SUBALPINE FUNGI AND SNOWBANKS

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Introduction

The study of the environment, especially the microenvironment, of the macromycetes (larger fungi) of the soil has received little attention. Persons describing the fungi of a region, or writing descriptions of new or interesting species of fungi, indicate something of the habitat but nothing of the actual conditions under which the fungus in question was growing. The present notes were prepared as a result of several seasons of field observations. They are presented in their present imperfect form in the hope that some student of biotic relationships may be interested in the problems involved and have the time and opportunity to subject them to further study.

Historical

Setchell and Watson (1926) attempted to correlate some of the climatic conditions they found at the soil surface with the occurrence of hypogaseous fungi (fungi which fruit underground) at a station in the Santa Cruz Mountains south of San Francisco, California. The study was very limited and of doubtful value, attempting to indicate some relationship between the occurrence of fruit-bodies and the three-day fogs reportedly characteristic of the region, but describing none of the actual soil conditions nor of the conditions giving rise to the fogs. Weir (1918) listed the wood decay fungi of northern Idaho and adjacent Montana, and Washington according to host range and highest altitude at which they had been collected. No further correlation was attempted. In the literature of phytopathology (Foister 1935, 1946) there is a large number of references to climatic factors in reference to plant disease fungi.

At high altitudes, however, few fungi are reported to be of economic importance. Those which are of some importance include species in the genera *Herpotrichia* and *Neopeckia*, smothering fungi of coniferous trees (Hedgcock 1914). In forest nurseries at high altitudes certain soil fungi (micromycetes) are also of importance, especially in the genus *Pythium* and physiologically related organisms which cause damping-off disease of seedlings (Baxter 1943). Both of these groups of fungi appear to require high relative humidities. The smothering fungi appear to develop only under the influence of the winter snowpack, the damping-off fungi develop only in moist soil. Both habitats are ones in which nearly, if not actually, 100 per cent relative humidity occurs.

Several collectors have reported on fungi collected at high altitudes and latitudes. Lind (1934) obtained from collections of vascular plants housed in Scandinavian herbaria a series of species of micromycetes to which the vascular plants were host in either living or dead tissues. He made several reports on these but no attempt was made to correlate the collections with climatic or edaphic factors beyond the assumptions inferred when the areas reported were listed as north of the Arctic Circle. Wehmeyer in Wyoming (1946, 1947) and Cooke (1944) on Mount Shasta, California, have reported on collections of fungi but no correlation other than host, specific location, or Merriam life-zone was attempted by either worker. Many collectors have published descriptions of macromycetes collected in the high mountains of western North America; many papers have been written on the species, but little or no information has been obtained as to the micro-environments of the various species discussed.

Following a severe drought, Shope (1936) reported that the fungi associated with spruce in subalpine habitats in the Colorado Rocky Mts. were killed out in spite of the fact that some could have been mycorrhizal and that observations were made over a very limited period of time by qualitative rather than quantitative methods. Shope (1937) indicated that revival of the populations was more rapid in soilborne fleshy species than in wood-borne species producing leathery or woody fruit bodies. Following the same period of drought, on the other hand, Martin (1937) found that fungi growing in the soil in Iowa revived and fruited after an interval which was somewhat longer than usual. Revival in Iowa appeared to have been correlated with moisture made available by precipitation. Again the report was based on observation of qualitative rather than quantitative data. Friedrich (1940) published data to show that certain species of agarics (mushrooms) can fruit at any elevation in the Austrian Alps, while others are restricted to certain elevations. Some species have a maximum altitude above which they are not found. Some are equally at home near a glacier at high altitudes or in a farm yard at rela-

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tively low altitudes near Vienna. These points were emphasized in a survey of fungus populations in the Otztaler Alps (Friedrich 1942).

During the eight summers spent by the writer on Mount Shasta in northern California, it was observed that around snowbanks special groups of macromycetes occurred. The first realization of the possible relationship between snowbanks and fungi came as the result of the observation of fruit bodies of *Polyporus alboluteus* and *Polyporus leucospongia*. In the case of the former, the fruit bodies appeared to have been developed before the snowpack melted for they were in fresh condition upon being exposed to the air. Within two weeks, most fruit bodies were piles of red dust under the logs on which they grew, having been eaten by small beetles (*Dacne picea*). The fruit bodies of the second species dried up soon after the snow melted and were found again in fresh condition only after infrequent showers. Eventually it was observed that other fungi were associated almost exclusively with snowbanks. A gray species of *Lyophyllum*, as yet unidentified, and *Tricholoma rhizoideum*, were found commonly around melting snowbanks. *Paxina nigrella* grew only near snowbanks in the process of melting and in one year, following a very heavy snowpack, it was found to occur at the edge of a snowbank week after week for at least four weeks as the snow receded. Over twenty specimens were found in fresh condition within a foot of the snowbank on each of four weekly visits. Away from the influence of water from melting snow, and the higher humidity near the melting snowbank, all specimens were dry. *Mycena griseoviride* and *Hygrophorus vernalis*, first reported by A. H. Smith from specimens collected near snowbanks in the Olympic Mountains, grew near snow and even up through snow at the edge of the pack from very rotten logs of Shasta fir (*Abies magnifica* var. *shastensis*) or from soil. *Secotium nubigenum* grew on decaying twigs, branches and logs of Shasta fir near or under snowbanks. Squirrels like to eat the fruiting bodies of this species and where it occurs away from snow in fresh or dry condition, they may show marks of having been tasted by them. Specimens have been found set out to dry on stones, branches of young trees, and in sunny places, apparently for later storage and subsequent use as food.

Similar series of species of fungi have been observed by the writer on Lassen Butte, California; Crater Lake, Santiam Pass, Williamette Pass, MacKenzie Pass and Mt. Hood, Oregon; Mt. Adams, Mt. Rainier and Mt. Baker, Washington; the Blue Mountains in northeastern Oregon, the Wasatch Mountains in Utah, and the Medicine Bow Mountains in Wyoming. From reports of collections, a more or less similar series also occurs in the Sierra Nevada of California, especially at Tioga Pass, and in the Olympic Mountains in northwestern Washington.

Climatologic Data

An estimate of the meterologic data for the macroenvironments of habitats in subalpine and timberline areas must be obtained by the observer in most cases. The 1946 meteorologic summaries show the inadequacies of standard Weather Bureau data for a study of climatic conditions at timberline on mountains in California, Oregon and Washington. The nearest Weather Bureau stations to habitats sampled lie in California at the base of Mount Shasta in the Sierra mixed conifer zone; in Oregon in the upper *Abies-Tsuga* zone or at timberline; and in Washington in the lower *Tsuga-Thuja* zone, the upper *Tsuga-Thuja* zone and in the *Abies-Tsuga* zone. Few, if any, published timberline data for year-round precipitation and temperature are available for Mt. Shasta, Mt. Adams, Mt. St. Helens, Mt. Rainier, or Mt. Baker. The habitats which have been studied here, and which are described below, lie in the upper *Abies-Tsuga* zone or higher.

The cooperative snow surveys maintained by the western states in connection with various private, state and federal agencies report monthly during the winter and early spring the status of the snow crop as to date of survey, depth of snowpack, density and water content of snow, both as to its present status and in comparison with the averages of the previous yearly surveys. On the basis of such surveys, an approximation of spring run-off in relation to floods and water available for irrigation is forecast. Such data have been obtained for areas near most of the sampling stations described below and the data for the deepest recorded pack for the season for the years in which the areas were visited are presented in the habitat descriptions in the following section of the paper.

At Mount Shasta, there is little precipitation between the melting of the snowpack of one season and the formation of the pack in the following season. Here the data for the deepest pack give a fair approximation of the total precipitation for the year. This is borne out by data obtained by the totalizer which, despite efforts to prevent loss by evaporation, records less precipitation than the water content recorded for the deepest snowpack. Other areas, subject to heavier summer and fall precipitation, require greater dependence on totalizer data or on data recorded by more adequate instrumentation.

Descriptions of Habitats

California

Lassen Butte.—Lassen Volcanic National Park. Above King Creek Meadows near California State Route 89, 7500-8000 feet. *Abies magnifica* var. *shastensis*—*Tsuga mertensiana* association, *Abies-Tsuga* zone. July 1, 1950. Slope gentle. Andesitic lava stones, pebbles and sand covered with a relatively thin layer of duff and litter. Southeast-facing.

Mount Shasta.—Shasta National Forest, Siskiyou Co., Panther Creek Meadows.

On May 4, 1948, snow depth at Sand Flats, 7000 ft., was 106.2 inches, water content 38.0 inches. At 8000 ft., Horse Camp, snow depth 131.1 inches, water content: 59.2 inches.

On March 17, 1951, snow depth at Sand Flats was 103.6 inches, water content 39.3 inches; at Horse Camp snow depth was 134.1 inches, water content 41.9 inches.

These were the deepest packs recorded for the season but total precipitation was probably somewhat greater than reported water content of snow.

Plot 1. Rocky creek valley on terminal moraine. Spaces between boulders have become filled in with gravel which is covered with a thin layer of duff and litter. Parent material andesite. *Abies magnifica* var. *shastensis*—*Tsuga mertensiana* association, *Abies-Tsuga* zone. Shrub layer composed of *Phyllodoce empetriformis, Vaccinium caespitosum,* and *Kalmia latifolia.* Nearly level. July 4, 1948. 7600 ft. South-facing.

Plot 2. Nearly level gravelly bench on a low lava ridge. *Abies magnifica* var. *shastensis* association, *Abies-Tsuga* zone. No shrubs, thin layer of duff and litter on fine gravel. July 5, 1948. South-facing. 7600 ft.

Plot 3. East side of Grey Butte Pass east of Panther Creek Meadows. Steep mid-slope facing southeast. *Tsuga mertensiana-Abies magnifica* var. *shastensis* association, *Abies-Tsuga* zone. 7600 ft. July 4, 1951.

Plot 4. Near Plot 3, little duff and litter, added factor of the presence of *Phyllodoce empetriformis* and fallen hemlock log. Same date.

Oregon

Crater Lake National Park.—Colonades area, Annie Creek. Forest floor level, with thick duff and litter layers on andesitic sand and gravel. *Tsuga mertensiana* association, *Abies-Tsuga* zone. June 29, 1948. 5000 ft. South slope. The snow survey made at 4500 feet, March 31, 1948, gave a snow depth of 129 inches with a water content of 49.8 inches.

Willamette Pass.—Along Oregon State Route 58, June 8, 1951. 5000 ft. Nearly level. Similar to Santiam Pass plot.

Santiam Pass.—Fairly level area at summit of ridge. Thin layer of litter and duff on fine to coarse andesite gravels. *Picea engelmannii*—*Tsuga mertensiana*—*Pinus contorta* var. *latifolia* association, *Abies-Tsuga* zone. July 7, 1948. 5000 ft. The snow survey on March 25, 1948, gave a snowpack of 97.0 inches with a water content of 34.2 inches.

Washington

Mt. Adams.—Between Mirror Lake and Bird Creek Meadows. *Tsuga mertensiana*—*Abies lasiocarpa* association, *Abies-Tsuga* zone. Thin litter and duff layers on fine to coarse andesitic gravels. Nearly level. 5000 ft. July 9, 1948. South slope.

Mt. Rainier—Mt. Rainier National Park. Southwest slope. Paradise River Valley along road below Paradise Lodge. *Abies lasiocarpa*—*Tsuga mertensiana* association with low tree layer of *Chamaecyparis nootkatensis* and shrub layer including *Vaccinium, Phyllococe* and *Alnus. Abies-Tsuga* zone. Thin litter and duff layers on fine to coarse granitic gravels. 4800 ft. July 9, 1948. The snow survey at 5000 ft. on Mar. 31, 1951, gave a snow depth of 190 inches with a water content 81.4 inches.

Mt. Rainier.—Mt. Rainier National Park. East slope. First switch-back below Sunrise Point, Yakima Park Road. 5700 feet. July 10, 1948. *Abies lasiocarpa*—*Tsuga mertensiana*—*Picea engelmanii* association, with a good herb layer, *Abies-Tsuga* zone. North-facing slope in creek valley. Thick litter and duff layers on granitic materials. The closest snow survey was made at 3000 feet at White River Entrance. On April 3, 1948 the snow depth was 65.0 inches with a water content of 22.9 inches. Although this lies in the "rain shadow" of the mountain, snow depth and water content were probably greater at 5700 feet although not as great as at Paradise Lodge on the west side of the mountain.

Oregon

Blue Mountains.—Horseshoe Prairie, Umatilla National Forest, Union Co., near Oregon State Route 204. Nearly level, south-facing slope. *Abies lasiocarpa*—*Larix occidentalis*—*Picea engelmannii* association, *Abies-Tsuga* zone. 5000 ft. June 10, 1949. Thin litter and duff layer on granitic gravels. The snow survey at Tollgate, Station 212, on March 29, 1949, gave a snow depth of 99.0 inches with a water content of 44.5 inches.

Blue Mountains.—Near head of Little Phillips Creek. Similar to preceding plot. Same date.

Utah

Wasatch Mountains.—Top ridge above Parrish Creek Experimental Plots, 9200 feet, Davis Co. Gentle slope under small grove of *Abies lasiocarpa* and *Picea engelmannii*, *Abies-Tsuga* zone. In an open fell-field. Thin litter and duff layer on granitic gravels. Grove isolated in an area dominated by *Artemisia* and other shrubs. Southeast-facing. June 20, 1950. The nearest snow survey station in 1950 was that at Barnard Creek where at 9000 feet on April 2 the snow depth was 75.9 inches with a water content of 30.3 inches.

Wyoming

Medicine Bow Mountains.—Vicinity of Tanner Lake, three miles above University of Wyoming Summer Science Camp, Albany Co., 10,000 feet. Aug. 20, 1950. Gentle south-facing slope. *Abies lasiocarpa-Picea engelmannii* association.

Such devious methods for obtaiinng climatic data only indicate that a supply of water is held in snow for a certain period of time on the ground surface. As the pack begins to melt, water is lost by evaporation and basal melting. Basal melting and melting near metabolizing organisms make water available to any organism which requires it. These organisms are then able to utilize the water and develop at low temperatures as the water is released from the snowpack.

Microclimatic data such as rate of snow-melt, local intermittent precipitation, air temperature, relative humidity and soil moisture must be obtained on the spot by the observer over a longer period of time than may seem to be required for the observation of the desired organisms.

Experimental

A trip to the Blue Mountains of northeastern Oregon in the early summer of 1948 pointed up a comparison between the fungi of snowbanks in that region and of Mount Shasta. It was thought that other areas might have a similar mycobiota and prior to a trip to the Cascade Mountains for polypore collecting, R. Daubenmire suggested a method for studying these habitats. Plots, 3 x 8 dm. in size, were set up in series from within the snowbank to the dry area beyond it. In the center of each plot a thermometer was inserted 1 dm. into the soil. After equilibrium had been reached the temperature of the soil was obtained by reading the thermometer as quickly as possible after removing it from the soil. Later a series of thermometers was placed along the edge of the snowbank. In the first series, no reading under zero degrees centigrade was obtained, and as one neared the edge of the snowbank and proceeded outward the temperature increased. In the second series, readings were approximately the same along the edge of the snowbank and similar to readings from comparable sites in the first series. The species of fungi and the location of their fruit bodies were recorded and mapped for each set of plots studied. Specimens of most species of the fungi collected in California were deposited in the herbarium of the University of California, Berkeley; material of most species from other states was deposited in the herbarium of the Department of Plant Pathology, The State College of Washington, Pullman.

Results

Snowbank fungi have been observed at stations from Lassen Butte to Mount Baker in the Cascade Mountains, and eastward in the Blue Mountains, the Wasatch Mountains and the Medicine Bow Mountains. For each of eight series of plots temperature of the soil at 1 dm. together with the date, time of observation and general weather conditions are presented in Table I. For ten sets of plots studied, Figure 1 gives the location of snowbank, fungus fruit bodies, and position of the stab thermometers. In the twelve mountain areas studied, certain fungi are common. Fifteen of these species are tabulated (Table II) indicating in which area each species was found at the time of observation. These fungi are present in other areas which were not included in this study. One species restricted to a host is included since it is seen only during the melting of snowbanks; it is almost invisible when dry. Species present in the area but not immediately adjacent to the snowbanks at the time of observation are noted.

These species are listed by location regardless of the year in which the observations were made for, to greater or less extent, the same species appear year after year as the snow recedes. Numbers of fruit bodies shown on the charts in and near the plots are not necessarily indicative of the abundance of the species for in some cases many more fruit bodies occurred in the area. In most cases, plots were set up where it was convenient to measure temperature at one dm.

Discussion

The soil in most of the areas observed is covered by a layer of duff overlain by a layer of litter, both of which are consolidated into a rather thick mat which may become cracked as it dries out.

TABLE I. *Soil temperatures in ° C. at 1 dm. depth*

Weather	Sunny	Sunny	Sunny	Low fog, clouds, rain	Overcast	Overcast	Sunny	Sunny
Date	6-29-48	7-4-48	7-4-48	7-5-48	7-7-48	7-9-48	6-10-49	7-4-51
Figure	1	2	3	4	5	6	7 & 8	9 & 10
Location	Santiam Pass 1:00 P.M.	Mt. Shasta 10:30 A.M.	Mt. Shasta 11:45 A.M.	Crater Lake 8:15 A.M.	Mt. Adams 1:45 P.M.	Mt. Rainier 6:00 P.M.	Blue Mts. 11:00 A.M.	Mt. Shasta 5:40 P.M.
Plot								
1	1.0	0.25	0.5	0.25	0.5	1.0	0.2	—
2	1.5	0.5	1.0	0.5	1.5	1.25	1.0	1.8
3	6.0	1.5	3.0	2.0	3.0	2.5	3.0	—
4	9.0	1.0	4.0	4.0	4.2	4.0	3.2	5.5
5	—	2.0	4.5	4.5	4.25	5.5	4.0	6.0
6	—	3.0	5.0	5.0	4.75	5.75	5.1	—
7	—	—	—	—	—	—	5.0	—

Snow line approximately in middle of second plot in each case.

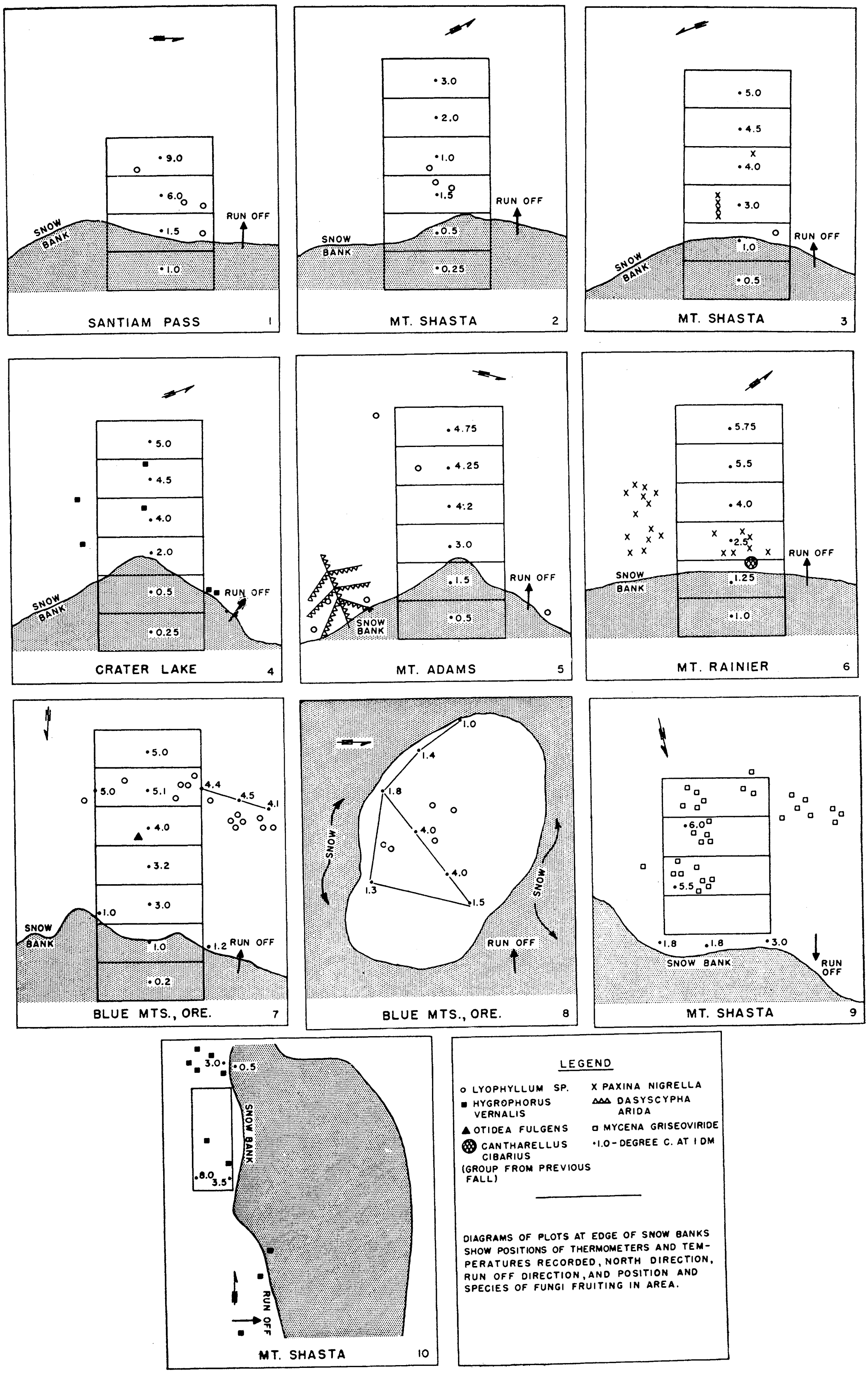
TABLE II. *Observed distribution of common subalpine fungi*

Locations	California		Oregon				Washington				Utah	Wyoming
Fungi	Lassen Butte	Mount Shasta	Crater Lake	Willamette MacKenzie Santiam Passes	Mount Hood	Blue Mts.	Mount Adams	Mount Rainier W	Mount Rainier E	Mount Baker	Wasatch Mts.	Medicine Bow Mts.
Arthrinium cuspidatum (Cke. & Harkn.) v. Hoehn.	*	*	..	..	..	..	..	..	..	*	..	*
Calvatia fumosa Zeller	..	*	*	*	*	..	*	*	*	..	..	*
Dasyschpha arida (Phil.) Sacc.	*	*	*	*	*	*	*	*	*	*	*	*
Gelatinodiscus flavida‡ Kanouse	..	..	..	..	..	..	..	*	..	..	..	..
Guepiniopsis alpinus (Tr. & Earle) Brasfield	*	*	*	*	*	*	*	*	..	*	*	*
Hygrophorus vernalis A. H. Smith	..	*	*	..	..	..	*	..	*	..	..	..
Lentinus sp.	..	*	*	..	..	*	*	*	*	..	*	..
Lyophyllum sp.	*	*	..	*	..	*	*	*	*	..	*	..
Metasphaeria sepalorum Vleugel	*	*	..	..	..	..	*	..	*	*	..	..
Mycena griseoviride A. H. Smith	..	*	..	*	..	*	*	..	..	..	..	..
Paxina nigrella Seaver	*	*	..	..	..	*	..	*	*	..	..	..
Polyporus alboluteus Ell. & Ev.	*	*	*	..	*	*	†	..	..	..	..	*
Polyporus leucospongia Cke. & Harkn.	*	*	*	*	*	*	*	*	*	..	*	*
Secotium nubigerum Harkn.	*	*	*	*	..	..	*	..	..	..	..	..
Stereum rugisporum (Ell. & Ev.) Burt	*	*	*	*	*	*	*	†	..	*	..	*

*Present in plot area at time of visit.
†Present in area but not in immediate vicinity of plots.
‡Associated only with *Chamaecyparis nootkatensis* (D. Don) Spach and observed only in snow-banks.

Beneath this mat is humus-bearing mineral soil which is very sandy and gravelly. Usually the soil is very shallow and much parent material is included in the top decimeter or two in the form of large pebbles, boulders, rock outcroppings, etc. In the lower part of the first decimeter, occassionally a gray layer is found which may be rather shallow. The water from the melting snow irrigates the soil within a few decimeters of the snowbank beyond which the soil dries out rapidly because of the high porosity producing rapid percolation or because of the relatively low surface air humidities. The soil wilting percentage for the fleshy fungus fruit bodies (mushrooms) appears to be very high here; in fact it appears to be much higher than that of the green plants which occur in the area. This factor appears not to have been studied in the field in relation to the fruiting of fleshy fungi. There are papers based on laboratory observations which discuss the temperature of and evaporation from both the upper surface and the greatly enlarged gill surface of fungus fruit bodies (Friedrich 1940). The fact that fungus fruit bodies dry out relatively near a source of water supply indicates that in addition to the requirement of the fungus mycelium for a high relative humidity in the soil, the fruit body itself requires a high relative humidity in the surface layers of air in which it develops, produces and discharges its spores. It may also indicate that the mycelia of these fungi inhabit mainly the superficial layers of the soil which become dried out quickly.

To study these phenomena of moisture relationships, including soil moisture, soil humidity and surface air humidity, and the relationships between the fungi and these phenomena and their habitat, certain data are required which cannot be obtained by existing techniques. In completely saturated soil, the fungus probably could not



DIAGRAMS OF PLOTS AT EDGE OF SNOW BANKS SHOW POSITIONS OF THERMOMETERS AND TEMPERATURES RECORDED, NORTH DIRECTION, RUN OFF DIRECTION, AND POSITION AND SPECIES OF FUNGI FRUITING IN AREA.

exist (or if present would be dormant) since it is an aerobic organism and a completely saturated soil would produce anaerobic conditions. Information is needed on the relative amounts of water and air present in the region of growth of the mycelium as indicated by fruit body production both under, next to, and away from the snowbank. Information is needed on the minimum, optimum, and maximum amounts of water and air in a given amount of soil at certain temperatures in relation to the growth and fruit body development of these fungi. Information is needed as to the approximate position of the mycelium in the soil, where it occurs in relation to the organic components, which fraction it utilizes (cellulose, lignin, or other), whether or not it is mycorrhizal, how much humidity is required to keep the fruit bodies turgid for spore discharge (including information on transpiration stress), and data on other factors as yet not determined. The techniques developed by Warcup (1951) for the study of Basidiomycetes in the soil, as well as other techniques could well be applied here.

Summary

A number of species of macromycetes has been found in widely spaced areas throughout the western United States in subalpine habitats. The occurrence of these species in relation to snowbanks is indicated. The climatic data available are presented, in part, and discussed. Pertinent questions to be answered are discussed together with some techniques which can be used to discover answers.

References

Baxter, D. V. 1943. Pathology in forest practice. John Wiley & Sons, New York. 618 p.

Chesters, C. G. C. 1948. A contribution to the study of fungi in the soil. Trans. Brit. Mycol. Soc. **30**: 100-117.

Cooke, W. B. 1944. Notes on the ecology of the fungi of Mount Shasta. Amer. Midl. Nat. **31**: 237-249.

Foister, C. E. 1935. The relation of weather to fungus and bacterial diseases. Bot. Rev. **1**: 497-516.

———. 1946. The relation of weather to fungus diseases of plants, II. Bot. Rev. **12**: 548-591.

Friedrich, K. 1940. Untersuchüngen zur Ökologie der höhren Pilze. Gustav Fischer, Jena. (3)-52-(1).

———. 1942. Pilzökologische Untersuchüngen in den Otztaler Alpen. Ber. deutsch. bot. Ges. **60**: 218-231.

Hedgcock, G. G. 1914. Notes on some diseases in our national forests. Phytopathology **4**: 181-188.

Lind, J. 1934. Studies on the geographical distribution of arctic circumpolar micromycetes. Kgl. Danske Vidensk. Selskab. Biol. Medd. **11**: 1-152.

Martin, G. W. 1937. Notes on Iowa fungi. VII. The drought and Iowa fungi. Iowa Acad. Sci. Proc. **44**: 45-53.

Setchell, W. A., and M. G. Watson. 1926. Some ecological relations of the hypogaeous fungi. Science **63**: 313-315.

Shope, P. F. 1936. Drought and the fungous flora of Colorado. Science **84**: 155.

———. 1937. Drought and the fungous flora of Colorado. Science **86**: 177.

Warcup, J. H. 1951. Studies on the growth of Basidiomycetes in the soil. Ann. Bot., N.S. **15**: 305-317.

Wehmeyer, L. E. 1946. Studies on some fungi of northwestern Wyoming, I. Pyrenomycetes. Mycologia **38**: 144-170.

———. 1946. Studies on some fungi of northwestern Wyoming, II. Fungi Imperfecti. Mycologia **38**: 306-330.

———. 1946. Studies on some fungi of northwestern Wyoming, III. *Pleospora* and *Leptosphaeria*. Lloydia **9**: 203-240.

———. 1947. Studies on some fungi of northwestern Wyoming, IV. Miscellaneous. Mycologia **39**: 463-478.

Weir, J. R. 1918. Notes on the altitudinal range of forest fungi. Mycologia **10**: 4-14.

RADIAL GROWTH IN NINE SPECIES OF TREES IN SOUTHERN LOUISIANA[1]

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Introduction

During recent years, especially since the publication by Reineke (1932) and Daubenmire (1945) of directions for making cheap, rapid, and reasonably accurate dendrometers, there has been increased interest in the subject of tree growth. Numerous papers, reporting on growth of trees in many parts of the United States and Canada, have appeared. The present paper is a report on observations made on tree growth in still another area, southern Louisiana.

The purpose of the study was to determine the magnitude and time of radial increase of trees of several species native to the New Orleans area, to correlate radial increase with leaf development and, as far as possible, with certain environmental conditions.

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