pollution, and defoliation by frost (abiotic factors), and defoliation by insects and fungi, attacks by sucking insects, and other foliar and stem diseases (biotic factors).

Damage
Causes dieback in a range of stand ages and types. Often develops into an epyphytotic, causing heavy mortality in stands of single-species conifers and in oak and birch stands. The volume of merchantable wood can be reduced by decay.

Distribution
Throughout Russia except mountain highlands, deserts, and tundra sites

Control
Observation
• Survey for disease centers during normal stand assessments primarily in coniferous stands and in stands affected by industrial pollution and other unfavorable factors.

Cultural
• Create mixed stands.
• Conduct sanitation thinnings in young and mature stands; remove diseased, dying, and dead trees to promote the vigorous growth of leave trees.
• Treat individual diseased trees in gardens and urban plantings to maintain high vitality. Selectively remove infected roots where possible.

Chemical
• Treat surface of stumps with fungicides (Topsin-M or Benomil).
Biological
• Treat surface of fresh stumps with inoculum of biofungicides such as *Peniophora gigantea* (Fr.) Mass., *Fomitopsis pinicola* (Sw. ex Fr.) Karst., and *Pleurotus ostreatus* (Fr.) Kamm.

Butt and Trunk Rot of Conifers

Class/Order: Basidiomycetes, Aphyllophorales

Pathogen
Phaeolus schweinitzii (Fr.) Pat.

Host
Species of spruce (*Picea*), pine (*Pinus*), larch (*Larix*), and, more rarely, fir (*Abies*), oak (*Quercus*), and hazel (*Corylus*)

Diagnosis
Basidiocarps develop at the base of stumps and on roots of old-growth trees (**Figs. 40-41**). They are annual, flat or funnel-shaped, thick, with yellow or brown caps, with or without a short tuber-like stalk. The upper surface is velvety-hairy, with indistinct zones lines. Internal tissues are soft-corky or spongy, rust-brown. Hymenophore tubes are short, with conspicuous angular (sometimes split) pores, rust-brown with a green shade. The decay of heartwood extends 2 to 3 m up the trunk (**Fig. 42**). Initially, infected wood is slightly dark with a red shade, later turning brown. Cracks form in decayed wood along the rays and annual rings. White, thin mycelial fans form in cracks. Decayed wood has a turpentine odor.

Biology
Living roots are infected by basidiospores or mycelium from previously infected roots. Basidiocarps form usually when moisture is high. Forest stands less than 60 years old are affected.

Damage
Causes dieback and windthrow of trees. The merchantable volume of the butt log may be reduced. Damaged trees range from 5-10 percent.

Distribution
European part of Russia, Siberia, Urals, Far East

Control
Cultural
• Conduct santitation cuttings to remove infected trees.
• Create mixed stands using resistant tree species of birch (*Betula)*, lime *(Tilia)*, and maple *(Acer)*.

♦♦♦

Pathogen
Phellinus pini (Thore: Fr.) A. Ames

Hosts
Species of larch (*Larix*) and pine (*Pinus)*, including Scots *(P. sylvestris)*, white *(P. strobus)*, Siberian *(P. sibirica)*, and Swiss mountain *(P. montana*)

Figure 40.—Basidiocarps of *Phaeolus schweinitzii* at the base of a pine (*Pinus sylvestris*) tree.

Figure 41.—Basidiocarps of *Phaeolus schweinitzii* on an old pine (*Pinus sylvestris*) stump.

Diagnosis

Basidiocarps are thick, hoof-like, or flat. They are woody and perennial, sometimes reaching 50 years of age. The upper surface is dark-brown, rough, with concentric rings and numerous radial cracks, often covered with lichens. Interior tissue is woody and yellow-brown. The hymenophore also is yellow and has large angular and labyrinth-like pores. Initially, infected wood is red-brown. Decay with pocket-like structures and white cellulose fibers form later. Cracks often arise in conjunction with annual rings. The fungus decays primarily the interior part of the trunk from 2-10 m. These tissues contain the least protective resins.

Biology

Infection by windborne basidiospores occurs in autumn through broken branches on 50- to 60-year-old trees with significant heartwood and many dying lower branches. Infection increases with the age of the stand. Pine stands in a range of growth conditions are susceptible to the disease. Disease incidence is higher in open pine stands, where branch shedding is poor. Trees are predisposed to disease by anthropogenic factors such as resin tapping, recreational activities, ground fire, and grazing.

Damage

Reduces trunk resistance to wind resulting in wind breakage. Decay reduces the merchantable volume of the butt log; commercial wood losses range from 20-60 percent. Disease in pine stands ranges from 10-60 percent.

Figure 42.—Wood decay caused by *Phaeolus schweinitzii*.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Maintain closed stands to promote rapid shedding of branches in young and middle-aged stands.
- Conduct timely thinnings to remove weakened and suppressed trees.

♦ ♦ ♦

Pathogen
Phellinus chrysoloma (Fr.) Donk (syn. *Phellinus pini* (Thore:Fr.) Pil. *var. abietis* (P. Karst.) Pil.

Host
Primarily species of fir (*Abies*), spruce (*Picea*), larch (*Larix*) and pine (*Pinus*)

Diagnosis
Perennial basidiocarps form on branches. They are thin, sometimes overlapping in clusters, more rarely resupinate (**Fig. 43**). The upper surface has deep concentric ridges, is roughened, and initially is sorrel, turning gray-black with age. The margin is thin. Interior tissue is hard, red-brown, 1-3 mm thick. The hymenophore has large winding, labyrinth-shaped pores covered with gray, fur-like mycelium. Decayed heartwood is initially light-purple and later red-brown. Decay develops rapidly and wood typically becomes mottled with well-defined pockets of white cellulose.

Biology
Infection occurs by windborne basidiospores through broken dead branches, scars, and other wounds. Trees 40 years old or older can be infected. Basidiocarps form on trees about 10 years afer infection. Disease occurs in a range of growth conditions and incidence increases with age.

Damage
Affected trees are weakened at the ground line and break mostly in response to wind. Decay can affect 50 percent of butt log volume, destroying most of the merchantable wood. Damage in spruce stands ranges from 10-15 percent.

Figure 43.—Basidiocarps of *Phellinus chrysoloma* on spruce (*Picea abies*) bark.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Thin young stands to create biologically sustainable stands with optimal density.
- Conduct regular sanitation cuts in mid-rotation and maturing stands; remove dead and windthrown trees and/or low-vigor trees with fungal basidiocarps.
- Minimize tree wounds during tending practices.
- Regulate populations of hoofed animals, primarily elk (*Alces alces*), foraging in the forests.
- Remove basidiocarps and treat cavities in trees in parks and urban forests.

♦♦♦

Pathogen
Onnia triqueter (Lentz.:Fr.) Imaz. (syn. *Polystictus circinatus* (Fr.) P. Karst. var. triqueter Bres.)

Host
Primarily species of spruce (*Picea*) but also larch (*Larix*) and pine (*Pinus*)

Diagnosis
Basidiocarps are annual, cap-like, with or without a short stalk, and occur individually or in clusters. The caps are thin, flat, yellow-brown, with sharp margins, and hairy when young. Interior tissue is dark-brown. The hymenophore is tubular. Tubes are short, with small gray or brown pores. Basidiocarps occur on the trunk about 70 cm above ground. On severely decayed trees, basidiocarps

Figure 44.—Basidiocarps of *Phellinus hartigii* on fir (*Abies sibirica*).

can be at 1.5 m on the trunk. The fungus causes heartwood or heartwood/sapwood decay, which usually moves both downward into the roots and 2 to 4 m up the stem. Resin exudation often occurs on diseased trees. Initially, affected wood is yellow. Light-brown spots and pockets with white mycelium form later. In final stage of decay, the wood has pocket-fibrous structure.

Biology
Infection occurs by basidiospores at wounds on dead broken branches and scars in the root-stem base. Major basidiospore production and spread occurs from May to September. Overmature spruce stands are the most seriously affected.

Damage
Causes susceptibility to windthrow and breakage. Merchantable wood in the butt log is destroyed and commercial losses range from 17-50 percent.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
- Conduct sanitation cuttings to remove infected and dead trees.
- Minimize damage to the trunk and roots during fellings.

♦♦♦

Pathogen
Phellinus hartigii (Allesch. et Schnabl.) Pat.

Host
Primarily species of fir (*Abies*) but also spruce (*Picea*) and pine (*Pinus*)

Diagnosis
Basidiocarps about 4-15(L) x 8-28(W) x 8-20(T) cm are perennial, hard, hoof-shaped, with thickened-rounded margins sometimes with wide concentric zones and radial cracks. The surface is yellow-brown, often gray or black with light edges (**Fig. 44**). The hymenophore is tubular, rusty-brown, with inconspicuous round pores. Tubes are stratified, with layers of sterile mycelium between stratums. Interior tissue of the basidiocarp is rusty-brown and woody. Heartwood and sometimes sapwood is

Figure 45.—Wood decay on a broken fir tree (*Abies sibirica*) caused by *Phellinus hartigii.*

decayed. Affected wood initially is red-brown, later turning dark-pink. Dark-brown conglomerations of mycelium form under the bark. In later stages of decay, the wood turns light-yellow and is soft and fibrous (**Fig. 45**).

Biology
Infection is by windborne basidiospores that penetrate tree tissues through broken dead branches or various mechanical bark injuries or canker wounds, including those caused by the rust fungus *Melampsorella cerastii* Wint. Infection occurs in mature and overmature stands over a range of site conditions.

Damage
Decay weakens the root-stem base and promotes wind breakage. It can spread up to 8 m in the stem and significantly reduces the volume of merchantable wood. Decay in fir stands ranges from 10-70 percent depending on the region in Russia.

Distribution
Southeastern area of the European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Conduct sanitation cuttings in midrotation and older stands.
- Remove felling residue and windthrown timber.

♦ ♦ ♦

Pathogen
Fomitopsis officinalis (Will.) Bond. et Sing.

Hosts
Primarily species of larch (*Larix*), pine (*Pinus*), especially Siberian (*Pinus sibirica*), and fir (*Abies*)

Diagnosis
Basidiocarps about 3-15 x 5-30 x 4.5-26 cm are perennial, hoof-shaped, or elongate cylindrical. The soft upper surface is white or yellow, sometimes with dark-gray areas, covered with cracks. Interior tissue is white or creamy and soft when dry. The hymenophore is yellow. Tubes are 5-10 mm long,

with inconspicuous, round or angular pores. Affected wood initially is light-brown but later turns dark-brown. In the final stage of decay, wide cracks associated with annual rings form in the wood. Creamy-white, thick, velvety mycelial sheets develop in the cracks. The decay is cubical rot. It develops primarily in the heartwood but can colonize sapwood. It can spread 15-20 m upward in the trunk.

Biology
Infection occurs by basidiospores that penetrate tree tissues through broken dead branches and various trunk injuries. Trees more than 30 years old are affected. The disease level increases with age. The fungus affects living trees but can continue developing and remain on dead trunks and stumps for extended periods. The disease occurs over a range of site conditions.

Damage
Trees are weakened at the root-stem base and break at the ground line during windstorms. Most of the diseased trees have dead tops. Damage in larch stands ranges from 5-10 percent.

Distribution
Urals, Siberia, Far East

Control
Cultural
- Conduct sanitation cuttings to remove weakened, dying, and dead trees.

♦♦♦

Pathogen
Fomitopsis pinicola (Sw. et Fr.) Karst.

Hosts
Primarily species of fir (*Abies*), larch (*Larix*), spruce (*Picea*), and pine (*Pinus*); also birch (*Betula*), lime (*Tilia*), alder (*Alnus*), and European aspen (*Populus tremula*)

Diagnosis
Basidiocarps are perennial, hoof-shaped, with a cushion-like or flat bottom. They differ in size but can reach 0.5 m in diameter. The upper surface of the young basidiocarp is yellow-red or rusty but with age turns red-brown to nearly black with a slightly shiny crust. The margin is edged by a yellow, bright-red, or dark-cherry band. The hymenophore is yellow-white, tubular, with relatively large, round pores. The interior tissues are light-yellow and corky or woody. Decay begins in the sapwood of the stem and spreads rapidly to the central core where it spreads slowly up the trunk. In the early stage of decay, wood is yellow-brown with a silky sheen; later, white stripes of fungal hyphal form in the wood. In the final stage of decay, wood turns dark-brown with numerous cracks filled with white sheets of mycelium. The decay is a typical cubical rot.

Biology
Infections of living trees occur primarily at wounds from mechanical injury. Basidiocarps form several years after infection.

Damage
Primarily a saprotroph but can cause significant economic loss in logs left in cutting areas or stored in timber yards. The fungus decomposes wood on the forest floor, accelerating the return of nutrients to the soil. Occasionally, the fungus infects living, weakened trees, predisposing them to wind breakage. Proportion of infected trees in a stand rarely exceeds 3 percent.

Distribution
Throughout Russia except deserts, semideserts, and tundra

Control
- Prompt removal of harvested wood from the forest.

Class/Order: Basidiomycetes/Agaricales

Pathogen
Pholiota adiposa (Fr.:Fr) Kumm.

Hosts
Primarily species of fir (*Abies*), spruce (*Picea*), pine (*Pinus*), and larch (*Larix*); also alder (*Alnus*), birch (*Betula*), beech (*Fagus*), poplar (*Populus*), and lime (*Tilia*)

Diagnosis
Basidiocarps are annual, cap-shaped, 4-15 cm in diameter, with a central or lateral stalk, 2-3 cm, often forming in clusters (**Fig. 46**). Caps are round, usually convex, with central hillock, and fleshy. The upper surface is sticky, golden-yellow or brown-yellow, with rare brown scales that disappear with time. Interior tissue is yellow-white. The hymenophore has gills that are dense, wide, and brown-yellow. The stalk is compact, white, darker and thicker in the lower part, with membranous rings and scales. Decay develops in the heartwood and spreads in the butt part of the stem up to 5 m and sometimes penetrates the roots. In the early stage of decay, wood appears yellow, and then turns brown. Small pockets and narrow channels with rusty-brown mycelium form in the wood. Cavities sometimes form in the final stage of decay.

Biology
Infection occurs by basidiospores through broken branches and stem injuries. In fir stands, the fungus penetrates into tree tissues primarily through wounds caused by the canker fungus *Melampsorella cerastii* Wint. Stands affected by the fungus range from 10-50 percent.

Damage
Causes susceptibility to wind breakage. Trees are weakened when decay spreads to the roots.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Cultural
- Conduct timely sanitation cuttings to remove weakened, dying, and dead trees.
- Remove trees infected by *M. cerastii.*

Figure 46.—Basidiocarps of *Pholiota adiposa* on the trunk of a spruce (*Picea abies*).

Figure 47.—Basidiocarps of *Laetiporus sulphureus* on the trunk of a larch (*Larix sibirica*).

Trunk and Limb Rot of Hardwoods

Class/Order: Basidiomycetes, Aphyllophorales

Pathogen
Laetiporus sulphureus (Bull.) Bond. et Sing.

Host
Primarily hardwoods species of maple (*Acer*), chestnut *(Castanea),* beech *(Fagus),* poplar *(Populus),* lime *(Tilia),* willow *(Salix),* and oak *(Quercus);* some conifers species of fir *(Abies),* larch *(Larix),* spruce *(Picea),* and pine *(Pinus)*

Diagnosis
Basidiocarps are annual, usually in clusters, often with a common base (**Fig. 47 and 48**). Individual basidiocarps have flat to slightly round caps about 10-40 cm in diameter and 1-4 cm thick. Initially, they are soft and fleshy but later become hard and brittle. The upper surface is light-yellow or pink-orange; interior tissues are light-yellow, almost white. The hymenophore is tubular and gray-yellow. Tubes, about 4 mm long, have round openings initially but later become angular. Decay develops in the healthy part of the trunk. It usually is found in the lower 2-3 m but can extend upward to 15 m. In the early stage of decay, wood is pink with thin, white streaks and dots. Later it turns dark red-brown, develops cracks in annual rings, and typically becomes cubical. Compact, velvety, yellow-white mycelial sheets are formed in the cracks.

Biology
Infection occurs by basidiospores through broken branches, wounds, and burn scars, primarily on mature and overmature trees. The basidiocarps develop from early to midsummer and begin sporulating. By autumn, most are destroyed by insects that inhabit them. The fungus attacks living trees but can continue to develop for 2 to 3 years after tree death. Basidiocarps are produced abundantly in high humidity.

Damage
Decay develops in trunks of living trees, causing weakening at the root-stem base and predisposing trees to wind breakage. Trees may dieback and become hollow. Decay in oak stands affected by the

Figure 48.—Basidiocarps of *Laetiporus sulphureus* on the trunk of an oak (*Quercus robur*).

fungus occurs in 10-50 percent ot the trees; up to 20 percent of larch stands are affected. Commercial wood losses can exceed 20 percent.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Cultural
• Conduct sanitation cuttings to remove trees with basidiocarps, as well as dying and dead trees.

♦ ♦ ♦

Pathogen
Inonotus dryophilus (Berk.) Murr.

Host
Species of oak (*Quercus*)

Diagnosis
Basidiocarps, 5-12 x 6-18 x 3-8 cm, are annual, usually hoof-shaped, initially soft and then hard (**Fig. 49**). The upper surface of a young basidiocarp is bright-yellow but with age turns a dark rusty-brown or red-brown. The surface is rough initially but is smooth when mature. The interior tissue is fibrous, light- to dark-brown with a silky shine, about 3 cm thick.

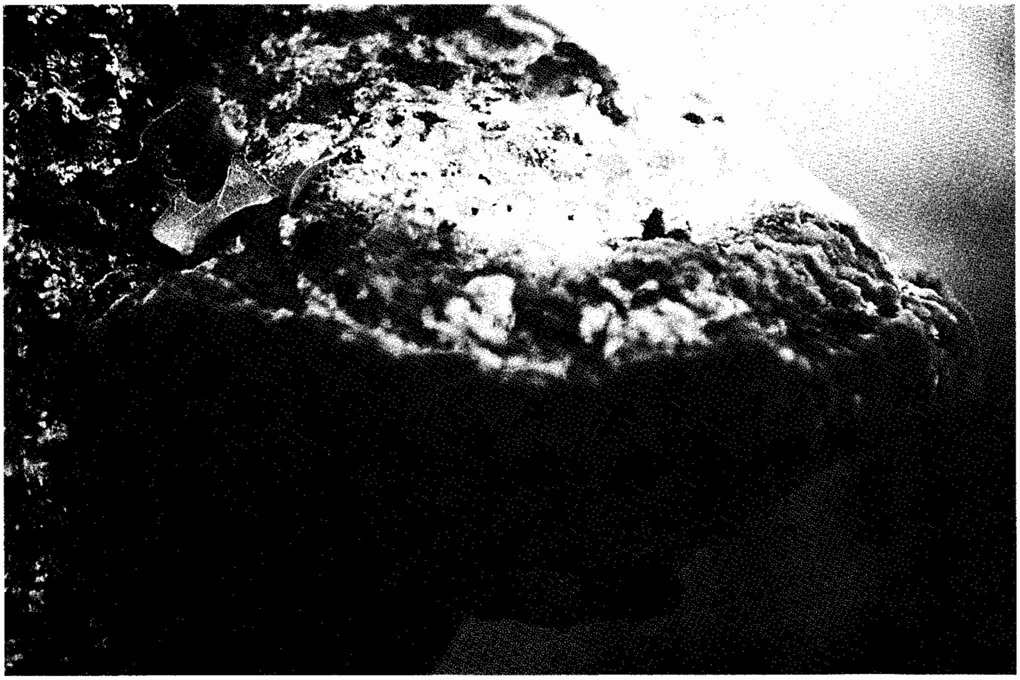

Figure 49.—Basidiocarp of *Inonotus dryophilus* on the trunk of an oak (*Quercus robur*).

The hymenophore is tubular. The tubes are about 0.5-2.5 cm long, brown or rusty-brown, with round or angular openings. Basidiocarps usually appear in June and are soon destroyed by insects. Decay develops in heartwood. Initially, brown spots appear in the infected wood, cellulose masses form in them later and the wood becomes mottled with white spots and elongate lines. In final stage of decay, wood becomes spongy and fibrous.

Biology
Infection is initiated by basidiospores that infect tree tissues through broken dead branches, frost cracks and mechanical injuries. The fungus is characterized as a prolific sporulator. Basidiospores mature and spread from June to October. High temperature and low humidity favors sporulation and dispersion. Oaks are affected at 40 years of age and older.

Damage
Causes crown dieback and radial increment losses. Decayed trees in affected oak stands range from 1-80 percent. Commercial wood losses can reach 70 percent.

Distribution
European part of Russia, Urals, Far East

Control
Cultural
- Create mixed hardwood stands.
- Conduct sanitation cuttings and remove dying and dead trees and trees with basidiocarps and scars.
- Conduct cuttings in October-May to minimize mechanical injury.

♦ ♦ ♦

Pathogen
Phellinus robustus (P. Karst.) Bourd. et Galz.

Hosts
Species of oak (*Quercus*), maple (*Acer*), buckeye (*Aesculus*), and hazel (*Corylus*)

Diagnosis
Basidiocarps are perennial, woody, cushion- or hoof-like, with a thick, wide, rusty margin, about 5-25 cm in diameter and up to 10 cm thick. The upper surface is dark-gray, nearly black, with wide concentric rings and cracks. Interior tissue is rusty-brown, woody, with concentric stripes. The hymenophore is poroid, rusty-yellow. Tubes, lighter in color than surrounding tissues, are about 2-5 mm long, with round openings. Infected wood turns brown and later becomes mottled with lighter flecks. In the final stage of decay, wood is yellow-white with thin, black, parallel lines. Rusty-orange mycelial masses often form in infected wood. The rot is primarily in heartwood but can spread to the sapwood.

Biology
Infection is initiated by basidiospores that mature and spread from June to October. High humidity favors sporulation and dispersion. Basidiospores infect tree tissues through broken dead branches, frost cracks, injuries from hoofed animals, e.g., elk, and mechanical injuries. Stand are affected at 20-30 years of age, infection and damage increase with age. Disease levels are highest in coppiced stands.

Damage
Causes tree weakening, partial crown decline, and wind breakage. Commercial wood losses range from 30-40 percent. Affected oak in stands range from 5-15 percent.

Distribution
European part of Russia, the southen Urals, Western Siberia, Far East

Control
Cultural
- Create mixed hardwood stands.
- Conduct timely thinnings to maintain optimal density.
- Conduct sanitation cuttings and remove all trees with large wounds/scars.
- Conduct cuttings in November-May when sporulation is scarce or absent.

♦♦♦

Pathogen
Phellinus igniarius (L.: Fr.) Quel.

Hosts
Species of maple (*Acer*), birch (*Betula*), hornbeam (*Carpinus*), buckeye (*Aesculus*), ash (*Fraxinus*), willow (*Salix*), lime (*Tilia*), elm (*Ulmus*) {forms: *f. igniarius* on willow (*Salix*), *f. sorbi* on mountain-ash (*Sorbus*), *f. betulae* on birch (*Betula*), *f. resupinatus* on birch (*Betula*), alder (*Alnus*), and mountain-ash}

Diagnosis
Basidiocarps are perennial, woody, hoof-shaped, with a flat or cushion-like bottom, more rarely resupinate, and 3-25 x 2-16 x 1.5-12 cm (**Fig. 50**). The upper surface is dark-gray, sometimes nearly black, with concentric rings. The hymenophore is rusty-brown with inconspicuous round pores. Tubes are stratiform, 3-5mm long, and become overgrown by white mycelium with age. Decay develops in heartwood of trunks. Affected wood is initially red-brown but later turns light-yellow and is separated from healthy wood by a thin, dark-brown ring (**Fig. 51**). A characteristic feature of the decay is the presence of winding black lines that spread as concentric circles in the affected part of wood. The extension of decay up the stem can vary but often occurs the entire length.

Biology
Infection is initiated by basidiospores. Mass sporulation occurs in early summer. Spores penetrate tree tissues mostly through dead limbs but also through bark scars. Trees are infected when they are 20-30 years old. The disease level increases with age. Timely diagnosis is difficult because the decay often develops with no external symptoms, basidiocarp formation, or signs of tree weakening.

Damage
Primarily commercial wood losses that range from 60-100 percent

Distribution
Throughout Russia

Figure 50.—Basidiocarp of *Phellinus igniarius* f. *betulae* on the trunk of a birch (*Betula pendula*).

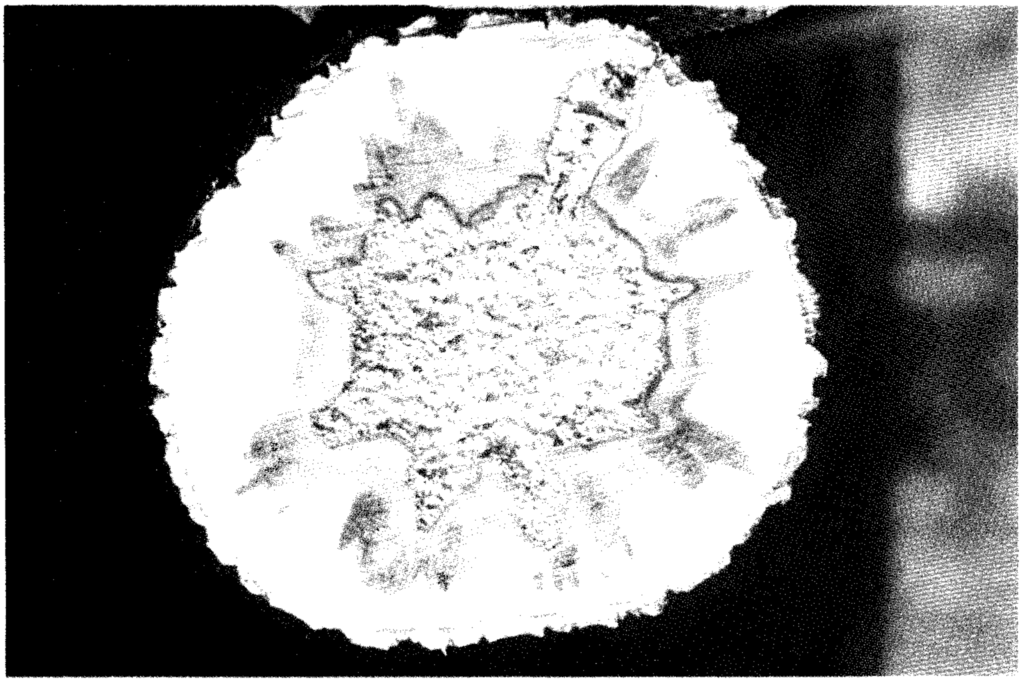

Figure 51.—Decay on birch (*Betula pendula*) caused by *Phellinus igniarius.*

Control

Cultural

- Conduct thinnings to maintain a high stem density, especially in young stands, and to promote intensive natural branching shedding.
- Conduct sanitation cuttings and remove trees with basidiocarps.

♦ ♦ ♦

Pathogen

Phellinus tremulae (Bond.) Bond. et Borisov.

Host

European aspen (*Populus tremula*)

Diagnosis

Numerous basidiocarps usually form on the affected stems. They are perennial, woody, often hoof-shaped, flat or cushion-like, more rarely resupinate, about 12 x 7 x 4 cm. The upper surface is dark-gray, sometimes nearly black, cracked, with concentric ridges. Interior tissue is rusty-brown and woody. The hymenophore is red-brown. Tubes are brown and 2-4 mm long. They become filled with white mycelium with age. Decay is separated from the healthy wood by a narrow dark-gray ring, about 1.5 cm wide. A green-brown zone about 1.5 cm wide usually forms around this ring. Rusty mycelial masses sometimes form in the decayed part of the trunk. Stems become hollow in the final stages of wood decomposition. Decay develops primarily in the middle of the trunk and then spreads to the upper part of the stem and branches, and to the lower part of the stem and roots.

Biology

Infection is initiated by basidiospores released early in the growing season. The main infection courts are dead, partly decomposed branches. More rarely infection occurs through trunk injuries; infection is enhanced if the wound is fresh. Decay develops gradually; the first symptoms appear in wood 2 to 3 years after infection and decay develops most actively in the next several years. The fungus produces basidiocarps 4 to 5 years after infection. In 30- to 40-year old aspen stands, suppressed and stunted trees are affected. Effects of decay increase with stand age. Mature stands are characterized by an accumulation of damage from wind and snow breakage of decayed branches and stems.

Damage

Causes snow and wind breakage, which increases with age. Infected trees in mature aspen stands range from 60-100 percent. Commercial wood losses range from 50-100 percent.

Distribution

European part of Russia, Urals, Siberia, Far East

Control

- Use decay-resistant aspen clones.
- Create mixed stands with other hardwood species.
- Conduct thinnings to maintain optimal growth.
- Conduct sanitation cuttings to remove weakened, dying, and dead trees, particular those with basidiocarps.

♦ ♦ ♦

Pathogen

Inonotus obliquus (Pers.:Fr.) Pil.

Hosts

Primarily species of birch (*Betula*) and alder (*Alnus*) but also maple (*Acer*), beech (*Fagus*), ash (*Fraxinus*), and mountain-ash (*Sorbus*)

Diagnosis

The characteristic feature of the disease is the formation of large sterile conks on living trunks (**Fig. 52**). Conks are black, hard, and woody, with numerous deep fissures. Interior tissue is primarily hard and rust-brown, but can be soft and light-brown with narrow yellow lines. Conks often arise at broken branches and mechanical and other trunk injuries. After tree death, basidiocarps develop under the bark near the sterile conks. They are resupinate, thin, brown, with a tubular hymenophore, can be 3-4 m long and 40-50 cm wide, and decompose quickly.

Figure 52.—Sterile conk of *Inonotus obliquus* on the trunk of a birch (*Betula pendula*).

Biology
Basidiocarps form under the bark and basidiospores are dispersed. Spores penetrate tree tissues through frost cracks, broken branches, and other bark injuries. Mycelium penetrates through the sapwood to the heardwood where active decay develops. Trees 40 years old and older are affected.

Damage
Decay results in significant wind breakage. Affected birch and alder range from 1-5 percent but can reach 20 percent.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
- Conduct sanitation cuttings and remove obviously infected trees with conks.

♦♦♦

Pathogen
Fomes fomentarius (L.:Fr.) Gill.

Hosts
Primarily species of maple (*Acer*), alder (*Alnus*), beech (*Fagus*), ash (*Fraxinus*), chestnut (*Castanea*), poplar (*Populus*), oak (*Quercus*), willow (*Salix*), lime (*Tilia*), and birch (*Betula*)

Diagnosis
Basidiocarps are perennial, hoof-shaped, often more flat or almost hemispherical, 5-20 x 10-40 x 2-20 cm (**Figs. 53-54**). The upper surface is light-gray, sometimes yellow, more rarely dark-gray, smooth, with concentric ridges. Interior tissue is yellow-brown, velvety, compact. The hymenophore is light-rust, tubes are 2-10 mm long, initially gray and then yellow, with round pores filled by white mycelium with age. Decay develops in sapwood and later spreads to heartwood. Affected wood is initially brown but later turns light-yellow, almost white, with numerous black and dark-brown streaks and winding lines (**Fig. 55**). In the final stages of decay, wood becomes light in weight, separates into thin plates along the annual rings, and then becomes stringy and turns to dust.

Biology
Infection is initiated by basidiospores at points of broken dead branches, physical wounds, fire wounds, and other bark injuries. Sporulation occurs from June to September. Decay develops rapidly and by the time basidiocarps are formed, trees are broken easily by wind.

Damage.
Decay results in wind breakage. Volume loss ranges from 5-15 percent and depends on stand age and composition. Commercial wood losses can reach 100 percent.

Distribution
Throughout Russia

Control
Cultural
- Conduct timely sanitation cuttings along with thinning operations.
- Routinely remove dead trees and branches.
- Use standard arboricultural practices to stabilize hollow trees in parks, arboretums, and other areas with valuable stands.

♦♦♦

Pathogen
Polyporus squamosus (Huds.:Fr.) Fr.

Figure 53.—Basidiocarps of *Fomes fomentarius* on the trunk of a birch (*Betula pendula*).

Figure 54.—Basidiocarps of *Fomes fomentarius* on the trunk of a fir (*Abies sibirica*).

Hosts
Primarily species of maple (*Acer*), birch (*Betula*), poplar (*Populus*), oak (*Quercus*), elm (*Ulmus*), and beech (*Fagus*)

Diagnosis
Basidiocarps are annual, 5-50 cm in diameter and 5-10 cm thick, with slightly bent margins, usually on a lateral stalk. The upper surface is slightly depressed, yellow, with large brown scales. The stalk is stout, brown, with a black base. Fresh basidiocarp tissue is white and soft, but after drying turns yellow and becomes brittle. The hymenophore is tubular; tubes are about 1-2 mm long, with large angular pores. Decay occurs mainly in heartwood but can spread to sapwood. It usually develops in the lower part of the trunk but can develop in the roots. In the advanced stage of decay, wood becomes white, often with dark lines, with numerous cracks. In the final stage, affected wood separates into plates and crumbles easily.

Biology
Infection is initiated by basidiospores from basidiocarps that form in midsummer, particularly during years with heavy precipitation. Sporulation also occurs at this time. Spores penetrate tree tissues through injuries such as frost cracks and mechanical wounds. The disease affects older forest trees and is widespread in urban forests.

Damage
Affected trees gradually weaken but few die. Affected trees in stands rarely exceed 5 percent as the fungus mostly decays wood in timber yards.

Distribution
European part of Russia, Urals, Far East

Control
<u>Cultural</u>
- Conduct sanitation cuttings to remove weakened trees.
- Minimize mechanical injuries of trunks during cuttings.
- Remove basidiocarps from trees in parks and street plantings before sporulation.

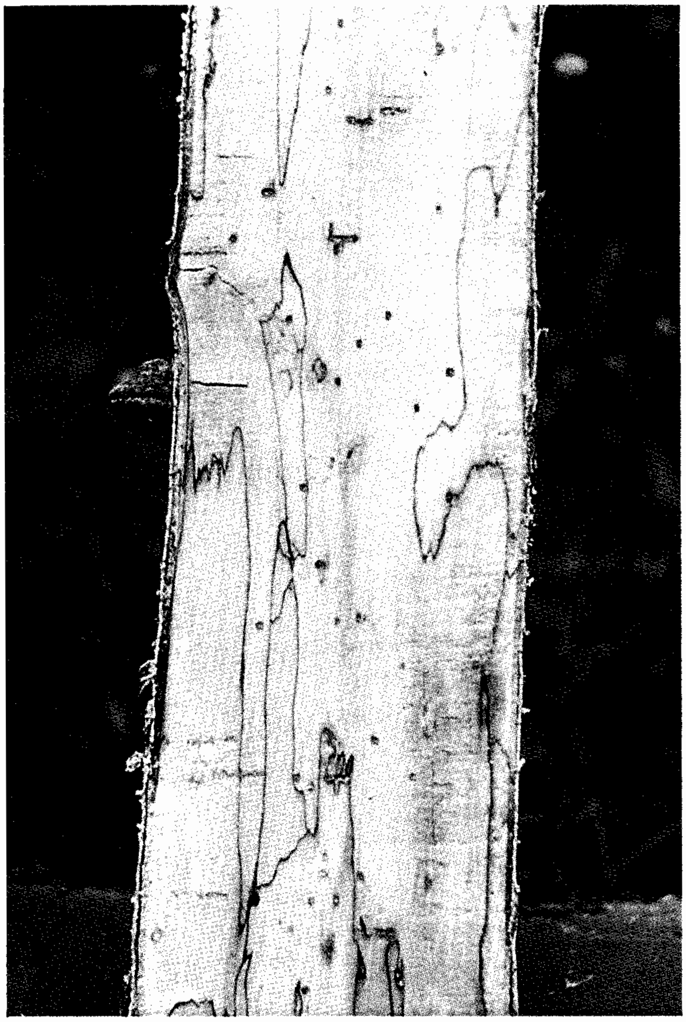

Figure 55.—Initial stage of decay in birch (*Betula pendula*) caused by *Fomes fomentarius.*

Pathogen
Oxyporus populinus (Schum. ex Fr.) Donk.

Hosts
Primarily species of maple (*Acer*), ash (*Fraxinus*), poplar (*Populus*), oak (*Quercus*), mountain-ash (*Sorbus*), lime (*Tilia*), birch (*Betula*), and elm (*Ulmus*)

Diagnosis
Basidiocarps are perennial and occur in clusters on a common base or, more rarely, individually. They are small, 5-15 x 3-5 x 1-2 cm, and have caps with a white, yellow-gray or black upper surface that is covered with green moss. Basidiocarps can be semiresupinate. Interior tissue is white or light-yellow, corky to woody, 2-6 mm thick. The hymenophore is poroid, yellow-white. Tubes are white or yellow, 2-4 mm long, with round or angular pores. In the initial stage of decay, wood is green-brown but later turns a lighter yellow. In the advanced stages, wood breaks apart along the rays. Trunk cavities often form in affected trees. Decay columns can be 5-7 m long but occasionally spread up the entire stem and penetrate the larger branches.

Biology
Infection occurs by basidiospores through frost cracks, dead branch stubs, and mechanical injuries mainly on the lower part of the trunk. The fungus can develop on stumps and woody debris on the forest floor; these can be inoculum sources.

Figure 56.—Basidiocarps of *Daedalea quercina* on an oak (*Quercus robur*) stump.

Damage

Trees are affected in the middle or lower part of the trunk; decay results in cavities and affected trees are susceptible to wind breakage. Infected trees, especially in parks, can reach 80 percent. Decay in the stem base causes commercial wood losses.

Distribution

European part of Russia, middle part of Urals, Siberia, Far East

Control

Cultural

- Conduct sanitation cuttings to remove infected trees.
- Remove woody debris.
- Treat tree cavities in parks and forest parks.

♦♦♦

Pathogen

Daedalea quercina (L.) Fr.

Hosts

Primarily species of oak (*Quercus*) but also beech (*Fagus*) and chestnut (*Castanea*)

Diagnosis

Basidiocarps are perennial, with flat caps, thickened on the base, broadly attached to the trunk, 4-12 x 6-20 x 2-5 cm (**Fig. 56**). The upper surface is light-brown or gray, smooth, with concentric zones. The hymenophore is labyrinth-like. Interior tissue is corky when young but woody with age. Decay develops in the lower part of the trunk and spreads upwards at least 3 m. Decayed wood is dark-brown with a gray shade. In the final stages of decay, narrow cracks form along rays and the wood separates into thin plates. Yellow-gray mycelial sheets develop in the cracks.

Biology

The fungus primarily invades stumps and freshly cut wood but can infect living trees. Infection is initiated by basidiospores through various injuries in the lower part of trunk. Sprouts can be infected not only by basidiospores but also by mycelium developing on the parent stumps. Weak, old and injured trees are most commonly affected.

Damage
Losses of commercial wood volume can reach 8 percent.

Distribution
European part of Russia, the southen Urals, Far East

Control
Cultural
- Conduct sanitation cuttings to remove weakened, dying, and dead trees.
- Remove cut wood from the forest.
- Restrict grazing in forest stands.

♦♦♦

Pathogen
Piptoporus betulinus (Bull.: Fr.) Karst.

Hosts
Birch species (*Betula*)

Diagnosis
Basidiocarps are annual, round or bud-shaped, with a slightly convex upper surface and a blunt rounded margin, with or without a rudimentary lateral stalk, 4-20 x 5-20 x 2-6 cm (**Fig. 57**). The upper surface is smooth, light -brown or gray, with a thin outer layer. Interior tissue is white, homogeneous, soft-corky. Hymenophore tubes initially are white but darken with age. They are 2-8 mm long. Decay develops in both sapwood and heartwood. In the first stage of decay, wood is yellow-brown and later turns red-brown; cracks develop in radial and tangential directions. Cream-white mycelial sheets can arise in the cracks. In the advanced stage, wood is typically cubical. Decay in the main stem can extend upwad to 10 m.

Biology
Infection occurs by basidiospores that penetrate tree tissues through broken branches and other wounds. Basidiocarps form from mid summer to autumn and are often quickly destroyed by insects. The disease occurs as a rule on sites unfavourable to birch but also on sites that have burned.

Damage
Decay predisposes trees to wind breakage; commercial wood losses can reach 100 percent.

Distribution
European part of Russia, Urals, Siberia, Far East

♦♦♦

Pathogen
Inonotus dryadeus (Pers.: Fr.) Murrill

Hosts
Nordmann fir (*Abies nordmanniana*) and species of chestnut (*Castanea*), beech (*Fagus*), and oak (*Quercus*)

Diagnosis
Basidiocarps are large, 30 to 40 cm in diameter, annual, cushion-like or flat, with a rounded thick margin. The upper surface is yellow-gray, gray-brown or dark-brown; margins often are lighter. The surface is irregular, rough, sometimes velvety. Hymenophore tubes are about 1.5 cm long and gray-brown; pores are small, round, or angular. The basidiocarp edge and hymenophore secrete yellow-brown drops of liquid. Interior tissue is stratiform, rusty-brown, with a silky shine. Basidiocarps form at the base of affected trees. In the early stage of decay, wood is brown but later turns yellow-white and becomes stringy.

Biology
Tree infection occurs by basidiospores through dead or damaged roots. Infection is common in mature and overmature stands; suppressed trees are the most susceptible.

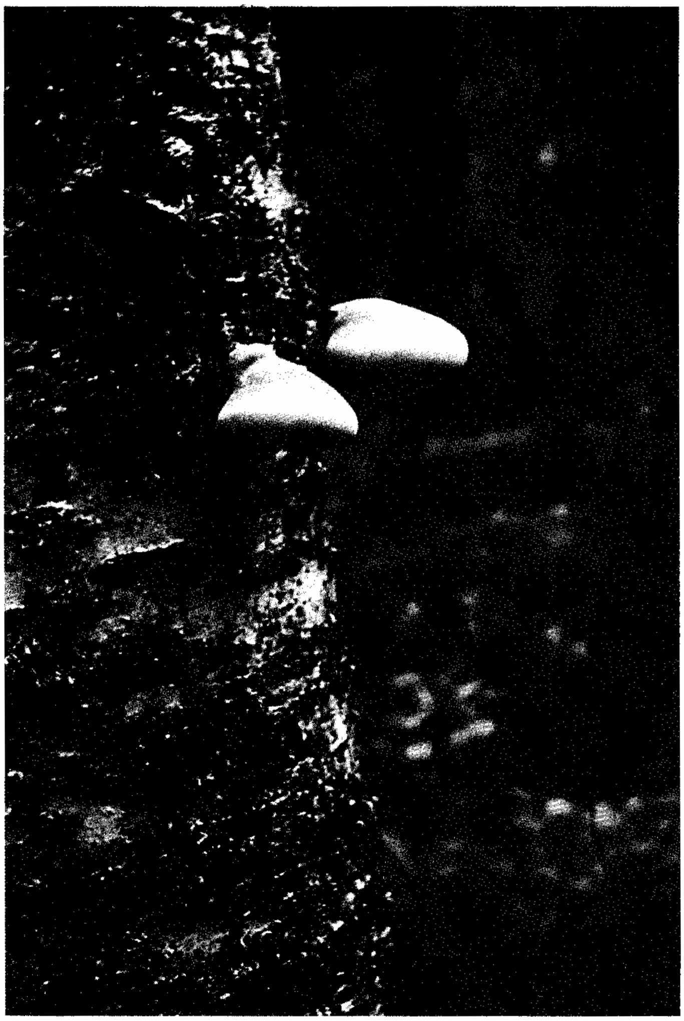

Figure 57.—Basidiocarps of *Piptoporus betulinus* on the trunk of a birch (*Betula pendula*).

Damage
Weakens trees but rarely kills them. Affected trees are susceptible to windthrow and wind breakage.

Distribution
Middle and southern areas of European part of Russia, southern Urals, Far East

Control
Cultural
- Conduct timely sanitation cuttings and thinnings.
- Maintain optimal stand density.
- Create mixed stands on favorable growing sites.

♦ ♦ ♦

Pathogen
Ganoderma applanatum (Pers.) Pat.

Hosts
Primarily species of maple (*Acer*), hornbeam (*Carpinus*), birch (*Betula*), poplar (*Populus*), willow (*Salix*), and lime (*Tilia*); also fir (*Abies*) and Siberian pine (*Pinus sibirica*)

Diagnosis
Basidiocarps are perennial, large (up to 40 cm in diameter), flat, semicircular, with relatively thick caps without stalks, sometimes hoof-shaped, and occur more often singly than in clusters (**Fig. 58**). The

Figure 58.—Basidiocarps of *Ganoderma applanatum* on the trunk of an aspen (*Populus tremula*).

upper surface is dull, chocolate-brown, sometimes gray-brown, usually irregular, rough or with concentric ridges, thin, and hard. Interior tissue is corky or velvety, brown, usually soft. The hymenophore, about 0.5-1.5 cm thick, is white initially but then turns brown. Decay begins in the heartwood and is light-yellow, with elongate pockets filled by white mycelium; later, the decay spreads to sapwood. In the final stages, wood turns white and becomes fibrous; tree cavities are common.

Biology
The fungus is found primarily on stumps and dead trees but can attack living trees. Trees can be infected through wounds to the roots and base of the trunk. Mycelium spreads in roots and the butt log. Infection occurs predominantly in mixed conifer-deciduous forests.

Damage
Causes susceptibility to windthrow and wind breakage. The disease is serious in urban and forest parks and urban plantations.

Distribution
European part of Russia, Urals, Far East

Control
Cultural
- Conduct timely sanitation cuttings to remove weakened, dying, and dead trees.
- Treat tree cavities in urban and park settings.

Fungal Diseases that Occur Only in Russian Forests

Diseases of Fruits and Seeds

Thecopsora Rust of Spruce Cones

Class/Order: Basidiomycetes/Uredinales

Pathogen
Thecopsora padi (Kze. et Schm.) Kleb. (syn. *Thecopsora aleolata* (Fr.) Magn.)

Hosts
Species of spruce (*Picea*), including Norway (*Picea abies,)* Siberian black *(P. obovata),* Finnish *(P. fennica)* and Caucasian *(P. orientalis);* alternate host is bird cherry *(Padus avium)*

Diagnosis
Infected cones darken and scales open widely. Aecia of the fungus develop on the inside surface of the cone. Initially, they are orange-brown but later turn dark-brown. Aecia are numerous, closely packed, globose, 1-2 mm in diameter, powdery, white and round or oblong, and occur in groups. Aeciospores are egg-shaped or round, yellowish, with a thick cover. Uredinia form on the lower surfaces of bird cherry leaves. Urediniospores are globose, egg-shaped, elliptical, colorless, 15.5-27 x 14-17.5 μ. Telia form on both surfaces of the leaf, but mainly on the upper surface. They are violet- or dark-brown, angular, crust-like. Teliospores are round or angular, 16-23 x 14-25 μ, with a light-brown cell wall.

Biology
This is a heteroecious, macrocyclic rust. Spermogonia and aecia develop on *Picea* cones, and uredinia and telia develop on *Padus* leaves. The pathogen overwinters in the teliospore stage on fallen leaves of *Padus*. In spring, basidia and basidiospores are produced and the spores infect young cones. Spermogonia form on the outside of cone scales in June. Later, aecia develop on the inside surfaces of the scales. Mature aeciospores infect *Padus* leaves. In late summer and autumn, urediniospores and then teliospores develop on them. The disease occurs in spruce stands where *Padus* species are common. Infection of cones is heaviest on trees growing in open stands.

Damage
Reduces the cone crop and hinders natural and artificial regeneration of spruce.

Distribution
European part of Russia, Urals, Siberia, Far East, Sakhalin, Kamchatka

Control
- Eliminate bird cherry near spruce seed plantations.

Acorn Mummification Deformity

Class/Order: Ascomycetes/Helotiales

Pathogen
Stromatinia pseudotuberosa Rehm.

Hosts
Species of oak (*Quercus*), including pedunculate (*Q. robur),* durmast *(Q. petraea),* and cork *(Q. suber)*

Diagnosis
Small, yellow-brown spots with sharp borders form on the cotyledons. These spots gradually enlarge, coalesce, and spread over the entire cotyledon. Gray, fungal mycelium forms on the surface of infected cotyledons. Interior cotyledon tissues turn dark. Eventually, the cotyledons become black, friable masses of sclerotial stroma. Affected cotyledons become enlarged and rupture the fruit coat, later separating from it. Apothecia (1 to 15) develop on the stromata. They are dark, 2-7 mm in diameter, on a stalk, 3-30 mm tall. Asci are cylindrical, 100-150 x 6-9 μ. Ascospores are oval or egg-like, colorless, 8-10 x 5-6 μ.

Biology
The fungus develops on acorns in natural forest environments as well as on acorns that are stored. In forest stands, acorn infection occurs by ascospores that are disseminated over most of the growing season. A portion of the acorn crop is infected on the tree, but most infection occurs after acorn drop. When healthy acorns contact previous-year acorns that are diseased, infection occurs by means of mycelium that penetrates acorn tissues through splits in the coat or through tracheal scars where the acorn was attached to the cup. In the forest, apothecia grow from the infected acorns the following year, but the sexual ascospore stage rarely forms. When humidity is high, the conidial stage develops on the uncovered stromata and conidia also can infect acorns. Disease development is most active during acorn storage, especially under improper storage conditions (high humidity-high temperatures). Mycelium develops on affected acorns and spreads rapidly to healthy ones.

Damage
Reduces acorn quality. Affected acorns lose germination power partially or completely. In storage, damage can reach 30 percent.

Distribution
European part of Russia, southern Urals, Far East

Control
Cultural
- Harvest acorns shortly after the shedding period.
- Collect acorns only from healthy and superior trees.
- Avoid mechanical injury during acorn harvesting and transportation.
- Dry acorns before storage; maintain temperatures below 5°C and good ventilation.
- Periodically sample stored acorns for presence of disease.

Chemical
- Apply fungicides (dust) before acorn storage.

Class/Order: Deuteromycetes/Melanconiales

Pathogen
Gloeosporium aucuparia Henn.

Host
Species of mountain-ash (*Sorbus*)

Diagnosis
Dark-brown or nearly black round spots form on the berries. Sporodochia are aggregated and resemble small, black cushions. Conidia are clavate or cylindrical, colorless, 7-14 x 3.5-4 μ.

Distribution
European part of Russia

Class/Order: Deuteromycetes-Hyphomycetales

Pathogen
Monilia linhartiana Sacc. (syn. *Ovularia necans* Pass.)

Host
Bird cherry (*Padus avium*)

Diagnosis
Initially small, later coalesced spots, 7-14 x 3.5-4 mm, form on the surface of berries. Gray, cushion-like conidiophores form on the spots in summer. In autumn, mycelium penetrates into the interior tissues; the berries turn black, become wrinkled, and fall or remain on the tree. In spring, apothecia, 3-7 mm in diameter on 2 cm stalks, form on infected berries. Conidia are spherical or lemon-like, 12-18 x 8-15 μ, and occur in chains that are colorless to gray in mass. Asci are cylindrically clavate, 200-260 x 17-19 μ. Ascospores are ellipsoid or egg-shaped, colorless, 17-18 x 9.5 μ.

Contents

Distribution
European part of Russia

Diseases of Needles and Leaves

Needle Diseases

Hypodermella Needle Cast of Pine Hosts

Class/Order: Ascomycetes/Phacidiales

Pathogen
Hypodermella sulcigena Tub. (anamorph: *Hendersonia acicola* Munch. et. Tub.)

Host
Species of pine (*Pinus*), including Scots (*Pinus silvestris*) and Siberian (*P. sibirica*)

Diagnosis
In summer, the tips of infected needles turn yellow. A brown band, 2-3 mm wide, separates infected from healthy tissue on the needle. Infected needles remain on the trees most of the growing season. Pycnidia form during the summer. On the dead portion of needles, black pycnidia about 140 μ in diameter form. Gray conidia, 3-celled, oval-cylindrical, 11-15 x 4-5 μ, develop in pycnidia. The sexual stage (ascospores) of the pathogen develops the next spring. Apothecia are convex, black, elongate. Asci are cylindrical, 90-100 μ long. Ascospores are clavate, with a thick, jellied enclosure, 42-60 x 12-16 μ.

Biology
Ascospores infect pine needles in spring. Ascospore maturation and release, and needle infection occurs during spring and summer when the humidity is high. Temperature is not a critical factor for pathogen development. Trees on borders of plantations, along forest edges, and in understory of open forests are particularly susceptible.

Damage
Repeated crown infection causes considerable crown loss that both weakens and reduces the height growth of understory and forest plantation trees less than 5 years old.

Distribution
European part of Russia, Urals, Siberia

Control
- Apply Bordeaux mixture when annual infection is repeated.

Chrysomyxa Rust of Spruce

Class/Order: Basidiomycetes, Uredinales

Pathogen
Chrysomyxa abietis (Wallr.) Unger.

Host
Norway spruce (*Picea abies)*

Diagnosis
Cushion-like bright-orange telia, 2-6 mm long, form along the midribs of the needles. Chains of teliospores mature in the telia. Teliospores are oblong, 1-celled, reddish-orange, 18.8-28 x 10.5-17.8 μ.

Biology
This microcylic rust has only the telio- and basidiospore stages. No alternate host is known or required for infection of spruce needles. Telia are produced on needles in early summer. They overwinter, germinate in the spring, and produce basidia with basidiospores that infect the newly formed needles. Mycelium penetrates epidermis cells, where telia develop. Damaged needles with telia fall during the next year and basidiospores are formed. The disease occurs mostly in overstocked plantations and on

understory trees. Disease development depends primarily on high humidity; the pathogen develops under moderate temperatures. The lower portion of the crown usually is affected but the entire crown can be damaged. The severity of current-year infection indicates the inoculum potential for disease development the following year.

Damage
Causes withering and premature drop of needles on understory and young trees in plantations, occasionally resulting in death.

Distribution
European part of Russia, western Siberia, Far East

Control
Chemical
- Bordeaux mixture can be used in late spring in heavily infected stands or plantations.

Class/Order: Deuteromycetes/Sphaeropsidales

Pathogen
Ceutospora abietina Delacr.

Hosts
Norway spruce *(Picea abies)*

Diagnosis
Initially, single brown spots form on needles; later, they coalesce. Stromata form in the spots and are black-olive, oval-oblong, about 0.6 mm in diameter. Stroma have 3 compartments with a common ostiole. Conidia are cylindrical, with rounded tops; they are colorless, 6 x 2.5 μ, and contain 2 oil drops.

Distribution
European part of Russia

Class/Order: Basidomycetes/Uredinales

Pathogen
Coleosporium pini-pumila Azb.

Host
Mountain pine (*Pinus pumila*)

Diagnosis
Yellow spots appear on the both surfaces of the needle. Later, convex, oblong, orange telia form. Teliospores are 1-celled, 45-152 x 20-37.5 μ.

Distribution
Urals, Siberia, Far East

♦ ♦ ♦

Pathogen
Melampsorella symphiti (DC) Bub.

Host
Silver fir *(Abies alba)* **(Fig. 59)** (alternate host: *Symphitum officianale,* and *S.cordatum)*

Diagnosis
Spermagonia and aecia develop on the lower surface of needles. Blister-shaped aecia are covered by the peridium. Uredinia are tiny, orange, and develop on the undersides of leaves of the alternate host, *Symphitum* spp. Telia develop subepidermally on these leaves. Aeciospores are globose, rarely egg-shaped, elliptical, with orange contents, a warty wall, 20-40 x 13-29 μ. Urediniospores are globose,

Figure 59.—Needle rust of fir (*Abies alba*) caused by *Melampsorella symphiti.*

egg-shaped or elliptical, with a colorless, warty wall, 22-35 x 20-28 μ. Teliospores are globose, elliptical or angular, 1-celled, with a pale-yellow colorless wall, 11-18 x 9-15 μ.

Distribution
European part of Russia, Siberia

♦♦♦

Pathogen
Pucciniastrum tiliae Hirat.

Hosts
Silver fir *(Abies alba)* and Siberian fir (*A. sibirica*); the alternate host is lime species *(Tilia)*

Diagnosis
Spermogonia and aecia develop on the underside of needles. Aecia develop deeply in the needle tissue. They are cylindrical, orange-yellow, about 3.5 mm high and 0.2 mm in diameter. Uredinia form on the lower surface of lime leaves. They are orange and covered by the peridium. Telia form on the same surfaces and appear as bright-orange-yellow crusts. Aeciospores are globose or elliptical, orange-yellow, small, with a shallow, warty wall, 19-33.5 x 12-22 μ. Urediniospores are globose or elliptical, yellow, 15-25 x 12.5-15 μ. Teliospores are globose or angular, 2- to 6-celled, with a light-brown wall, 18-38 x 14-27 μ.

Distribution
Siberia, Far East

Leaf Diseases

Powdery Mildew of Siberian Pea Tree

Class/Order: Ascomycetes/Sphaeriales

Pathogen
Microsphaera palczewskii Jacz.

Host
Siberian pea tree (*Caragana arborescens*)

Diagnosis
White, cobwebby mycelium forms on both surfaces of leaves in early June. Mycelium and conidia develop on the foliage and become felty and prominent. In late June, numerous cleistothecia form in the mycelial mat and cover the leaf surface. Infected foliage is a gray to blue at this time. Cleistothecia are dark-brown, nearly black, spherical, 90-120 μ in diameter, with oblong, hexangular cells in the peridium. Cleistothecia have 5-10 appendages that are colorless, without partitions, 80-147 x 5-9 μ, with dichotomous branches on the tips. Four to eight mace-shaped asci form on short pedicles, 47-55 x 8-12 μ. Ascospores are elliptical or egg-shaped, on short pedicles, 14-21 x 8-12 μ.

Biology
Asci form in the cleistothecia in summer and overwinter on fallen infected leaves. Asci mature early the following summer. Mature ascospores infect new leaves in the crown. In 2 weeks, superficial mycelium appears on the leaves; 7-10 days later, conidia form that cause secondary infections of young leaves on the middle and upper crown. In late June, the first cleistothecia are produced on the mycelial mats. By late July, numerous cleistothecia are formed. High humidity is the most important factor in disease development. Development occurs at moderate (18°-20°C), or higher (25°-30°C) temperatures. Environmental factors that delay leaf maturation increase susceptibility to powdery mildew.

Damage
Causes complete loss of aesthetic appearance of trees. Damaged leaves wither and drop prematurely. The plants are weakened and lose resistance to low temperatures.

Distribution
Middle regions of European part of Russia, Siberia, Far East

Control
Observation
• Survey for the disease in early June when the mycelium develops.

Chemical
• Apply colloid sulfur or BAYMEB when the white tender superficial mycelium appears on leaves. Apply 3-4 treatments at intervals of 10-12 days.

Other Powdery Mildews

Class/Order: Ascomycetes, Sphaeriales

Pathogen
Microsphaera divaricata Lev.

Host
Buckthorn *(Frangula alnus)*

Diagnosis
Mycelium forms on the surfaces of leaves, often cobwebby, sometimes in several spots. Cleistothecia occur in groups or individually and have 7-16 appendages, dichotomously branched, 135-330 x 6-9 μ. Asci have short pedicles, 48-60 x 25-40 μ. Asci contain 4-6 ascospores, 18-24 x 9-13.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Uncinula clandestina Schroet.

Hosts
Species of elm (*Ulmus*)

Diagnosis
A cobwebby mycelium forms on both surfaces of leaves. Cleistothecia occur in groups or are dispersed, and have 9-30 appendages. Appendages are simple, colorless, rough or smooth, hooked on the tips, 135-165 x 3-4.5 μ. Asci are spherical or elliptical, on short pedicles, 40-56 x 30-45 μ, and contain 2 or 3 ascospores. Ascospores are elliptical, 25-36 x 11-18 μ.

Distribution
European part of Russia

Orange Leaf Spot of Padus

Class/Order: Ascomycetes/ Sphaeriales

Pathogen
Polystigma ochraceum (Wahl.) Sacc.

Host
Bird cherry (*Padus avium*), Asian cherry (*Padus asiatica*)

Diagnosis
Circular or angular, orange stromata, about 1 cm in diameter, form on leaves in early July (**Fig. 60**). Pycnidia develop in stromata during summer. Maturing conidia are colorless, convex, with a prominent narrow upper portion. The leaf spots darken in autumn and perithecia form. Mature asci are cylindrical, on a long pedicle, about 90-100 x 15 μ. Ascospores are elliptical, colorless, 14 x 5-6 μ.

Biology
Pycnidia containing conidia are formed in stromata during summer. Conidia mate to form the sexual stage. Asci form in autumn and overwinter on fallen leaves. Asci mature early in the growing season of the next year. Ascospore maturation and release, and leaf infection occur over most of the growing season. Infection by ascospores usually takes place in early June in Siberia. The first symptoms of disease develop on leaves in July and the abundance of spots increases in relationship to the extended period of ascospore release. The amount of precipitation in spring and early summer plays an important role in infection. High humidity promotes ascospore maturity and release from the perithecia as well as their germination and penetration of leaf tissue.

Figure 60.—Leaf spot of bird cherry (*Padus avium*) caused by *Polystigma ochraceum.*

Damage
Causes premature withering and dropping of leaves, reduced fruit production in the current year, and partial or complete loss of fruit in the next year.

Distribution
Siberia, rarely in European part of Russia

Red Spot of Ussurian Plum

Class/Order: Ascomycetes/Sphaeriales

Pathogen
Polystigma ussuriensis (Natal. et Jacz.) A. Proz.

Host
Ussurian plum (*Prunus ussuriensis*)

Diagnosis
Small, circular spots, 2-8 mm in diameter, develop on infected leaves. They are pale-yellow initially and later bright-orange. Lower surfaces of spots are convex and covered with numerous, dark dots. These dots are the pores at the top of stromata containing pycnidia. As they age, the spots turn brown and on lower surfaces of leaves, nearly black. Pycnidia are 200-300 x 150-210 µ. Conidia are colorless, thread-like, 15 x 1 µ. Asci are narrow, mace-shaped, 85-90 x 10-11. Ascospores are colorless, elliptical, 8-11 x 3-5 µ.

Biology
The pathogen overwinters on fallen leaves in the sexual stage. Ascospores mature in perithecia in late May or early June. Ascospores are disseminated by wind and infect leaves. The first spots appear on leaves in late June and continue to increase; this is related to the long period of pathogen sporulation. Conidia are not involved in foliage infection but mate to form perithecia in autumn. Asci and ascospores do not mature until the next year. The amount of precipitation at the beginning of the growing season influences maturation and release of ascospores and subsequent foliage infection.

Damage
Causes premature foliage damage and reduces fruit yield. Successive infections weaken or kill the tree.

Distribution
Far East, Primorski and Khabarovski regions of Russia

Control
Cultural
- Collect and burn fallen foliage to eliminate the inoculum source of the overwintering pathogen.

Chemical
- Spray three applications of Bordeaux mixture: 1) during the period of foliage expansion;
2) immediately after flowering; and 3) 10-12 days after the second application when humidity is high at the beginning of the growing season.
- Spray with Bordeaux mixture in autumn (before leaf drop) to reduce overwintering inoculum.

Foliage Anthracnoses, Spots, and Blights

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen
Ascochyta borjomi Bond.

Host
Siberian pea tree (*Caragana arborescens*)

Diagnosis
Leaf spots are round, 4-6 mm in diameter, whiteish, surrounded by brown margins. Pycnidia form on the upper surfaces of spots as small, black dots. Conidia are cylindrical, with rounded ends, straight or curved, usually 1-, or 2-celled, colorless, 8-10.5 x 4.5-5 μ.

Distribution
Southern area of European part of Russia

♦♦♦

Pathogen
Ascochyta crataegi Fckl.

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Spots form on the upper surfaces of leaves, often along the margin. They are round or angular, about 6 mm in diameter, brown, with dark borders. Pycnidia form in these spots as brown dots. Conidia are oblong cylindrical, with rounded ends, 2-celled, colorless, 8-12 x 2-3 μ.

Distribution
Southern area of European part of Russia

♦♦♦

Pathogen
Ascochyta elaeagni Sacc.

Hosts
Species of oleaster (*Elaeagnus)*

Diagnosis
Spots usually form near the leaf margins and are irregular, creamy, with a narrow brown border. Pycnidia form on upper surfaces of spots as small black dots. Conidia are spindle-like, 2-celled, light-olive, 8-10 x 3.5-4 μ. Mycelium forms on both surfaces of leaves. It has a cobwebby appearence. Cleistothecia occur in groups or are dispersed, with 9-30 appendages that are simple, colorless, rough or smooth, hooked on the tips, 135-165 x 3-4.5 μ. Asci are spherical or widely elliptical, on a short pedicle, 40-56 x 30-45 μ. Ascospores are elliptical, 25-36 x 11-18 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Ascochyta piricola Sacc.

Hosts
Species of apple (*Malus)* and pear *(Pyrus*)

Diagnosis
Leaf spots are bright-gray-white. Pycnidia form on upper surfaces of spots as small, black dots. Conidia are oblong, olive, 10 x 2 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Ascochyta populina Sacc.

Host
White poplar (*Populus alba*)

Diagnosis
Leaf spots are brown and vary in size. Pycnidia form on upper surfaces of spots as small brown dots. Conidia are cylindrical, 2-celled, colorless, 8-10 x 2 µ.

Distribution
Southwestern area of European part of Russia

♦♦♦

Pathogen
Ascochyta ribesia Sacc. et Fautr.

Host
Species of currant *(Ribes)*

Diagnosis
Leaf spots are small, white or pale-brown, with dark borders. Pycnidia form on the upper surfaces of spots as brown dots. Conidia are cylindrical, with rounded ends, 8-12 x 3 m.

Distribution
European part of Russia

♦♦♦

Pathogen
Ascochyta sarmentica Sacc.

Host
Honeysuckle *(Lonicera tatarica)*

Diagnosis
Leaf spots are white with dark borders. Pycnidia form on upper surfaces of spots as dark dots. Conidia are elongate-oval, widened at the top, 2-celled, colorless or smoke-gray, 20-25 x 8 µ.

Distribution
Western area of European part of Russia

♦♦♦

Pathogen
Coniothyrium salicicola Rossi.

Hosts
Species of willow (*Salix*)

Diagnosis
Leaf spots are yellow-brown, sometimes with black borders; in dry conditions they are gray-white. Pycnidia form on upper surfaces of spots as black dots. Conidia are egg-shaped, brown, 5-6.5 x 3-3.5 µ.

Distribution
European part of Russia

Class/Order: Deuteromycetes/Hyphomycetales

Pathogen
Cercospora padi Bub. et Serebr.

Host
Bird cherry (*Padus avium*)

Diagnosis
Leaf spots are small, irregular, sometimes coalesced, white on upper surfaces and brown on the lower, about 0.5-3 mm in diameter. Conidia are spindle-shaped, cylindrical or elongate and wide at the top, slightly curved, 2- or more-celled, pale-olive, 20-70 x 4-6.5 µ.

Distribution
European part of Russia, Western Siberia, Far East

♦♦♦

Pathogen
Coniothecium phyllophilum Desm.

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Leaf spots are black and small; they occur on both surfaces of leaves. Conidia are spherical or irregularly spherical, smoke-gray, 4-celled, about 12 μ.

Distribution
European part of Russia

Class/Order: Deuteromycetes/Melanconiales

Pathogen
Cylindrosporium avellanum (B. et Br.) Jbr. et Ach.

Host
Hazel (*Corylus avellana*)

Diagnosis
Leaf spots are numerous, round or angular, brown, sometimes coalesced. Conidia are cylindrical, straight or curved, 2- to 4-celled, colorless, 25-32 x 2-3 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Cylindrosporium platanoides (Allesch.) Died. (teliomorph: *Mycosphaerella latebrosa* (Ckl.) Schroet.)

Host
Bosnian maple (*Acer platanoides*)

Diagnosis
Leaf spots are small and dark-brown, elongate. Sporodochia are pale, later dark and spherical. Conidia are thread-like or narrow, cylindrical; one end is narrow, straight or slightly curved, 4-celled, colorless, 27-80 x 1.5-3.5 μ.

Distribution
Southern area of European part of Russia

♦♦♦

Pathogen
Cylindrosporium pseudoplatani (Rob. et Desm.) Died. (teliomorph: *Mycosphaerella pseudoplatani* Zer.)

Hosts
Species of maple (*Acer*)

Diagnosis
Leaf spots are dark-brown, on both surfaces of leaves, single or coalesced, about 3 mm in diameter. Sporodochia are small, dark, in clusters. Conidia are cylindrical; one or both ends are narrow, straight or slightly curved, 4-celled, colorless, 22-56 x 2-3.5 μ.

Distribution
European part of Russia

Pathogen
Cylindrosporium propinquum (Bub. et Vleug.) Vassil.

Hosts
Species of willow (*Salix*)

Diagnosis
Leaf spots are irregularly shaped, brown or yellowish, sharply delimited or diffuse. Sporodochia form on the lower surfaces of spots; they are numerous, brown or pale-yellow. There are two types of conidia: microconidia are spindle-shaped, straight or slightly curved, colorless, 10-22 x 2-3.5 μ; macroconidia are spindle-shaped or widened at the top, curved, rarely straight, colorless, 4- to 6-celled, 22-80 x 3.5-7.5 μ.

Distribution
Southeastern area of European part of Russia

♦♦♦

Pathogen
Gloeosporium acericolum Allesch.

Hosts
Species of maple (*Acer*)

Diagnosis
Leaf spots are gray or brown, coalesced. Sporodochia form on the lower surfaces of spots, are inconspicuous, light-yellow, cushion-like, under the epidermal layer. Conidia are cylindrical, colorless, 1-celled, 6-12 x 2-2.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Gloeosporium capreae Allesch.

Hosts
Species of willow (*Salix*)

Diagnosis
Leaf spots are large, gray-brown. Numerous small, black, cushion-like sporodochia form on upper surfaces of spots. Conidia are oblong, straight or curved, colorless, 6-18 x 2-4.5 μ.

Distribution
European part of Russia.

♦♦♦

Pathogen
Gloeosporium perexiguum Sacc.

Hosts
Species of mountain-ash (*Sorbus*)

Diagnosis
Leaf spots are red-brown, small, and eventually drop out of the leaf to form shot holes. Bright-yellow, cushion-like sporodochia form on lower surface of spots. Conidia are elongate, elliptical, 1-celled, colorless, 5-6 x 2-3 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Pestalotia malorum Elenk. et Ohl.

Hosts
Species of apple (*Malus*)

Diagnosis
Leaf spots are gray-brown, roundish, 3-7 mm in diameter, and coalesced. Sporodochia form on the upper surfaces of spots, are black, cushion-like, and inconspicuous. Conidia are spindle-like, 4-celled, with 3-4 appendages, dark-olive, 17 x 6.5 µ.

Distribution
European part of Russia

Class/Order: Deuteromycetes/Sphaeropsidales

Pathogen
Hendersonia piricolea Sacc.

Hosts
Species of pear (*Pyrus*)

Diagnosis
Leaf spots are white-gray on the upper surfaces of leaves. Pycnidia occur as black dots. Conidia are egg-shaped, 3- to 4-celled, brown, 10x5 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phleospora oxyacanthae (Kze. et Schum.) Wallr. (teliomorph: *Mycosphaerella oxyacanthae* Jaap.)

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Spots are round, form on the both surfaces of leaves, are brown on the upper surface and gray on the lower. Perithecium form on the upper surfaces of spots, and are buried in leaf tissue. Perithecia form under the stroma. Asci are wide at the top, 90-110 x 10 m. Ascospores are cylindrical, sickle-like, with a wide top, yellow-brown, 6- or 7-celled, with oil drops, 66-78 x 4-5 µ.

Distribution
Siberia

♦♦♦

Pathogen
Phoma betulae Jacz.

Hosts
Species of birch (*Betula*)

Diagnosis
Leaf spots are small, brown, scattered over entire leaf surface. Pycnidia are black and inconspicuous. Perithecia form on upper surfaces of spots buried in leaf tissue. Conidia are elliptical, colorless, 1-celled, 12-14 x 2 µ.

Distribution
European part of Russia, Siberia

♦♦♦

Pathogen
Phyllosticta aceris Sacc.

Host
English field maple (*Acer campestre*)

Diagnosis
Leaf spots are small, light-brown, later whitish with a dark border. Scattered pycnidia form on the spots as black dots. Conidia are oblong, pointed, colorless, 5-7 x 2.5-3 μ.

Distribution
European part of Russia, Siberia

♦♦♦

Pathogen
Phyllosticta aucupariae Thum.

Hosts
Species of mountain-ash (*Sorbus*)

Diagnosis
Leaf spots are gray, with wide, dark-brown borders. Pycnidia form on upper surfaces of spots, scattered or in groups, inconspicous, black. Conidia are elliptical, colorless, 1-celled, 5-8 x 3 μ.

Distribution
European part of Russia, Siberia

♦♦♦

Pathogen
Phyllosticta associata Bub.

Host
Pedunculate oak (*Querqus robur*)

Diagnosis
Leaf spots form on both surfaces of leaves; they are brown and coalesced. Scattered, black pycnidia form on the lower surfaces of spots. Conidia are short and cylindrical, with rounded ends, colorless, 2-4 x 1 μ.

Distribution
Southwestern area of European part of Russia

♦♦♦

Pathogen
Phyllosticta bellunensis Mart.

Hosts
Species of elm (*Ulmus)*

Diagnosis
Leaf spots are large, round, and brown. Pycnidia are small and inconspicous. Conidia are cylindrical, 1-celled, colorless, 2.5-3 x 0.75-1 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Phyllosticta borschzowii Thum.

Host
Siberian pea tree (*Caragana arborescens*)

Diagnosis
Leaf spots form on the lower surface of leaves; they are gray- or light-brown. Pycnidia form on the lower surface of spots, rarely both sides. Conidia are ellyptical, colorless, 3 x 1.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta cathartici Sacc.

Host
European buckthorn (*Rhamnus cathartica)*

Diagnosis
Leaf spots are round, light-brown, with a dark border. Pycnidia form on the upper surface of spots; they are black, spherical, and flat. Conidia are oval spindle-shaped, 1-celled, colorless, 10 x 4 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta corylaria Sacc.

Host
Hazel (*Corylus avellana*)

Diagnosis
Leaf spots are scattered on both surfaces of leaves; they are large, irregularly shaped, yellow-brown, with a brown border. Pycnidia form on the upper surfaces of spots; they are scattered, inconspicuous, spherical, and black. Conidia are oval, 1-celled, light-olive, 4-4.5 x 2 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta globulosa Thum.

Host
Pedunculate oak (*Quercus robur*)

Diagnosis
Leaf spots form on the upper surfaces of leaves, are irregularly shaped, and gray-white. Pycnidia are scattered, spherical, and black. Initially, they are buried in leaf tissue but later erupt. Conidia are spherical, widely egg-shaped, 1-celled, colorless, with 1-2 oil drops, 6 x 9 μ.

Distribution
Southwestern area of European part of Russia

♦♦♦

Pathogen
Phyllosticta lacerans Pass.

Hosts
Species of elm (*Ulmus*)

Diagnosis
Leaf spots are round, 0.4-0.6 mm in diameter, gray, and eventually drop out, leaving holes in leaves. Black pycnidia form on the upper surface of spots. Initially, they are buried in leaf tissue but later erupt. Conidia are egg-shaped, 1-celled, colorless, 4-7.5 x 2.5-3 μ.

Distribution
European part of Russia, Urals

♦♦♦

Pathogen
Phyllosticta monogyna Allesch.

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Leaf spots vary in size, are round and rusty-brown. Pycnidia form on lower surface of spots, are scattered, spherical, and black. Initially, they are buried in leaf tissue but later erupt. Conidia are oval-elongate, 1-celled, colorless, 3-8 x 2.5-3 μ.

Distribution
Southwestern area of European part of Russia

♦♦♦

Pathogen
Phyllosticta michailowskoensis Elenk.

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Leaf spots form on the upper surface of leaves, are round or angular, light-brown, with a dark border. Pycnidia form on the upper surface of spots, are scattered or in groups, spherical, and black. Initially, they are buried in leaf tissue but later erupt. Conidia are egg-shaped or cylindrical, with rounded ends, 1-celled, sometimes with 1-2 oil drops, 4-6 x 2.5-3 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Phyllosticta populi-nigrae Allesch.

Hosts
Species of poplar (*Populus*)

Diagnosis
Spots are round and initially gray-brown, later white to gray, with a dark border. Pycnidia form on the upper surface of spots, are inconspicuous and spherical; they are initially buried in leaf tissue but later erupt. Conidia are elongate, oval, 1-celled, colorless, 15 x 2.5-3.5 μ.

Distribution
Urals, Siberia

♦♦♦

Pathogen
Phyllosticta quercina Thum.

Host
Pedunculate oak (*Quercus robur*)

Diagnosis
Leaf spots are round, red-brown, with diffuse margins. Pycnidia form in the center of the upper surface of spots, are black and spherical. Conidia are egg-shaped or oval, 1-celled, grayish, 3.5-5 x 2.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta tambowiensis Bub. et Serebr.

Hosts
Species of maple (*Acer*)

Diagnosis.
Leaf spots are round or oval, about 10 mm in diameter, initially gray and later brown. Pycnidia form on the lower surface of spots. They are black, spherical, numerous, and aggregated. Conidia are cylindrical, 1-celled, colorless, 4-7.5 x 1 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phyllosticta ulmaria Pass.

Hosts
Species of elm (*Ulmus*)

Diagnosis
Leaf spots are round, white, with a dark-brown border. Pycnidia are black, spherical, and scattered. Conidia are oval, 1-celled, colorless, 3.5-4 x 2.5 to 3 μ.

Distribution
European part of Russia, Urals

♦♦♦

Pathogen
Phyllosticta ulmi H.C. Greene

Hosts
Species of elm (*Ulmus*)

Diagnosis
Leaf spots form on both surfaces of leaves, are round, gray, scattered, sometimes coalesced. Pycnidia form on both surfaces of spots, are spherical, black, and scattered. Conidia are egg-shaped, 1-celled, colorless, with 1-2 oil drops, 10 x 5 μ.

Distribution
European part of Russia, Urals

♦♦♦

Pathogen
Septoria acerella Sacc. (syn. *S. acerina* Sacc.)

Hosts
Species of maple (*Acer*)

Diagnosis
Spots are white, round or angular, small, and form on upper surfaces of leaves. Pycnidia are black, spherical, and rare. Conidia are cylindrical, curved, 1-celled or without a clear partition, colorless, 20-22 x 2 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Septoria candida (Fckl.) Sacc.

Host
White poplar (*Populus alba*)

Diagnosis
Spots are round, white, and form on the upper surface of leaves. Pycnidia are spherical, brown, and dispersed. Conidia are cylindrical, curved, 4-celled, colorless, 28-30 x 2.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Septoria crataegicola Bond. et Tranz.

Host
Hawthorne (*Crataegus oxyacantha*)

Diagnosis
Spots form on both surfaces of leaves and are scattered. Initially, they are yellow-green, later chestnut-brown and gray in the center. Black, spherical pycnidia form on the upper surface of spots. Conidia are wide, cylindrical or spindle-shaped, curved, 2- to 6-celled, colorless or light olive, 45-80 x 3.5-4 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Septoria ebuli Desm. et Rob.

Hosts
Species of elderberry (*Sambucus*)

Diagnosis
Spots form on both surfaces of leaves, initially pale-yellow but later red, with a brown border. Pycnidia form on the upper surface of spots; they are brown and later black. Conidia are thread-like, slightly curved, 2-celled, colorless, 30-50 x 1-1.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Septoria frangulae Guep.

Host
Buckthorn *(Rhamnus frangula)*

Diagnosis
Spots are yellow-brown with light borders and form on the upper surface of leaves. Pycnidia are black, spherical, and raised or flat. Conidia are cylindrical, 1-celled, colorless, 18-25 x 2 μ.

Distribution
European part of Russia, Urals

♦♦♦

Pathogen
Septoria pallens Sacc.

Hosts
Species of plum and cherry (*Prunus*)

Diagnosis
Leaf spots are pale-yellow, later brown. Black, spherical pycnidia form on the upper surface of spots. Conidia are thread-like, straight or curved, 1-celled, colorless or greenish, 8-18 x 0.5-1 μ.

Distribution
European part of Russia

Pathogen
Septoria tiliae Westend.

Hosts
Species of lime (*Tilia*)

Diagnosis
Leaf spots are brown, often with a lighter center, scattered, sometimes coalesced. Pycnidia form on both surfaces of spots. Conidia are cylindrical, straight or curved, 3- to 5-celled, colorless, 20-40 x 2-3 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Septoria tremulae Pass.

Host
European aspen (*Populus tremula*)

Diagnosis
Brown spots form on both surfaces of leaves, sometimes coalesced. Black pycnidia form on the lower surface of spots, buried in leaf tissue. Conidia are thread-like, twisted, 1-celled, colorless, 20-25 x 1.5 μ.

Distribution
European part of Russia, Urals

Class/Order: Deuteromycetes/Hyphomycetales

Pathogen
Polystigmina rubra (Desm.) Sacc. (teliomorph: *Polistigma rubra* Sacc.)

Hosts
Species of cherry and plum (*Prunus*)

Diagnosis
Bright-red, shiny, convex, stromata form on the lower surface of leaves. Initially, pycnidia develop inside stromata. Conidia are colorless, hooked, 25-30 x 1-1.5 μ. Perithecia later form near pycnidia. Asci are wide on top and elongate. Ascospores are oval, 1-celled, colorless, 11-13 x 4.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Ramularia sorbi Karak.

Hosts
Species of mountain-ash (*Sorbus*)

Diagnosis
Leaf spots are red-brown, with diffuse margins, and coalesced. There are two types of conidia: peach-like, colorless or greenish, 2-celled, 21-24 x 4-8 μ; cylindrical, colorless or greenish, 2- to 4-celled, 20-40 x 4-6 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Ramularia tiliae Lobik.

Hosts
Species of lime (*Tilia*)

Diagnosis
Leaf spots are gray-brown, 0.7-1.2 mm in diameter. Conidiophores form on the lower surface of leaves as small, gray, fur-like spots. Conidia are cylindrical, pointed, colorless, 2- to 4-celled, 23-36 x 2.2-3.8 μ.

Distribution
European part of Russia

Class/Order: Ascomycetes/Phacidiales

Pathogen
Rhytisma symmetricum Joh. Mull.

Hosts
Species of willow (*Salix*)

Diagnosis
Black, shiny stromata, about 5 mm in diameter, form on both surfaces of leaves. Asci are wide on top, 135-162 x 12-9 μ. Ascospores are thread-like, wide at one end and pointed at the other, colorless, 108 x 2.5 μ.

Distribution
European part of Russia

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Pathogen
Rhytisma xylostei Naum.

Hosts
Species of honeysuckle (*Lonicera*)

Diagnosis
Black, shiny stromata, 5-12 mm in diameter, are formed between leaf veins. Asci are wide at one end, 69-82 x 8-11 μ. Ascospores are 1-celled, colorless, elongate, wide at one end, 50-55 x 2.8 μ.

Distribution
Siberia

Leaf Rusts

Class/Order: Basidiomycetes/Uredinales

Pathogen
Melampsora larici-caprearum Kleb.

Hosts
Willow (*Salix caprea)* and species of larch (*Larix*)

Diagnosis
Spermagonia and aecia develop on the needles of larch. Uredinia form on the lower surface of leaves of willow (the alternate host). They are light-orange, powdery, cushion-like. Telia form on the upper surface of willow leaves. They are initially yellow, later dark-brown, 1-1.5 mm long, and coalesce to cover the entire leaf surface. Urediniospores are oval, sherical or angular, with a warty wall, 14-21 x 13-15 μ. Teliospores are prismatic, with a light-brown enclosure, 30-45 x 7-14 μ.

Distribution
European part of Russia, Siberia, Far East

Pathogen
Melampsora larici-populina Kleb.

Hosts
Poplar (*Populus nigra)* and species of larch *(Larix*)

Diagnosis
Spermagonia and aecia develop on larch needles. Uredinia develop on both surfaces of poplar leaves. They are orange, powdery, cushion-like. Telia form on the upper and rarely on the lower surface of leaves, are light-brown, later turning dark-brown and becoming crust-like. Urediniospores are elongate, with a thorny, warty wall, 30-40 x 13-17 μ. Teliospores are prismatic, with a round top and a thin, light-brown wall, 40-70 x 10 μ.

Distribution
European part of Russia, Siberia, Far East

♦♦♦

Pathogen
Melampsora larici-tremulae Kleb.

Hosts
Species of poplar (*Populus tremula, P. alba*) and larch *(Larix*)

Diagnosis
Spermagonia and aecia develop on larch needles. Uredinia form on the lower surface of poplar leaves. They are orange and powdery. Telia develop on the lower surface of poplar leaves. They are small, dark-brown, single or clustered. Urediniospores are oval, oblong, elliptical, sometimes globose, with a thorny wall, 15-22 x 10-15 μ. Teliospores are prismatic, with round ends, 40-50 x 7-12 μ.

Distribution
Siberia, Caucasus Mountains

♦♦♦

Pathogen
Pucciniastrum coryli Kom.

Host
Hazel (*Corylus avellana*)

Diagnosis
This is an autoecious rust. Orange pustules of uredinia form on the upper surface of leaves. Telia form on the lower surface, are crust-like, small, initially yellow but later yellow-brown. Urediniospores are egg-like, elliptical, globose, orange, 17.5-25 x 12.5-17.5 μ. Teliospores are single or in groups, 2- to 8-celled, oblong, with a light-brown wall, 18-30 x 12-5 μ.

Distribution
Far East

♦♦♦

Pathogen
Puccinia coronifera Kleb.

Host
European buckthorn *(Rhamnus cathartica),* species of oats *(Avena),* and fescue grass *(Fustuca)*

Diagnosis
Globose spermogonia develop beneath the epidermis on the upper surface of leaves of *Rhamus*. Cup-like aecia develop on the lower surface and on leaf petioles. Damaged leaves and shoots are deformed. Uredinia and telia develop on leaves of *Avena* and *Festuca* species. Aeciospores are globose or angular-globose, with orange contents and a colorless, warty wall, 16-24 x 12-18 μ.

Distribution
European part of Russia, Urals, Siberia

Class/Order: Ascomycetes-Taphrinales

Pathogen
Taphrina autumnalis Palm.

Hosts
Species of birch (*Betula*)

Diagnosis
Red spots form on both surfaces of leaves. Asci are cylindrical, 44-80 x 14-30 μ. Ascospores are globose, colorless, 3-4 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Taphrina betulae Johans.

Hosts
Species of birch (*Betula*)

Diagnosis
Leaf spots are round, swollen, white to yellow. A layer of asci develop on the upper surface of spots; they are cylindrical with round tops, 40 x 8-12 μ. Ascospores are globose or elliptical, 3-5 μ.

Distribution
European part of Russia, Urals, Siberia

♦♦♦

Pathogen
Taphrina betulina Rostr.

Hosts
Species of birch (*Betula*)

Diagnosis
Infected leaves are curled with a layer of asci on the lower surface. Brooms of numerous, shortened shoots develop from sprouting, latent buds. Asci are cylindrical, 45-55 x 15 μ. Ascospores are globose, colorless, 3-5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Taphrina crataegi Sad.

Hosts
Species of hawthorne (*Crataegus*)

Diagnosis
Red, swollen spots with a white, waxy surface form on the lower surface of leaves, rarely on calix lobes. Asci are cylindrical, with round tops, 25-35 x 8 μ. Ascospores are globose, colorless, 4-6 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Taphrina turgida Sad.

Hosts
Species of birch (*Betula*)

Diagnosis
Infected leaves are curled with a gray, waxy layer of asci on the lower surface of leaves. Brooms of numerous, shortened shoots with dwarfed leaves develop. Asci are cylindrical, with blunt, usually concave tops, 45-50 x 15 μ. Ascospores are globose, 4 μ.

Diseases of Roots, Stems, and Branches

Diseases in Tree Nurseries and Young Forests

"Infectious Damping" of Coniferous Seedlings

Class/Order: Ascomycetes/Helotiales and Basidiomycetes/Aphyllophorales

Pathogens
Sclerotinia graminearum Elen. and *Typhula graminearum* Tul.

Hosts
Scots pine (*Pinus silvestris*), Norway spruce (*Picea abies*), and species in the following genera: *Phleum* L. *Poa* L., *Festuca* L., *Agropyron, Alopecurus* L., *Dactylis* L., *Bromus* L., *Lolium* L., *Myosotis* L., *Sellaria* L., *Cerastium* L., *Potentilla* L., and *Achillea* L.

Diagnosis
The first symptoms of infection occur immediately after snowmelt. Needles of infected seedlings are covered by a gray-white cobwebby mycelium that disappears after several days. Affected dead needles are red-brown but later turn gray. The tops of infected seedlings die and fall off. Sclerotia form on the stems near the buds, sometimes inside the stem. Sclerotia drop to the ground when seedlings are disturbed. Sclerotia of *S. graminearum* are dark-brown, almost black, often irregularely shaped, about 6 mm in long. They produce yellow-gray, stalked, saucer-like apothecia, about 7 mm in diameter. Asci are cylindrical, 175-225 x 10-13 μ. Ascospores are colorless, oval, 14-21 x 6.5-9 μ. Sclerotia of *T. graminearum* are dark-brown, almost black, spherical, about 2 mm in diameter. They produce clavate fruiting bodies about 17 mm long; basidia with basidiospores develop on them.

Biology
Infection of conifer seedlings is from spores produced by germinating fruiting bodies from the fallen sclerotia, ascospores of *S. graminearum*, or basidiospores of *T. graminearum*. Warm and wet weather in autumn promotes germination of *S. graminearum* sclerotia. High humidity also is important for germination of *T. graminearum* sclerotia. Sclerotia can survive 1-2 years. For both fungi, spore discharge and seedling infection continue through the growing season until temperatures are constantly below 0°C. Disease development occurs in winter under the snow layer. Mycelium develops inside needles until mid-March when growth on the needle surface begins. Healthy seedlings are infected by aerial mycelium during this time. Damaged needles remain alive and green until snowmelt and then die and turn gray-green. Warm winters with numerous thaws and deep snow cover along with long springs with slow snowmelts favor disease development, i.e., small cavities are formed around seedlings under the snow cover. Herbaceous hosts are sources of inoculum for infection of conifer seedlings.

Damage
Growth is reduced and tops dieback in affected seedlings, which become deformed. Heavy infection may kill seedlings. Infection in nurseries fluctuates yearly and ranges from 10-80 percent; mortality ranges from 10-40 percent.

Distribution
European part of Russia, Middle Urals, Western Siberia, Far East

Control
Prevention
- Establish nurseries on level, well-drained soil; avoid low, wet areas.

Figure 61.—Lesion on three-year-old pine (*Pinus sylvestris*) branch caused by *Sclerophoma pithia.*

Cultural

- Do not repeat sowing of pine and spruce seeds in the same nursery beds for at least 2 years.
- Control weeds in and near nurseries to reduce inoculum sources.
- Survey seedlings just after snowmelt and remove and destroy infected seedlings within a week after snowmelt.

Chemical

- No fungicides are registered for control of snow molds of conifer seedlings.

Sclerophoma Disease of Pine Shoots

Class/Order: Deuteromycetes/Sphaeropsidales

Pathogen
Sclerophoma pithia v. Hohn

Host
Scots pine *(Pinus sylvestris)*

Diagnosis
Isolated, brown, necrotic lesions, elongate and about 1 to 1.5 cm long, form on shoots (**Fig 61**). Affected shoots become bright rusty-brown, often curved. Later, lesions turn gray and numerous pycnidia form on the surface of necrotic areas. Longitudinal lines of pycnidia form in bark cracks.

Pycnidia are spherical, black, about 460 μ in diameter. Conidia are egg-shaped, colorless, 1-celled, 6-7 x 2-2.5 μ. Needles of diseased shoots turn brown and dark bands about 2 mm wide form on the boundary with the healthy part of needles. In autumn, pycnidia form on dead ends of needles. Infected shoots are covered by picnidia, turn black, and drop in autumn.

Biology
In spring, shoots are infected by conidia from pycnidia on previously damaged shoots. Infection severity depends on seedling age. The number of diseased plants decreases significantly as plantation age increases. In plantations more than 6 years old, only shoots of upper nodes are infected. Environmental conditions also play a role in disease development. High levels of sunlight and low humidity promote moisture deficits in seedlings and stimulate rapid and vigorous fungal development. Cool, moist weather can cause outbreaks to collapse. Attacks by the pine tip moth (*Rhuacionia petrova*) promote infection of shoots by *Sclerophoma*.

Damage
Affects seedlings in nurseries and in plantations less than 12 years old. Causes seedling death in nurseries and reduces the number of seedlings for standard planting material. Infection in plantations less than 5 years old results in deformed crowns and, with repeated epiphytotics, seedling death and plantation decline.

Distribution
European part of Russia

Control
Observation
- Survey nurseries and pine plantations in the beginning of summer during drought years.

Cultural
- Remove and burn infected seedlings in the nurseries.
- Maintain row spacing in young pine plantations to allow for ploughing infected shoots into the soil.

Pine Shoot Rust

Class/Order: Basidiomycetes/Uredinales

Pathogen
Melampsora pinitorqua Rostr.

Hosts
Species of pines (*Pinus*), including Scots (*Pinus sylvestris),* Siberian *(P. sibirica),* and white *(P. strobus);* the alternate host is poplar *(Populus)*

Diagnosis
Aecia form from May to June on current-year shoots or on needles (**Fig. 62**). They develop beneath epidermis as oblong, orange swellings. Mature aeciospores burst through the epidermis as a bright-yellow, powdery mass. Aeciospores are 1-celled, oval or globose, 15-22 x 11-17 μ. The infected shoots lose turgor and bend. Small pitching wounds remain on the shoot's surface after aeciospore release. Numerous dormant (latent) buds can grow from below injured shoots and one can replace the dead leader, creating a false whorl.

Biology
The spermogonial and aecial stages develop on *Pinus* species. Uredinial and basidial stages develop on *Populus tremula* and other *Populus* species. In June, aeciospores disperse and infect leaves of *Populus* species. In summer, uredinia with urediniospores develop and spores are dispersed by wind to reinfect poplar; this continues until August. In late summer (August to early September), telia form in place of uredinia. Telia are brown or black and crust-like. Teliospores are brown, irregularly prismatical, 20-35 x 7-11 μ. Teliospores overwinter in fallen leaves. In spring, they produce basidia with basidiospores, which forms a golden layer on fallen poplar leaves. Basidiospores disperse in May and infect pine. Wet and warm springs favor the maturity and dispersion of basidiospores, and the infection of pine. The degree of injury also depends on growing conditions and seed origin (provenance). Optimal growing conditions increase pine resistance. The disease can be severe where *P.tremula* and *P.alba* grow near pine seedlings or plantations.

Figure 62.—Current-year shoots of pine (*Pinus sylvestris*) infected with *Melampsora pinitorqua.*

Damage
Damages pine seedlings and plantations less than 20 years old but rarely affects pine understory. Infected seedlings weaken and some die. Young seedlings (1-2 years old) are deformed by the bending or dieback of the terminal shoot. Heavy infection reduces the number of standard seedlings for planting by 40 percent. Infection of older seedlings distorts current-year shoots, including the main terminal (**Fig. 63**). Lateral shoots replace the leader and the main stem is deformed. Dieback of infected branches does not occur even with heavy infection. However, infection significantly reduces height growth. Upper crown injury in seed plantations reduces seed production.

Distribution
European part of Russia, Urals, Siberia, Far East

Control
Observation
• Survey pine nurseries and plantations in May-June for the presence of aecia on shoots and needles.

Cultural
• Locate new pine nurseries at least 250 m from *P. tremula* and *P. alba* plantations.
• Gather and burn fallen poplar leaves.
• Eliminate poplar sprouting near pine nurseries and plantations less than 10 years old.

Chemical
• Apply Bordeaux mixture (1%), Zineb (1%), or poliram combi 3 times beginning in mid-May, followed by 2 additional applications 6-7 days apart.

Chrysomyxa Rust of Spruce Shoots and Needles

Class/Order: Basidiomycetes/Uredinales

Pathogen
Chrysomyxa woroninii Tranz.

Figure 63.—Distortion of a current-year pine shoot (*Pinus sylvestris*) caused by *Melampsora pinitorqua*.

Hosts
Species of spruce (*Picea*) and *Ledum*

Diagnosis
Aecia form on current-year needles in spring, are elongate, sometimes the entire needle length, about 0.5 mm wide. Aeciospores are elliptical, 27-52 x 19-32 µ. Infected needles are short, covered by aecia, and resemble bright-yellow or orange brushes (**Fig. 64**) within an otherwise green crown. The telia stage of the pathogen develops on *Ledum* species and causes the formation of witches'-brooms.

Biology
This pathogen is heteroecious but not macrocyclic. Spermagonial and aecial stages develop on spruce. The telial stage develops on *Ledum* species. The fungus overwinters on *Ledum* as teliospores. In spring, basidiospores infect opening buds and expanding spruce needles; spermogonia and aecia form on them. Maturing aeciospores are windblown and infect the alternate host *Ledum*. Infection can be severe in good growing conditions as well as during wet springs and dry summers.

Damage
Affects seedlings in the understory, rarely occurring in overstory crowns. Causes dieback of shoots, malformed trees, and reduced vitality and height growth. Damage can occur on up to 40 percent of the shoots on 35-40 percent of the trees.

Distribution
Kolsky Peninsula, Karelia, and Lake Baikal, Siberia, Far East

Figure 64.—Current year shoot of spruce (*Picea abies*) infected by *Chrysomyxa woroninii.*

Control

<u>Cultural</u>

- Remove diseased plants in nurseries.

Diseases of Forest Stands

Dieback and Canker Diseases

Black Cytospora Canker of Poplar

Class/Order: Deuteromycetes, Sphaeropsidales

Pathogen

Cytospora foetida Vl. et Rr.

Hosts

Species of poplar (*Populus*), including white (*P. alba*), Carolina (*P. canadensis),* black (*P. nigra*), and Bolle's (*P. bolleana)*

Diagnosis

The fungus affects interior bark and outer sapwood. Both are colonized by mycelium and turn dark-brown. The exterior color of bark may not change. Diatrypoid stromata form inside bark and extend along trunks and branches. Stromata can be several cm to 1.5 m long. In the final stage of disease development, stromata can encircle stems and branches. The stroma is dark-brown, almost black, powdery, 1-4 cm thick. Multichamber pycnidia, 1-4 mm in diameter, form beneath the periderm on infected stems and branches with smooth bark. Pycnidia chambers are irregularly spherical or oval, 100-300 μ in diameter, in one or more layers. A solid layer of conidiophores forms on the chamber wall. Each conidiophore is nearly colorless, but in mass conidiophores are light-orange; they measure 24-29 x 0.5-1 μ. Conidia are colorless, alantoid, 5-7 x 1.5-2 μ. They exude from pycnidia as blood-red drops and ribbons. A characteristic symptom of the disease is the fishy odor of infected bark. Some infected trees die annually branch by branch while others die rapidly. The crown is sparsely foliated with small leaves that suddenly turn chlorotic and drop. Severely affected trees may not produce foliage in spring, or foliage withers 1-2 weeks after expansion.

Biology
The fungus sporulates in late May to early June and again in late August through September. Infection occurs at the same times in moist conditions. Spores are spread by rain, insects, on plant material, rarely by air. In stool-bed plantations, infection occurs on trees left after shoot cutting. In tree plantations and natural stands, infection occurs through mechanical and insect injury, cracks on the base of branches, and severely weakened branches. After penetration, the pathogen secrets toxins, kills inner bark and sapwood tissues, forms cankers, and causes dieback. External symptoms can be absent in the first year after infection. The sexual stage of the fungus, (*Valsa* sp.), rarely develops.

Damage
Trees of a range of ages are affected, but most damage occurs in poplar stands that are 21-60 years old. The fungus forms distinct cankers, causing dieback. In young stands, sprouts form in response to dieback but also can dieback over a 2- to 4-year period. In older stands, dieback occurs gradually, causing partial loss of upper crown and epicormic sprouting. Damage is severe in stands affected by unfavorable environmental factors, e.g., drought, winter damage, nutrient imbalances, and insect injury.

Distribution
Southeastern area of European part of Russia

Control
Observation
- Survey poplar plantations in spring after full leaf expansion and again in late summer and early autumn.

Cultural
- Establish plantations in areas with appropriate soil and climate conditions for vigorous growth of poplar.
- Use healthy, canker-free plant material to establish nursery beds and plantations.
- Minimize mechanical injury during nursery and plantation maintenance.
- Conduct shoot cutting for vegetative propagation in early spring before sap ascent.
- Use resistant poplar clones to establish nursery beds and plantations.

Chemical
- Use fungicides (ENT987, DITHANE Z-78) to treat cuttings before planting.
- Spray copper fungicide in late summer to prevent autumn infection.

Biatorella Canker

Class/Order: Ascomycetes, Lecanorales

Pathogen
Biatorella difformis (Fries.) Rehm. (anamorph: *Biatoridina pinastri* Golov. et Stzedr.)

Host
Scots pine (*Pinus sylvestris)*

Diagnosis
Cankers form on branches and stems and often occur at the juncture of the main stem and limb (**Fig. 65**). Twenty or more cankers can occur on a single understory tree. Young cankers are orbicular or oval and encircled by pitch-covered callus. Old cankers are open, deep, with sharp edges and covered

Figure 65.—Young pine tree (*Pinus sylvestris*) affected by the fungus *Biatorella difformis.* Note the "target" canker on the trunk.

with pitch. Cankers form yearly concentric rings of dead wood. In mature and overmature forests, cankers develop for several decades. The surface of old cankers, often black, is caused by the nonparasitic fungus *Auerobasidium pullulans* (de Bary) G.Arnaud. The imperfect stage of the canker fungus forms on the surface of wood and appears as a circle of black pycnidia, about 2.5-3 mm, resting on a brown matrix of mycelium. Bottle-like conidiophores about 6 to 8 μ long form in the pycnidia. Conidia are oval, colorless or light-olive but dark-olive in mass, 1.8-3 μ. Conidia are extruded as a dark, slimy mass. Black, waxy apothecia form very rarely. They are 500-800 μ in diameter and form in the same brown matrix as pycnidia.

Biology
Infection and spread from tree to tree occurs by conidia produced in early summer. A second sporulation occurs in autumn when temperatures are lower; most infections occur at this time. Conidia penetrate tree tissues through natural openings but primarily through mechanical injuries, including borer damage. Insects that are important in development of this disease are *Eveteria resinella* L., *Hylobius abictis* L., and species of *Pissodes.* Mycelium spreads from damaged to living tree tissue, affecting the phloem, cambium, and eventually sapwood, where mycelium spreads up and around the stem at a rate of 1-2 cm per year. The disease mostly affects weak and suppressed trees growing off-site. High moisture and low light are predisposing factors in the understory, where infected trees range from 20-80 percent. In plantations growing in full sunlight, infection is 2 percent.

Damage
Trees that are 10-80 years old are damaged. Understory trees and forest plantations are affected more than natural mature forests. Infection reduces radial growth in both understory trees and forest plantations. Severe infection on understory trees increases branch breakage by snow, but few trees

are killed. Mature trees in natural forests are rarely damaged but cankers on the stem base will reduce the volume of commercial wood. The disease is most severe on trees growing off-site.

Distribution
European part of Russia, East and West Siberia

Control
- Conduct improvement and sanitation cuts.
- Remove and destroy severely damaged trees.
- Control insects that promote infection by the canker fungus.

Pitch Blister Rust Canker

Class/Order: Basidiomycetes, Uredinales

Pathogen
Cronartium flaccidum Wint. and *Peridermium pini* (Willd.) Let. et Kleb.

Hosts
Species of pines (*Pinus*), including Scots (*P. sylvestris*), Swiss mountain (*P. montana*), and Austrian (*P. nigra*)

Diagnosis
Both pathogens cause the same symptoms. Cankers form on stems and develop over years to decades, and can occur along the entire length of the stem **(Fig. 66).** Bark on infected areas sloughs and resin flows out from infected tissues and congeals as gray-yellow spots. Cankers can be 2.5 m long. Affected stems are deformed by eccentric growth near the cankers. Aecia are produced on young cankers on stems and branches. They erupt through the bark as orange blisters, 3-7 mm high and 3-4 mm wide, and release aeciospores. Yellowish, highly visible cracks in the bark remain after spore release on branches and stems with thin smooth bark (**Fig. 67**).

Biology
The fungus *C. flaccidum* is heteroecious and macrocyclic. Aecia with aeciospores form in June on stems and branches of pine. Aeciospores infect leaves of herbaceous plants such as *Vincetoxicum officinale* (syn. *Cynanchum vincetoxicum), Pedicularis palustris, Impatiens* species, and *Verbena* species. Uredinia and telia develop on these plants. Telia form in autumn and are columnar, 1-2 mm high. Vertical chains of teliospores form; they are elleptical, yellow-brown, 25-60 x 9-16 μ. Teliospores overwinter, germinate in spring, and produce basidia with basidiospores that infect pine.

The fungus *P. pini* develops only on pine in the aecial stage. Mature aeciospores reinfect the pine. Infection occurs through young succulent shoots. The mycelium penetrates and destroys wood cells and resin ducts. Two to three years after infection, cambium cells are killed and wood production ceases. About the same time, aecia form on the cankers. Affected young shoots usually die along with pathogen mycelium in 1-2 years. If the mycelium penetrates the stem before the branch dies, it develops a perennial canker. Disease development is favored by wet conditions; pure pine forests are damaged more than mixed stands. Both pathogens are enhanced by sunlight and most injury occurs on trees in partially stocked stands and those at the forest edge, along roads, and clear areas.

Damage
Damages young understory, plantation, and mature trees. Affected understory plantation trees are weakened and can wither in a short time. Also weakens mature trees and reduces terminal growth, causing partial and later total crown dieback. Cankers deform the stem and reduces the volume of commercial wood. Affected trees often are attacked by bark beetles, e.g., *Ips acuminatus, Tomicus piniperda, T. minor, Pityogenes quadridens*, and *P. irkutensis*. Beetle attack accelerates dieback and mortality.

Distribution
European part of Russia, Urals, Siberia

Control
<u>Observation</u>
- Survey for the disease in May-June during aecial development.

Figure 66.—Pitch blister rust of pine (*Pinus sylvestris*) caused by *Cronartium flaccidum* and *Peridermium pini*. The affected pine has a canker on upper portion of the trunk.

• Determine tree condition and canker distribution (location) on the stem, e.g., low, middle, or upper portion of crown.
• Determine the degree of canker development around the stem circumference: less than 1/2, more than 1/2 but less than 3/4, more than 3/4 to complete.
• Record species and abundance of bark beetles on affected trees.

Cultural
• Conduct a 2-stage sanitation cutting at intervals of 3-5 years. Remove heavily weakened, suppressed, and dead trees with below-crown cankers and evidence of attack by bark beetles; cut stag-headed trees in the second stage.
• Create mixed-pine stands and forest plantations with high initial planting density.

Endoxylina Canker of Ash

Class/Order: Ascomycetes, Diaporthales

Pathogen
Endoxylina stellulata Rom. (syn. *Valsaria stellulata* Rom.) (anamorph: *Libertella fraxini* Ogan.)

Host
European ash (*Fraxinus excelsior* L.)

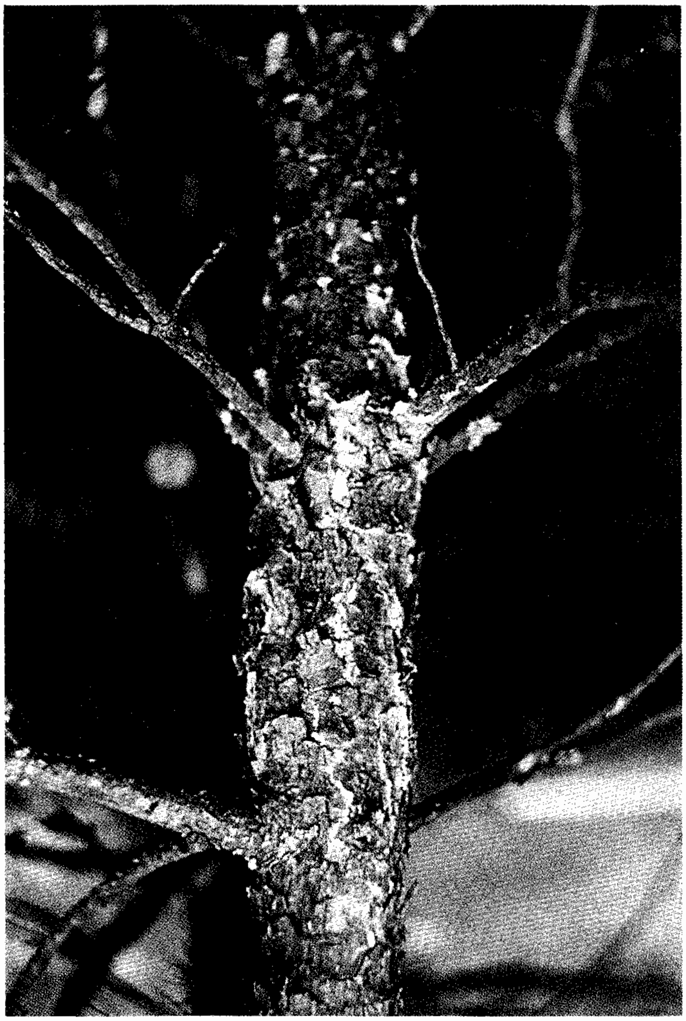

Figure 67.—Aecia of *Peridermium pini* breaking through the bark surface on the stem of a young pine (*Pinus sylvestris*) tree.

Diagnosis

Usually 1-2 perennial cankers form on the stem, primarily below the crown. They are elongate-oval, target-like, with clear annual concentric ridges of wood, up to 0.7 m long. Dark, almost black stromata develop under dead bark. The wood of the canker is exposed annually after dead bark and stromata slough. Injured wood in the canker is characteristically dark because of the remains of stromata. The surface of canker wood is covered by numerous, thin, transverse splits. Perithecia are buried in the stroma but necks form a solid layer of black, dotted hillocks. Perithecia are black, bottle-shaped, single, with a thickened pore on top, 375-800 x 150-360 μ. Asci are clavate, on long stalks, 135-150 x 10-12 μ. Ascospores are 2-celled, olive-brown, allantoid, 14-20 x 4-6 μ. The characteristic symptom of the disease is the marbled or yellow appearance of decayed heartwood and sapwood. It spreads upward and downward from the initial canker.

Biology

Infection occurs through cracks on dry, low branches on the lower portion of the trunk. Mycelium develops in bark, cambium, and heartwood over several years. In the second year after wood tissues die, perithecia form. Mycelium grows into the base of the stem; multiple stems can be infected. The disease usually persists for 7-17 years, but it can develop quickly and kills trees in 5-7 years. More weakened than healthy trees are affected. Most canker damage occurs in understocked stands, on dry slopes, where soils are high in alkalinity.

Damage

Cankers form on the stem below the crown and are relatively fast growing. The result is weakening and gradual dieback and decline of the tree. The pathogen often penetrates tissues at the base of the stem, causing dieback of sprouts. Sapwood and heartwood decay reduces resistance to wind, promoting breakage. Coppice stands are less resistant to the disease; damage in these stands ranges from 40-60 percent.

Distribution
Steppe zone of southeastern area of European part of Russia.

Control
Cultural
- Conduct sanitation cuttings to remove dying and dead trees within disease centers.
- Remove or uproot stumps after sanitation cutting to prevent sprout infection.

Cankers and Diebacks

Class/Order: Deuteromycetes/Sphaeropsidales

Pathogen
Camarosporium ribicolum Sacc.

Host
Golden currant *(Ribes aureum)*

Diagnosis
Necrotic lesions develop on the bark. Pycnidia are dispersed or coalesced in groups in necrotic areas. They are black, spherical, similar to stromata. Conidia are oblong-globose or egg-shaped, brown, with 3-4 transverse and 1-2 longitudinal walls, 12-16 x 6-8 μ.

Distribution
European part of Russia

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Pathogen
Coniothyrium inisitivum Sacc.

Hosts
Bird cherry (*Padus avium*), barberry *(Berberis vulgaris)*, and lilac *(Syringa vulgaris)*

Diagnosis
Dark, necrotic lesions form on the bark. Pycnidia develop in the necrotic areas in clusters. They are black and spherical. Initially, they are buried in leaf tissue but later erupt and release conidia. Conidia are elongate-egg-shaped, 1-celled, brown, 4.5 x 2.5 x 4 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Cytospora tumida Lib.

Host
Pedunculate oak *(Quercus robur)*

Diagnosis
Necrotic lesions form on the bark; later, black stromata develop that are cushion-like, black, round or angular. Initially, they are buried in leaf tissue but later erupt. Conidia are alantoid, colorless, 6 x 1.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Diplodia amphisphaerioides Pass.

Host
Pedunculate oak *(Quercus robur)*

Diagnosis
Black, sphaerical or flat-spherical pycnidia form on the bark of dead, dry branches. Initially, they are buried in tissue but later erupt. Conidia are ellipsoidal, brown, 2-celled, 17.5 x 7.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Microdiplodia ascochytula (Sacc.) Allesch. (syn. *Diplodia ascochytula* Sacc.)

Hosts
Species of honeysuckle *(Lonicera)*

Diagnosis
Brown necrotic lesions form on dead areas of bark. Brown pycnidia in groups form on the dead bark and are initially buried in tissue but later erupt. Conidia are spindle-like with blunt ends, 2-celled, olive-brown, 8-12 x 2.5-3 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Diplodia juniperi Westend.

Host
Red cedar *(Juniperus virginiana)*

Diagnosis
Bark on branches dies. Black, spherical, single, scattered pycnidia form in the cracks of dead bark. Conidia are oblong-egg-shaped, 2-celled, brown or dark-brown, 18-20 x 8-10 μ.

Distribution
Southwestern areas of European part of Russia

♦♦♦

Pathogen
Diplodina tatarica Allesch.

Host
Honeysuckle (*Lonicera tatarica)*

Diagnosis
Bark dies on affected branches. Numerous, black, spherically-flat, dispersed pycnidia form in bark cracks. Conidia are spindle-like, 2-celled, with a small septum, colorless, 8-12 x 2.5-3 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Dothiorella robiniae Prill. et Delacr.

Host
Black locust *(Robinia pseudoacacia)*

Diagnosis
Black, erumpent stromata form in the bark of dead, dry branches. Pycnidia, oblong or irregularly shaped, develop in the stroma. Conidia are egg-shaped or elliptical, 1-celled, colorless, with 2-3 oil drops, 10.5-12 x 3.5-4 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Fucicoccum obtusulum Grove

Hosts
Species of maple (*Acer*)

Diagnosis
Stromata form within the bark of dead branches. They are dark-gray, with yellow centers, flat-conical, dispersed. Conidia are spindle-like with blunt ends, straight, 1-celled, colorless, 12-14 x 2-2.5 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Hendersonia pseudoacaciae Ell. et Barth.

Host
Black locust *(Robinia pseudoacacia)*

Diagnosis
Black, dispersed pycnidia form in the bark of dead branches. Conidia are oblong-oval, 4- to 8-celled, brown, 15-24 x 6-10 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Phoma aceris-negundinis Arcang.

Host
Species of maple (*Acer*)

Diagnosis
The affected bark surface is rough and light-yellow. Pycnidia form under the epidermis; they are slightly raised, black, and spherical. Conidia are oval, colorless, with 2 drops of oil, 8-3 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Rhabdospora passerinii Sacc.

Hosts
Species of maple (*Acer*), primarily boxelder *(A. negunda).*

Diagnosis
Affected branches and sprouts dieback. Brown-black pycnidia form in the cracks in dead bark in longitudinal lines. Conidia are cylindrical, straight, slightly narrowed on the ends, 4-celled, 30-32 x 2.5 µ.

Distribution
European part of Russia

Class/Order: Ascomycetes/Helotiales

Pathogen
Lachnellula angustispora Raitv.

Hosts
Species of fir *(Abies)* and larch (*Larix*)

Diagnosis
Apothecia form on the bark of dead branches. They have a short stalk, white outside surface, bright-orange center, 0.3-3 mm in diameter. Asci are clavate, 101-106 x 9.7-10.2 µ. Ascospores are ellipsoid to spindle-shaped, asymmetrical, colorless, 1-celled, 12.8-14.2 x 5-5.2 µ.

Distribution
Middle Urals, Siberia

♦♦♦

Pathogen
Lachnellula flavovirens (Bres.) Dennis

Hosts
Species of spruce *(Picea)*, fir *(Abies)*, and larch (*Larix*)

Diagnosis
Apothecia form on the bark of dead branches. They have a short stalk, brown, hairy outside surface, bright-orange center, 1-3 mm in diameter. Asci are clavate, 55-65 x 6.2-6.6 µ. Ascospores are ellipsoid to spindle-shaped, asymmetrical, colorless, 1-celled, 7-7.5 x 3.5-3.8 µ.

Distribution
Urals, Siberia, Far East

♦♦♦

Pathogen
Lachnellula fuckelii (Bres. in Rehm.) Dharne.

Hosts
Species of spruce *(Picea)* and pine (*Pinus*)

Diagnosis
Apothecia form on the bark of dead branches. They have a short stalk, snowy-white outside surface, bright-orange center, 0.3 to 3 mm in diameter. Asci are clavate, 113-118 x 9.3-10.5 µ. Ascospores are ellipsoid to spindle-shaped, asymmetrical, 1-celled, colorless, 12.8-13.2 x 6-6.4 µ.

Distribution
Middle Urals, Far East

♦♦♦

Pathogen
Lachnellula kamtschatica Raitv.

Hosts
Mountain pine *(Pinus pumila)*

Diagnosis
Apothecia form on the bark of dead branches. They have a short stalk, snowy-white outside surface, and a bright-orange center. Ascospores are widely ellipsoid, 1-celled, colorless, 6-7 x 4-5 µ.

Distribution
Far East

♦♦♦

Pathogen
Lachnellula minuscula Raitv.

Host
Species of fir (*Abies*)

Diagnosis
Apothecia on short stalks form on the bark of dead branches. The outside surface is covered with hairs; the inside disk is bright-orange, 1-2 mm in diameter. Asci are clavate, 44-56 x 4.4-5 μ. Ascospores are ellipsoid to spindle-shaped, 1-celled, colorless, 5.1-5.7 x 1.8-2.3 μ.

Distribution
Siberia, Far East

♦♦♦

Pathogen
Lachnellula pseudofarinacea (Cronan.) Dennis

Host
Species of pine (*Pinus*)

Diagnosis
Apothecia form on the bark of dead branches. The outside surface is covered with snowy-white, dense hairs; the inside disk is bright-orange, 1-1.5 mm in diameter. Asci are clavate, 100-115 x 9-10.5 mm. Ascospores are thread-like, without a septum, colorless, 73-97 x 1.5-2 μ.

Distribution
Northern area of European part of Russia, Siberia

Class/Order: Deuteromycetes/Melanconiales

Pathogen
Didymosporium profusum Fr.

Host
Species of maple *(Acer)*

Diagnosis
Cushion-like, conical structures form in cracks on dead bark. Conidia are oblong or egg-shaped, 2-celled, a smoky color, 10-12 x 8-9 μ.

♦♦♦

Pathogen
Melanconium desmazierii (Berk. et Br.) Sacc.

Hosts
Species of lime (*Tilia*)

Diagnosis
Black, depressed, cushion-like stromata, slightly erumpent, form under the epidermis of dead branches and stems. Conidia are short, spindle-like, with blunt ends, smoky-blue, 1-celled, with 2 oil drops, 30-35 x 6-10 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Melanconium czerniaiewi Poteb.

Hosts
Species of oak (*Quercus*)

Diagnosis
Bark dies on young branches. Black, conical stromata, 1-2 mm in diameter, form under the bark. Conidia are oval, ellipsoid or pear-like, dark-brown, 1-celled, 18-24 x 11-14 μ.

Distribution
Southwestern area of European part of Russia

♦♦♦

Pathogen
Septogloeum hartigianum Sacc.

Hosts
Species of maple (*Acer*)

Diagnosis
Affected branches and sprouts dieback and turn brown. Sporodochia form in longitudinal bark cracks. They are cushion-like, oblong, brown, 1-3 mm in diameter. Conidia are oblong-oval, 3-celled, colorless, 4-15 x 2-4 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Septomyxa negundinis Allesch.

Hosts
Species of maple (*Acer*)

Diagnosis
White-yellow or gray necrotic lesions with dark borders form on affected branches. Numerous, aggregated sporodochia form on dead bark. Initially, they are buried in tissue but later erupt. They are cushion-like, red- or dark-brown. Conidia are fusiform, pointed, rarely oval, initially 1-celled, and later 2-celled, colorless, 10-20 x 3-4.5 μ.

Distribution
European part of Russia

♦♦♦

Pathogen
Stilbospora angustata Pers. (teliomorph: *Pseudovalsa berkeleyi* Sacc.)

Hosts
Species of hornbeam *(Carpinus)* and beech *(Fagus)*

Diagnosis
Black, cushion-like, convex, often coalesced sporodochia form under the epidermis of affected bark. Conidia are cylindrical, elongate, 4-celled, olive, often with a sticky jelly cover, 35-50 x 10-14 μ.

Distribution
European part of Russia

Class/Order: Ascomycetes/Sphaeriales

Pathogen
Leucostoma diatrype Fr.

Hosts
Species of alder (*Alnus*)

Diagnosis
Black, conical, dispersed stromata with white or gray-white disks form in the bark of dying and dead branches. Each stroma contains 3-7 perithecia. Asci are clavate, 80-100 x 8-16 µ. Ascospores are cylindrical, colorless, 16-18 x 3-6 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Nitschkia cupularis (Pers.) Winter (anamorph: *Phoma fuckeli* Sacc.)

Hosts
Species of elm (*Ulmus*)

Diagnosis
Affected branches, especially sprouts, die. Perithecia form in clusters in dead bark. They are black, round but more often elongate, 0.5-3 mm in diameter, and resemble small hillocks erupting the epidermis. Asci are elongate, clavate, 40-60 x 7-8 µ. Ascospores are short, cylindrical, slightly curved, colorless, with oil drops, 9-10 x 2-3 µ.

Distribution
European part of Russia

♦♦♦

Pathogen
Nummularia succenturiata (Tode) Nitschke

Hosts
Species of elm *(Ulmus)*

Diagnosis
Affected trees die. Stromata form within dead bark as black, flat disks, 3-5 mm in diameter. Perithecia form on the surface of the stromata. Asci are elongate, clavate, 120-150 x 9 µ. Ascospores are ovoid or fusiform, straight or slightly curved, brown, 16-18 x 5-7 µ.

Distribution
European part of Russia

Class/Order: Ascomycetes/Dothideales

Pathogen
Cucurbitaria rhamni (Nees.) Fckl. (anamorph: *Diplodia rhamni* Gaap.

Host
Species of buckthorn *(Frangula alnus, Rhamnus cathartica)*

Diagnosis
Initially, pycnidia form on dead branches. They are single or clustered, black, and spherical. Initially, they are buried in bark tissue but later erupt. Black pseudothecia form in bark cracks. They are spherical, cup-like, concave, black, often in long rows. Conidia are oblong, egg-shaped, dark-brown, 2-celled, 20-25 x 7.5-10 µ. Asci are clavate, elongate, 120-140 x 12 µ. Ascospores are oblong-elliptical, yellow-brown, with 3-6 transverse walls and 1 incomplete londitudinal septum, 16-21 x 7-8 µ.

Distribution
European part of Russia

Wood-Decaying Diseases

Class/Order: Basidiomycetes, Aphyllopherales

Ganoderma Butt Rot of Beech

Pathogen
Ganoderma pfeifferi Bres. (syn. *Polyporus laccatus* Kalchbr.)

Host
Oriental beech (*Fagus orientalis*)

Diagnosis
Basidiocarps are perennial, semicircular, hoof-shaped, 10-30 x 7-15 cm. The surface of the basidiocarp is covered with a resinous, initially orange-red then brown, varnish-like crust that blackens with age. They have a yellow-red, shiney margin. Interior tissues are corky and fibrous and rusty- or chestnut-brown. The hymenophore is tubular; pores are round, 150 m in diameter. Basidiospores are yellow-brown, egg-shaped, with a thorny spore wall, 9-12 x 6-8 μ. Hymenium surface is yellow or gray-yellow and covered by a resinous material. The decay affects both heartwood and sapwood; the wood is white and pale-yellow, fibrous.

Biology
Sporulation occurs from early summer to autumn. Infection occurs by basidiospores in wounds at the stem base or exposed roots. The fungus requires warm temperatures for development; optimal temperatures ranges from 22°-30°C. Basidiocarps are resistant to temperature fluctuation, enduring even severe temperature drops in winter. Mycelium and basidiocarp development requires high moisture conditions. Basidiocarps rapidly absorb and retain water, so saturation can occur after a short period of rain. Spores are airborne but also can be spread by insects, animals, and humans.

Damage
The butt log of beech decays, often resulting in wind breakage

Distribution
Northern Caucasus Mountains

Control
• Conduct sanitation cuttings; remove trees with sporophores.

Vuillemenia Decay

Pathogen
Vuillemenia comedens Maire.

Host
Primarily species of oak (*Quercus*) but also beech (*Fagus*), hornbeam (*Carpinus*), buckeye (*Aesculus*), birch (*Betula*), and hazel (*Corylus*) species

Diagnosis
Basidiocarps arise under the epidermis of the stem or lower surface of branches. The bark splits open and basidiocarps emerge. They resemble pellicles, covering the entire length of the branch. Pellicles are 1-1.6 mm thick and closely attached to the substrate. The hymenial layer is smooth and waxy but cracks in dry weather. Hymenial layer ranges from white to light-brown. This layer produces clavate basidia, 80-100 x 3 μ. Basidiospores are cylindrical, with round ends, colorless, 12-24 x 5-9 μ. The fungus causes a white, peripheral decay.

Biology
Sporulation intensity depends on weather conditions; it ceases in dry weather and returns after rain. As a result, there are several periods of mass spore formation and dissemination during a year. Branch infection occurs by basidiospores through wounds, including insect injury **(Fig. 68).** Mycelium develops in the sapwood of stems and branches, causing rapid dieback of young trees.

Damage
Causes dieback in oak plantations less than 25 years old that are growing off-site. In young oak plantations, damage ranges from 10-70 percent.

Figure 68.—Infection of a branch stub by *Vuilleminia comedens* on a young white oak (*Quercus robur*).

Distribution
European part of Russia, southern Urals

Control
Observation
• Survey stands shortly after foliage emergence; affected dead stems and branches are prominent at this time.

Cultural
• Remove infected trees from plantations.

Trunk and Limb Rots

Pathogen
Hericium cirrhatum (Fr.) Nicol.

Hosts
Species of maple (*Acer*), birch (*Betula*) and lime (*Tilia*)

Diagnosis
Basidiocarps are annual, almost semicircular, one above another in clusters, joined at the base. They are initially white, turn yellow, and later are leathery-yellow or dirty-orange. The margin is blunt or thin, sharp, and wavy. The hymenophore is thorny **(Fig. 69);** each thorn is sharp, up to 10 mm long, white when fresh and dirty-yellow after drying. Interior tissue is thick, up to 3 cm, soft and then soft corky. Spores are widely ellipsoid or nearly globose, with 1 large drop of oil, 3.5-4 x 3-3.5 μ. Decay is white, laminately fibrous, and develops in sapwood and heartwood.

Distribution
European part of Russia, Urals, Far East

Figure 69.—Basidiocarp of *Hericium cirrhatum* on a broken limb of a fir (*Abies sibirica*).

Pathogen
Inonotus polymorphus (Rostk.) Bond. et Sing.

Hosts
Species of beech (*Fagus*) and hornbeam (*Carpinus*)

Diagnosis
Basidiocarps form on dead branches, are annual, small, tightly grown, rounded, later coalesced and elongate, about 50 x 6-10 x 1-1.5 cm. The margin is wide, sterile, and disappears with time. The hymenophore is tubular. The tubes are sloped, about 3-4 mm long, brown or yellow-brown, angular. Spores are ellipsoid, initially yellow, later brown, with thick covers, 4-6.5 x 3-5 μ. Decay is white and fibrous, and develops in sapwood and heartwood.

Distribution
Southern area of European part of Russia

♦ ♦ ♦

Pathogen
Phellinus baumii Pil.

Hosts
Amur honeysuckle *(Lonicera maakii),* coralline honeysuckle *(L. chrysantha),* amur lilac *(Syringa amurensis),* and cranberry tree *(Viburnum opulus)*

Diagnosis
Basidiocarps form on the trunks of living and dead trees and stumps, are perennial, semicircular or hoof-like, 1.5-8 x 3-13.5 x 1-5.3 cm. The upper surface of young conks are swollen and furrowed, brown with an orange margin, covered with short bristles. The upper surface of old basidiocarps is dark-brown, almost black, roughened by tile-shaped cracks. The margin is sharp, rarely blunt. The interior tissue is radially fiberous, hard, golden-brown, with a silky shine, 0.2-1 cm thick. The hymenophore is tubular, with a smooth, chocolate-brown, lower surface. Tube length is 1-4 mm. Pores are circular or angular, inconspicuous. Spores are widely ellipsoid to nearly globose, with thin coverings, colorless, 3.7-4.6 x 3.5-3.7 μ. Decay is white, laminately fibrous, and develops in sapwood and heartwood.

Distribution
Far East

♦♦♦

Pathogen
Phellinus microporus (Pil.) Parm.

Hosts
Species of fir (*Abies*), spruce (*Picea*), and pine (*Pinus*)

Diagnosis
Basidiocarps form on the trunks of living and dead trees and roots of windthrown trees, are perennial, attached to the substrate at one point or by the entire base, 2-5.5 x 1.5-4 x 0.2-0.6 cm. The upper surface is brown-yellow, chestnut-brown or black, bristly or velvety, with narrow furrows. The margin is straight, thin, and sharp. Interior tissue is thin, 1-2 mm thick, corky to woody, and brown. Tubes of the hymenophore are stratiform, 2-5 mm long, lighter in color than the trama. The lower surface of the hymenophore is brown. Pores are circularly-angular. Spores are widely ellipsoid, slightly ovoid, with thin covers, colorless but turn yellow with age, 4.5-5.1 x 3.5-4 µ. Decay is brown with white spots, pocket-fibrous, and develops in sapwood and heartwood.

Distribution
East Siberia, Far East

♦♦♦

Pathogen
Piptoporus quercinus (Schrad. ex Fr.) Pil.

Hosts
Species of oak (*Quercus*)

Diagnosis
Basidiocarps form on the trunks of living and dead trees, are annual and are elongate, fan- or tongue-shaped conks, 4-9 x 6-11 x 1.5-3 cm, with a thickened base on stalks. The upper surface is initially velvety, later rough, initially pale-yellow, later light-chestnut to chestnut-brown. The margin is blunt. The interior tissue is 2-3 cm thick. The young trama initially is soft and wet, then soft-corky, white and pale-cream after drying. The hymenophore is tubular. Tubes are 2-3 mm long, with rounded or angular pores, 0.3-0.5 mm in diameter. The lower surface of the hymenophore shrinks after drying, and the margins turn white to yellowish with age. Spores are fusiform or ovoid, with sharp ends and several oil drops, colorless, 6.5-9 x 3-3.5 µ. Red-brown decay develops in the heartwood, cracks into prismatic chunks, and later crumbles to dust.

Distribution
European part of Russia

♦♦♦

Pathogen
Spongipellis litschaueri Lohw.

Hosts
Species of oak (*Quercus*), elm (*Ulmus*), maple (*Acer*), poplar (*Populus*), lime (*Tilia*), and pine (*Pinus*)

Diagnosis
Basidiocarps form on the trunks of living and dead trees, are primarily annual but sometimes 2-5 years old, flat, hoof- shaped, 3-12 x 4-20 x 2-6 cm. They are initially soft, spongy, or fibrous but later become hard. The upper surface is nearly white, later yellow to brown, and becomes soft felty-bristly, bare or rough; the margin is sharp. The interior tissue is white, pale-brown after drying, radially fibrous. Hymenophore tubes are 1-2 cm long, initially white or creamy, later orange with fringy or tattered margins. Pores are irregular, rounded angular, 0.3-2 mm in diameter. The lower surface of the hymenophore is white to cream and turns brown after drying. Spores are widely ellipsoid, nearly globose, colorless, with 1 large oil drop, 5.5-7 x 4.5-6 µ. The decay is white and fibrous; initially, it develops in heartwood but later spreads to sapwood.