FUNGI REGENERATION FOLLOWING PRESCRIBED FOREST BURNS AND FUNGI SPECIES LIST FOR THE MOOSEHORN NATIONAL WILDLIFE REFUGE

Summer

1995

by

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CONTENTS

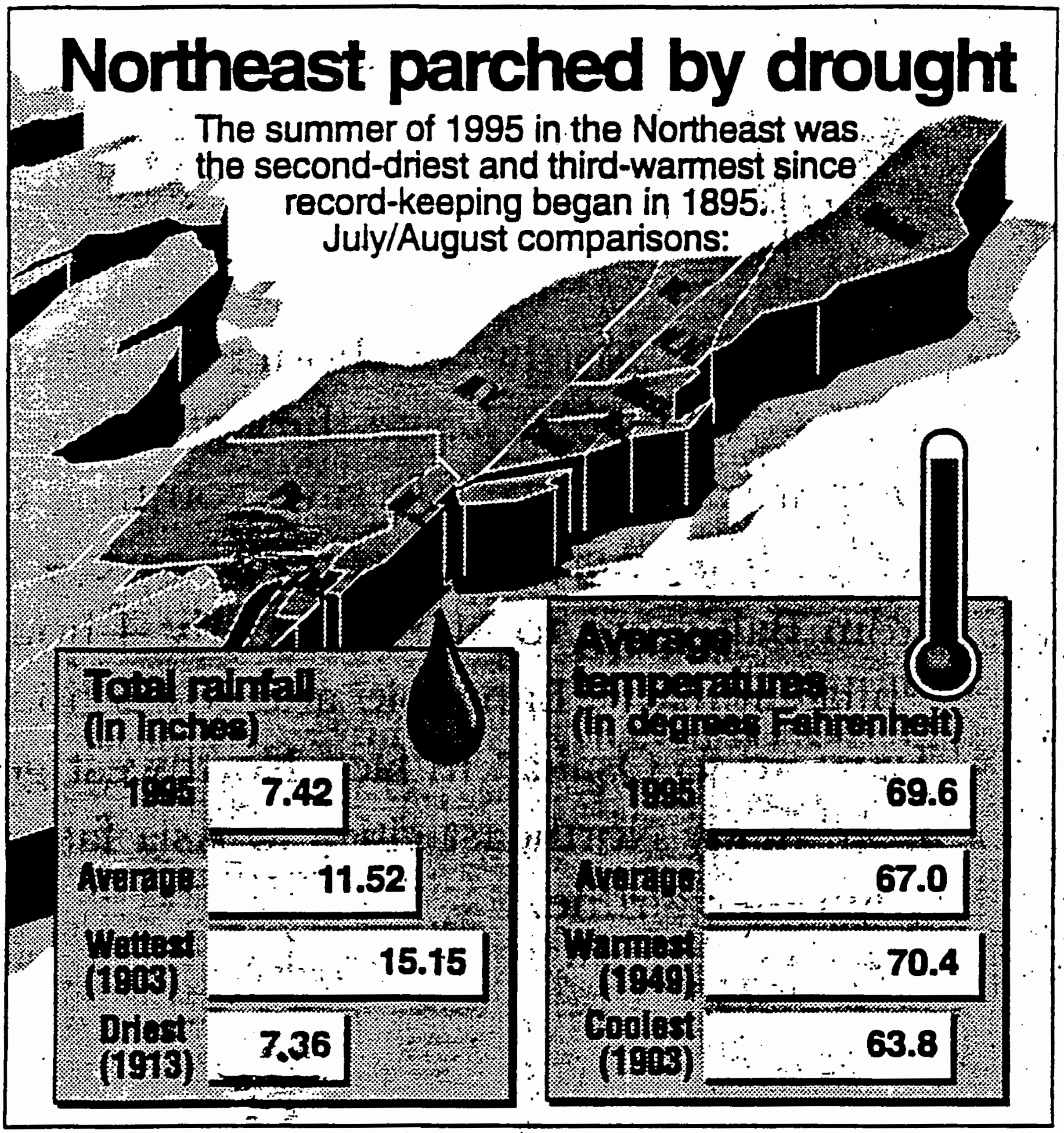
INTRODUCTION

This study was conducted during the summer of 1995 as a special project. Other assigned work took precedent. Also, the summer proved to be one of the driest in New England history, see Figure 1, drastically reducing the number of fungi species found and identified. This study was premised on the knowledge that fungi has an important role to play in a forestry eco-system and that any management practice that alters that system should take fungi, as well as other factors into account.

Fungi, through its decomposition role, contributes to the "O" Horizon, which is the surface layer ("O" standing for organic) of our soils. This layer, which may vary in depth from a few inches to a foot or more, is composed of fresh or partially decomposed organic material. In fact, nearly all of the decaying process takes place in the upper layer of soil. This upper layer is where life, including bacteria, fungi and protozans (actinomycetes), as well as a wide diversity of insects, serve as conditioners of the soil. In other words, the fate of that litter, whether in a cropland or a forest habitat, and in turn the development of the humus layer is conditioned by the activity of the fungi and animals to be found in that "O" Horizon.

Off all the horizons of the soil, none is more important than the organic horizon, i.e. the forest floor. A vital link in the food chain exists between forest litter and humus

Figure 1--



Source: National Climate Data Center

By Marcy E. Mullins, USA TODAY

9/14/95

production. The role and effectiveness of fungi in serving as this link is dependent upon the environmental conditions in the forest community--the internal microclimate of the soil, the moisture regime, its chemical composition, and its biological activity.(20) This natural process in a forest environment, just as in an agricultural cropping environment, can be severely curtailed or destroyed by the action of men.

Prescribed burning, although considered important for some forestry management objectives, may not be nearly so advantageous when all after effects are studied. Prescribed burning reduces the amount of organic matter in the "O" horizon and sharply curtails the decomposition cycle for up to a decade in the future. While the affect on the "O" horizon may not be of severe consequence in cases where the burned area is to be left to reforest itself at its own pace in a non-profit situation like on the Moosehorn National Wildlife Refuge, a burn does reduce not only the fungi, birds (and bird nests with eggs when burn is ill-timed), small mammals, herps and insects. This, of course, upsets both the food chain and the vegetation cycle of life, death and decay. In the absence of this cycle, life on earth would eventually cease.(21)

<u>Humus Development</u> In a mature forest condition where roots often go deep, the layer of humus may not seem important, but it is this layer from which minerals leach down to these roots

and in which moisture is collected. And a forest is not only trees. The young trees and lower canopies cannot fully develop without a good layer of "O" horizon humus. This argument goes one step further with regard to the effects of burning. That is the absorptive capacity, not only of the humus layer itself, but also the absorptive capacity of forest debris. (This will be discussed later.)

Thus, it stands to reason that any disturbance of this humus-building process, a burn for example, will lead to the depletion of the "O" horizon and in turn, a less productive soil. This body of knowledge is not new. Darwin, in 1881, pointed out the influence of mold and worms on the soil. (1)

This concern, of course, has led to the debate: are current day forestry management practices conducive to the maintenance, or improvement, of the "O" horizon, or do they lead to its long-term depletion? What effect does burning have on fungi, and in turn, humus development? What effect does clear-cut, pile and burn have?

<u>Effect of Forest Fires on Fungi</u> Forest fires may be of two types. The first, a surface fire which skims over the top of the thick mat of organic material, will have little direct, short-term effect on the soil. However, indirectly it effects the soil by killing not only the trees but also certain types of wood-hosted fungi. In the long run, surface fires do effect not only the tree population, young as well as old, but also the entire forest environment.

Second, a ground fire in the same area would consume this mat of organic material and expose the mineral soil giving rise to direct and substantial soil effects. (17) Such fires generating high heat destroy not only the spore producing fruiting bodies of bracket-type fungi and others, but also are detrimental to the mycelium, bacteria and protozoans. Heat from these fires reaches 400 degrees F and higher on the soil surface. It varies considerably by the amount of litter. A study by Beadle (Beadle, N.C.W., 1940, Soil Temperature During Forest Fires and Their Effect on the Survival of Vegetation, Journal Ecology, 28:180-192.) (See ref no. 17 p. 49-60) found that natural fires with little dead fuel, soil heating might cause lethal damage to soil organisms to a 1-inch depth, whereas with the maximum-intensity natural fires, having much dead fuel (debris) some damage might occur down to 3 inches. Prolonged fires in heavy fuels will likely cause lethal heating 6 to 9 inches down. Results of Beadle's study indicate that all life in the "O" horizon will not always be killed, but in the case of ground fires especially ones set in a managed burn whereby the wind speed is likely to be low and the under debris heavy, a good percentage will be killed. In addition, to the damage done to the mycelium, bacteria, etc. in the soil, the heat could kill much of the animal life as well. Certainly enough damage is done to the "O' horizons ecosystem to greatly interfere with the regeneration of "O" humus for several years following the burn. Related are two other factors: (1) ground fires and skimmers increase the erosion potential and thus further destruction of the "O" horizon, and (2) both leave a large quantity of charred dead tree stubs, stumps and limbs that may not decompose for years. On the positive side, nevertheless, two advantages do arise out of such burning, (1) bracket fungi feeding primarily on live broadleaf trees are destroyed, and (2) with less ground cover the soil is warmed by the incoming solar radiation, thereby increasing the metabolism of whatever soil life may remain.

Burning as opposed to just clear-cutting has both advantages and disadvantages. Fire takes care of excess organic matter quickly and effectively. According to Cheyney(16), in the cold, humid climates of the northeast, decomposition is so slow that litter accumulates in the form of raw humus to a depth of six or eight inches and, therefore, becomes a prohibitive barrier to the establishment of new stands of most species (This condition was noted in the wilderness--forest study area. See Attachment A). If a managed burn is to take place, Cheyney suggests, that the most effective method is to conduct the burn in the spring, when the lower part of the humus layer is still frozen. This way, only a portion of the ground litter is burnt and the soil is not generally heated to a temperature destructive to the animal and plant life in the "O" horizon.

Habitat Management Considerations On the Moosehorn National Wildlife Refuge an increasing number of areas are being clear cut and burnt to provide added habitat diversity for the American Woodcock. These areas are generally small in size. After both clear-cutting and burning, the ground tends to be covered with logs and limbs even though in the case of fires they are usually slow and hot enough to completely turn the smaller twigs, leaves and needles to ash.

The obvious difference between clear cutting and controlled, or prescribed, burn is their effect on the ecology or life, death, decay cycle. Likewise, obvious difference between a prescribed burn and a natural (lightening) burn is wind-related and thus the amount of heat generated. Prescribed burns are "zero" wind-related, whereas nature-related fires are significant wind (storm) related.--a much faster moving fire.

Thus, given the pros and cons of burning vs clear cut, pile, and burn there appears to be some trade off between these management practices and long-run effects on soil organic content. The question to be addressed in this study, therefore, is that if the fungi are killed, or a large percentage killed, how long will it take for (1) the remaining mycelium to spread within the soil, and (2) the spores to be blown back into the cleared and burned habitats? Is not use of the Hydro-axe a better method of accomplishing the same objective? How critical is the buildup of humus in the "O" horizon to coniferous-type tree production?

REVIEW OF LITERATURE

The subject of this study required a review of three major divisions of science: soils, forestry, and fungi (mycology).

The Moosehorn National Wildlife Refuge had one previous compilation of fungi species in 1963 and 1965 by Curtis(14). No other fungi-related studies are known to have been conducted. Resource materials at the Refuge Headquarters were limited to a few relatively old books on soils, forestry, and botany with a few primarily on the more popular edible-type mushroom. To obtain more advanced resource materials on the subject the University of Maine Library at Orono, ME was used.

To identify species, keys by Thomas(11), Pacioni(7), Lincoff and Nehring(3), Smith(10), and the McKnights(6) were used. (These references are better known as the Thomas, Simon and Schuster, Audubon, Smith, and Peterson mushroom field guides, respectively.) These references were generally inadequate for identifying slimes, jellies and crust like species. As an aid to slime mold identification, Martin (4), was obtained from the Univ. of ME library.

The most detailed accounting of the effects of forest burns on fungi was found in <u>Fungal Ecology</u> (Ref. Dix and Webster(18)). These two authors stated that chemical changes associated with burning can result in an increase in pH and an initial is followed by differential leaching of salts-- an increases of 3-5 pH units following burns seems common. Such burns and soil chemical changes, according to Dix and Webster may create a condition conducive to an increased bacterial population, but at the same time prescribed and other burns may destroy all existing spores and mycelium in the area of the fire.

The review of literature suggested that at a minimum, a specialized group of phoenicoid fungi (mostly ascomycetes and agarics) could appear on the burn areas amongst the ashes within months, if the fires have not heated the soil to a temperature beyond approximately 104-105 degrees F.

A more thorough review of the literature would have been conducted had time permitted.

METHODOLOGY

Given the style of existing Refuge Management, considerable emphasis being placed upon a habitat conducive to American Woodcock propagation, the methodology selected for this study closely relates to those management practices directly related the establishment of new woodcock habitats. One objective of this study was to derive a measure (speed) of fungi regeneration after the trees are cleared off selected areas by burning. The second objective was to determine how conducive the remaining charred debris is to moisture absorption and fungi regeneration. The third, and final, objective was to develop a species list for the Refuge.

The study was conducted over a four (4) month period, approximately June 1 to September 20, 1995.

Study Areas For the first two objective data were collected from 8 selected areas scattered throughout the Refuge. (See Figure 2). Five of these areas represented burn areas; one a clear-cut area; one a regrowth area of primarily broadleaf trees at the upper canopy; and one a wilderness area of primarily conifers. The latter three areas were chosen as control areas.

On each selected habitat, fungi species currently growing were determined. Each area was surveyed, by walking in a criss-cross once a month from about June 20 to September 20.

Refuge Species List A checklist of species, including gilled fungi (basidiomycetes), Polypores, Boletes, etc. was compiled showing location of find. This list was compiled, for the most part, while attending to other Refuge work, and while walking the eight study areas.

Soil Profiles and Vegetation Census During the July 4, holiday weekend, profile samples of the "O" horizon soil were taken on each of the eight study areas. Each profile was analyzed to document depth of the top layer, live animal and plant matter. Each profile was examined closely for signs of mycelium. Findings are shown in the Study Area Profiles.

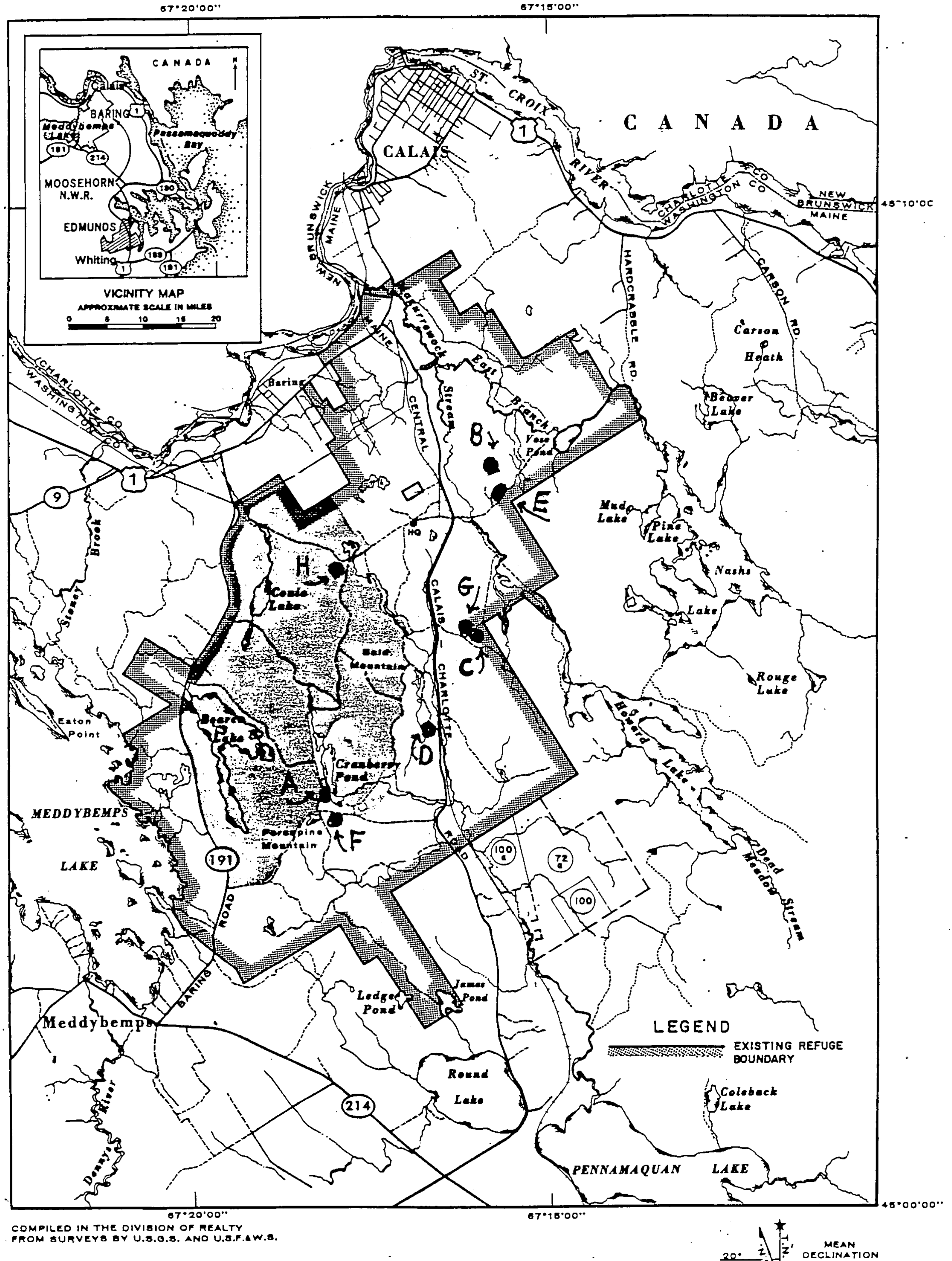
MOOSEHORN NATIONAL WILDLIFE REFUGE

BARING DIVISION

WASHINGTON COUNTY, MAINE

UNITED STATES DEPARTMENT OF THE INTERIOR

UNITED STATES FISH AND WILDLIFE SERVICE



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MEAN DECLINATION 1977

Figure 2. -- Fungi Study Areas (see preceeding page)

Note the depth of the litter, decomposing layer, and the decomposed layer as well as other findings.

The data generated by the study area profile analyses were used to test, empirically, the following hypothesis: (1) Prescribed burns destroy fungi; both above and below the ground. <u>If so, to what degree</u>? (2) Fungi regenerates, or reestablishes itself to full population within five (5) years. <u>If not, how soon</u>? (3) Populations of certain polypores regenerate slower than soil based fungi. <u>If so, is there any significant difference</u>?

<u>Absorption Capacity of Charred Wood</u> To measure the ability of charred wood to absorb moisture, broadleaf limbs approximately 30-40 cm long and 4-5 cm in diameter were selected as follows:

4 Clear cut, no-burn
4 1984 burn
4 1988 burn
4 1991 burn
4 1995 burn

These small sticks were tied in pairs and labeled A and B for each of the five sampled areas. All sample pieces were stored in a dry place at room temperature for one month. Each pair was then weighed prior to being wetted.

Ends of each stick were coated with polyurethane to prevent end penetration by the water. Then the two pairs from each sampled area were submerged in water for 15 minutes then weighed; for 30 minutes, then weighed, and for 45 minutes, and then weighed.

RESULTS

As can be seen by reviewing the Study Area Profiles very little fungi regeneration was found to have taken place on the Moosehorn NWR burn areas, even the ones dating back 5-10 years ago (Compare list of fungi found on the burn areas vs the Refuge-wide species list.

This finding is perhaps of little consequence with reference to live or dead wood-hosted species as the host material is either gone (burnt) or charred (too dry for fungal activity to commence). And, given (1) the small size of the burnt areas, and (2) the surrounding habitat of trees in most cases, regeneration of wood-hosted fungi will likely take place as soon as potential host material exists again as a result of spores being blown in from surrounding areas. On larger burn or cleared areas the results might be expected to differ.

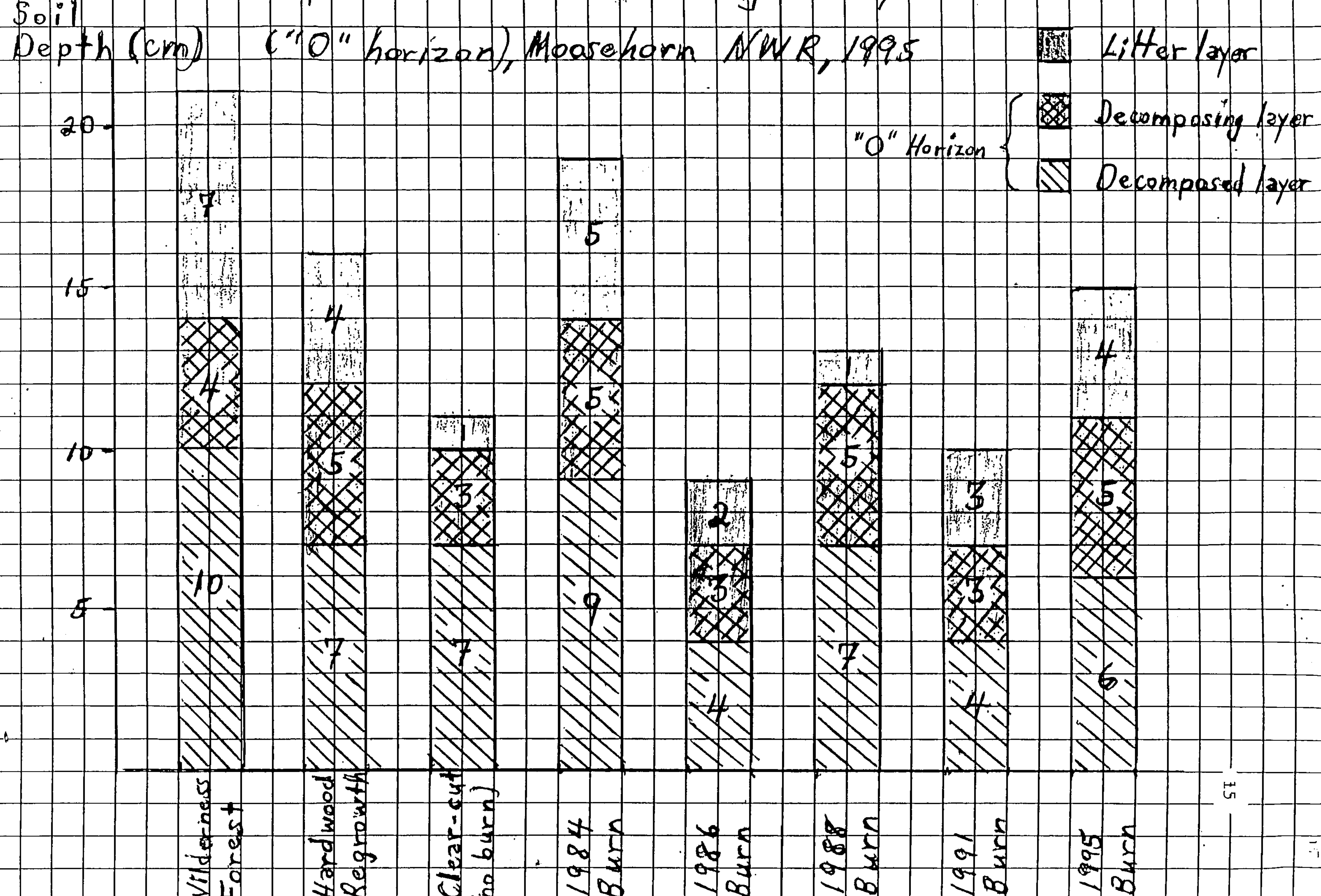
However, the more serious short term problem is related to soil hosted, or ground-based fungi, which is needed to decompose the regenerated plant material--the significant link in the growth-death-decay cycle. Results of this study show that the burn areas had practically no ground based fungi species. Even in the dry 1995 summer, there were quite a few species of this type in other parts of the Refuge, but practically none on the burn areas. (Note: Compare Species List with Study Area Profiles.)

Study Area Profiles It was noted throughout the burn areas that conifers tend to both burn and decompose before hardwoods. Therefore, given the results of this study that show that burns do destroy the wood-hosted, polypore-type fungi, but numerous pieces of charred hardwood remain undecomposed for long periods, it would seem that the process of burning does speed "O" horizon soil depletion. And, given the fact that much of the hardwood regrowth is sprout (ones that will fall for whatever reason at a young age), as opposed to good rooted trees, there remains a question as to how soon additional fungi will be needed in these areas to once again participate in the growth death decay cycle? (All of the sprouts that grow off of a given stump cannot be expected to survive.)

The study area profile results suggest, further, that time is not as great a factor as the burn intensity and the charring of remaining debris.

As shown in Figure 3, the "O" horizon appeared to be quite shallow for the 1986-1995 burn areas. Perhaps most critical is the limited amount of litter remaining to decompose, even if there were fungi to do so. One particularly alarming finding was on the clear-cut area where most of the wood-needed to host fungi was hauled off and also burned it created a similar situation.

Figure 3-Soil Profiles: 8 selected areas, showing depth of litter and the organic layer ("O" horizon), Moosehorn NWR, 1995



The fact that very few insects were found in the burn area soils is further proof that the "O" horizon regeneration will be slow. The lists of prominent vegetation on each study area (Shown in the Area Profiles) will allow further research on changing dominance of plant species over time.

Absorption Capacity of Charred Wood Review of the literature suggested that the absorptive capacity of dead wood is vital to decomposition and that the burning process might effect absorption.(16)(17)(18).

This is not to say that fallen or dead wood, must be saturated with water to activate fungi. Fungi do colonize at a faster rate once dead pieces are on the ground. But certain fungi, primarily the polypores, are largely confined to the heartwood, growing at first on living trees and then, sometimes, continuing to survive and fruit on a dead trees and stumps. "Heartwood has a lower water content than the sapwood of living trees, and high water content is known to inhibit mycelial growth of many fungi and the limit decay because of low "O" diffusion rates"(18) Thus, the degree of absorption capacity which is of importance to fungi colonization is in the moderate range of 20-30 percent.

In this study it was observed that the char on wood, essentially reflects the burning away of the cork and cambium layers. This burning process effectively seals the wood substantially slowing the decomposition--fungi activity. Fungi requirements are food, suitable temperature, and suitable moisture content. Wood with a moisture content of less than approximately 20% will not decay owing to the lack of sufficient moisture for fungi development. A lower moisture level was found in the samples of charred wood tested even after prolonged periods of wetting, reference Table 1. To compare the absorption rates the two pairs of each sampled area were added together and percentage gains computed, see Table 1 and Figure 4.

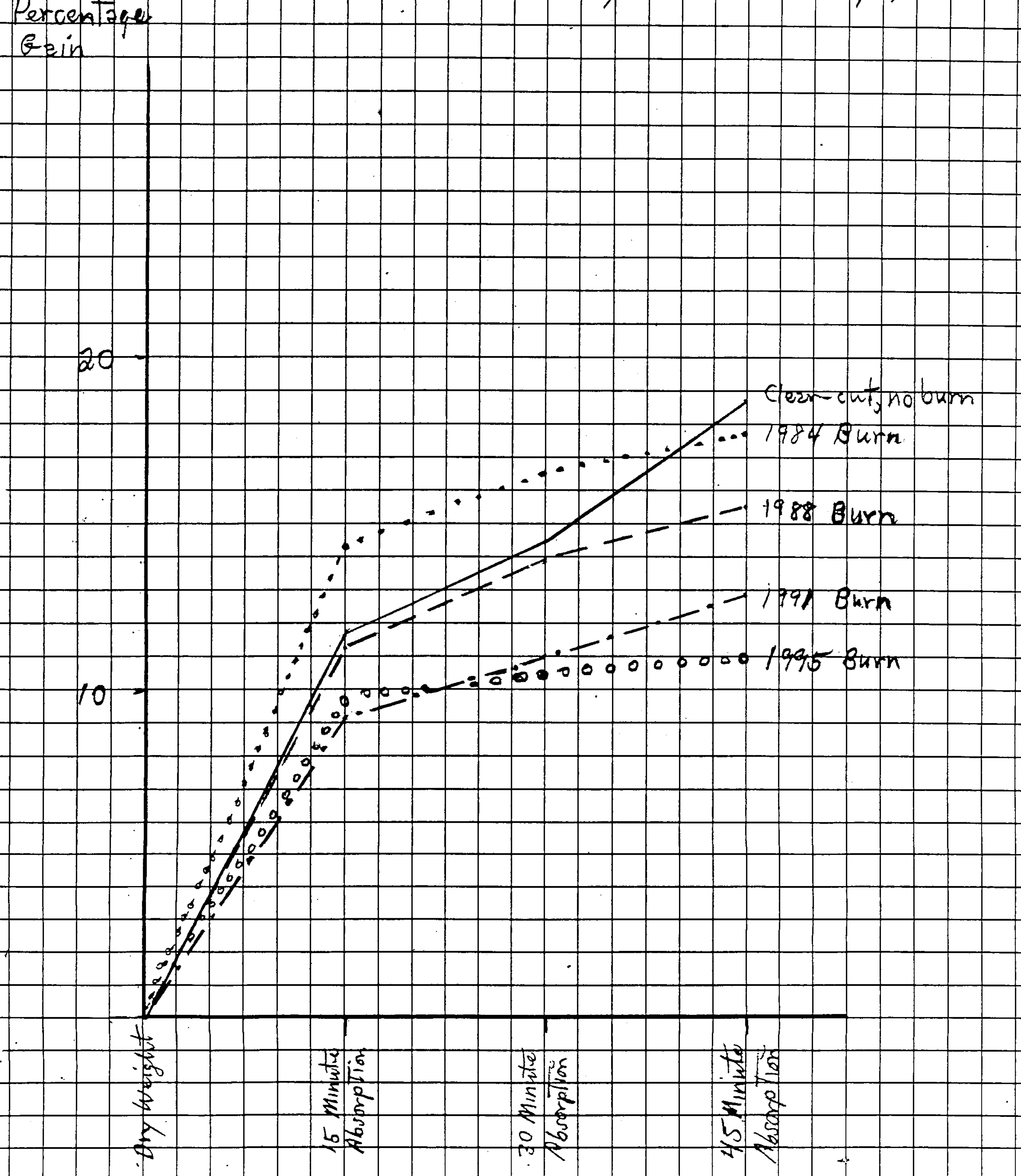
Situation--Naturally dying wood on the Moosehorn NWR is complete, having all layers from the bark, inward through the heartwood. In contrast areas that have been burnt, either via skimmer fires or ground fires, are often characterized by a significant aftermath of partially burnt heartwood. It was observed that this wood will lie undecomposed for up to 10 years, or longer, while in clear-cut, non-burn areas after a decade only very decomposed large peices of wood, if any, remain.

Conclusion The hypothesis that exposure to fire retards absorption capacity was confirmed. Charred wood from the four burn areas consistently took on water, ranging from 9.1% to 14.3% in the first 15 minutes. Then a noticeable leveling off occurred over the next 30 minutes. In contrast the clear-cut, non-burn sample continued to absorb water, reaching 118.7% of its original weight by the end of 45 minutes. This prompted a resubmerging of this sample for one full hour. The result was a weight increase of 28.9%!

Table 1 -- Absorptive Capacity of Selected Wood Samples Taken From Burn and Non-Burn Areas, Moosehorn NWR, 1955

Wood Sample	Initial Weight	15 Min. Absorption		30 Min Absorption		45 Min Absorption	
		Weight	Gain	Weight	Gain	Weight	Gain
Clear Cut	gr.	gr.	%	gr.	%	gr.	%
Sample A	204	224	1.0980	230	1.1275	237	1.1618
Sample B	218	247	1.1330	253	1.1606	264	1.2110
Total	422	471	11.6	483	14.4	501	18.7
1984 Burn							
Sample A	204	234	1.1471	240	1.1765	242	1.1863
Sample B	236	269	1.1398	273	1.1568	276	1.1695
Total	440	503	14.3	513	16.6	518	17.7
1988 Burn							
Sample A	160	178	1.1125	183	1.1438	185	1.1562
Sample B	170	189	1.1118	193	1.1353	196	1.1529
Total	330	367	11.2	376	13.9	381	15.5
1991 Burn							
Sample A	178	196	1.1011	199	1.1180	202	1.1348
Sample B	185	200	1.0811	204	1.1027	208	1.1243
Total	363	396	9.1	403	11.0	410	12.9
1995 Burn							
Sample A	168	183	1.08928	184	1.0952	185	1.1012
Sample B	176	195	1.07954	196	1.1136	197	1.1193
Total	344	378	9.9	380	10.5	382	11.0

Figure 4 -- Comparison of Absorptive Capacity of Selected Wood Samples Taken From Burn and Non-burn Areas, Moosehorn NWR, 1995



Going back to the requirement of a 20% moisture content for decomposition, the results of this study wood seem to confirm the reason why it takes charred wood so long to be decomposed. This finding would suggest a double retardation of wood-hosted fungi regeneration following a forest fire. First, all mycelium in the remaining wood has likely been destroyed. Second, the remaining charred wood lacks the moisture content for spores that may be carried in by wind, or otherwise, to gain a threshold and survive. A normal rainfall on the refuge will never provide the saturation that it takes for decomposition to commence and progress at a high speed. (If further study of absorption rates is undertaken, the statistical significance of these recorded weight differences can be measured.)

<u>Refuge Species List</u> Curtis (19) listed 128 species found on the refuge during her two periods of observation. Both the length of time and specific months this (assumed) volunteer devoted to her study are unknown. (A copy of her letter to the then Refuge Director and her species list is attached.) Also unknown was the weather condition in each of those two years, wet or dry. However, the proportion of Agaricaceae species, alone, suggests summers with normal or abundant moisture. Curtis' list has only a few of the same species when compared with the list compiled in this study.

The collection process in this study, it must be remembered, was limited to four(4) months, June-September, and by time. (Most species, it will be noted, were found along the Refuge woodcock trap trails). It was also limited by the abnormally dry year (See Figure 1).

The accompanying list of approximately 60 species can be used to supplement or update Curtis' list. Expected change in species in a given location over a 30 year period is unknown.

It is known that all species found in this study were keyed out and confirmed by using all of the reference guides listed. Spore prints were also made to confirm identification. Had not 1995 been a very abornormally dry year, this list should have been more than doubled, with most of the additional species being the ground-hosted, gill-type basidiomycetes. Some species of the phoenicoid fungi should have appeared on the burn areas as well.

The species list of fungi observed and identified in this study is shown in Attachment B.

CONCLUSIONS

Numerous hypothesis were raised in the process of this study. Some can be answered, some not.

(1) Is current day forestry management practice of burning conducive to maintaining or improving the "O" horizon? No.

(2) Is humus buildup critical to young conifer tree establishment? Yes.

(3) Prescribed burns destroy fungi both above and below the ground. Too often they do, because it is difficult to achieve a skimmer burn in managed conditions which call for

calm winds when burning. Too frequently all litter is turned to ash.

(4) Fungi regenerates itself to full population levels within five (5) years. This hypothesis should be tested in a normal rainfall year. This may more important in the case of ground-hosted fungi which are needed first to decompose lower story vegetation that reestablishes itself on burn areas before tree populations reach the growth-death-decay stage again.

(5) Fire (charring) retards absorptive capacity of debris. Yes, the results of this study were conclusive.

(6) Clear-cut is a preferred method to burning when creating small clearings. It would be only if some of the larger dimension debris is left to serve as the spore-producing host-wood, thereby generating the fungi needed to decompose the remaining debris. It is definitely preferable in the case of ground-based fungi. (Although, not too many ground-based species were documented in the one clear-cut area included in the study, there is reason to believe that conditions on a normal rainfall year this area would have produced a population of fungi not too different from that of other parts of the Refuge.)

(7) Use of the Hydro-ax to clear-cut an area, leaving large tree trunks where they fall should prove superior to the clear-cut-stack-burn approach, if the purpose of the activity is only to allow hardwood regrowth. Yes.

(8) On small area burns, like those on the Moosehorn NWR, both ground (soil)-hosted fungi will regenerate within a decade. This hypothesis could not be tested and confirmed due to the lack of soil moisture. The speed of fungi regeneration question needs further study.

In conclusion, fungi species on the burn areas were found to be nil as expected. Few new species should be expected during the first decade after a burn, except for a few selected phoenicoid species.

As a final comment, it is hoped that this study will prompt further analysis of the role of fungi, not for the mushroom collectors' interest, but rather for Refuge habitat management. Fungi has an important role to play.

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ATTACHMENTS

ATTACHMENT A;FUNGI STUDY AREAS

A. 1984 Burn

B. 1986 Burn

C. 1988 Burn

D. 1991 Burn

E. 1995 Burn

F. Clar-cut (No burn)

G. Hardwood Regrowth

H. Wilderness-Forest

See map of the Baring Division of Moosehorn National wildlife Refuge for location of fungi study areas, Figure , and the following pages for a description of each study area.

Study Area 1984 Burn

<u>Location</u> Adjacent to Cranberry Lake Road

<u>Situation</u> Many big stumps remaining after 10 years, indicating fire was more of a skimmer than a ground burn. Most stumps are in an advanced stage of decomposition. Pieces of charred wood, remaining after a decade, can be found throughout the area.

<u>Regeneration</u> A fair stand of broadleaf trees have established themselves on this site. Also prominent are:

1. Some grasses
2. Heavy population of bunchberries
3. Good population of bracken ferns
4. Dogbane
5. Numerous British Soldiers

<u>SOIL PROFILE</u>

	cm	
litter	5	"O" Horizon
decomposing	5	
Decomposed	9	

Primarily bare surface, vegetation-wise, with sparse stand of fine-stemmed grass describes this area. An upper canopy of hardwoods now dominate the area. A large amount of decomposing leaves make up a high percentage of the material yet to be decomposed. There was a significant amount of very small tree rootlets extending down below the "O" horizon and little sign of any roots of annual grasses or broadleafs. Found 1 spider, (1 mm in length), 1 aphid, and 6 viable grass seeds in the soil profile.

<u>Fungi Species</u>

Amanita muscaria
Hygrophorus flavescens
Boletus felleus

Study Area 1986 Burn

Location Off end of McConvey Road to right (Popcorn mist net area)

Situation Ground burn was nearly complete or else remaining pieces were piled and further burnt; few remaining charred pieces. Return growth was cut again in about 1991.

Regeneration Regrowth consisted of, primarily, broadleaf trees (up to 1 m tall), bracken fern, sheep laurel, and blueberries. A nearly 100% mat of healthy moss was noted as a ground cover. Decomposition was nearly 100%, with only a scattering of unburnt, but charred pieces of wood remaining. Moose tracks and droppings and woodcock probe holes were apparent in the few areas not covered with moss. No visible fungi fruiting bodies were observed.

Soil Profile

Growing atop this soil profile were rock moss, a bunch berry plant, a wild strawberry plant and three birch saplings approximately 16 cm in height. A mass of fine roots in the "O" horizon was so intertwined that the soil could barely be separated for analysis. Ample sign of minute live worms existed in the "O" horizon. Some of the mass of live roots had penetrated the soil below the "O" horizon. No sign of decomposing wood pieces was observed. This was expected as very few burnt pieces remained in view on the surface, suggesting, as previously mentioned, the area was either raked after a skim burn or had undergone a hot ground burn.

Fungi Species

None

<u>Study Area</u> 1988 Burn

<u>Location</u> Off Snare Meadow Road just east of where Moosehorn Ridge Road Y's off Snare Meadow Road.

<u>Situation</u> Burn left numerous charred limbs, stumps and other pieces of trees (Area has many larger boulders. Therefore, fire probably did <u>not</u> linger in the litter in the more rocky areas. Likewise, the remaining slash was not piled and burnt.)

<u>Regeneration</u> Regrowth of broadleaf trees has reached 3 m in height. Also, several hazelnut bushes (1 m) were spotted. This area has a heavy population of sweet fern, grasses and rock moss. Numerous bunchberries, sheep laurel and wild strawberries were also observed (as of 7/1/95). As of 8/20/95 the shorter plants had been overshadowed by the taller species.

<u>Soil Profile</u>

Primarily moss covered the surface of this profile; a mass of fine live roots penetrated the surface to 5 cm. Numerous pieces of wood up to 6-7 mm in diameter and partially decomposed were observed in the top 5 cm of soil as well. Well developed, high-humus content, soil comprised the lower 7 cm of the "O" horizon. Profile contained 1 wood tick and 2 live seeds.

<u>Fungi Species</u>

None

Study Area 1991 Burn

Location On south side of Mile Bridge Road near Charlotte Road.

Situation Study of burn area suggested that the slash remaining after the burn was piled and burnt. Still some stumps and a few timber pieces were left on the surface. From the debris left it would appear to have been a fast skimmer fire. Many of the remaining charred pieces in this area have not yet begun decomposing. Yet debris in the unburnt perimeter area (cut in advance of the burn) shows significant decomposition.

Regeneration Regrowth of grasses and other species of perennial plants is dense. Some caneberries and a sparse stand of young broadleaf trees, 1-2 m have populated the area. Numerous pieces of partially burnt limbs were observed on the ground. Of these, approximately 60% were decaying; 40% were still in immediate post-burn condition. Several citings of fungi growing on the decomposing wood also suggest a skimmer fire (see above). The stand of grass and other plants in the area was too dense for fungi with above ground fruiting bodies to be present.

Soil Profile

	cm	
litter	3	"O" Horizon
decomposing	3	
Decomposed	4	

The profile area was covered with tickle grass and lance-leafed goldenrod. Since the area's surface had been so disturbed by heavy equipment, it was difficult to obtain a true soil profile sample. The profile selected showed very few roots below the decomposing layer, but a mass of small rootlets in the decomposing layer. No live seeds or insects were found.

Fungi Species

Polyporus versicolor
Pycnoporus cinnabarinus

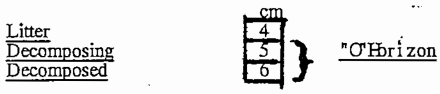
<u>Study Area</u> 1995 Burn

<u>Location</u> On north side of Goodall Heath Road just west of McConvey Road.

<u>Situation</u> Burn in some places completely charred all ground litter suggesting the hot, ground type. In other parts of the area, it left numerous limbs and other wood pieces, most thoroughly charred. Many of the remaining pieces are large enough to need a healthy population of fungi to achieve decomposition with the next decade.

<u>Regeneration</u> Regeneration, or regrowth, had not commenced as of 5/31/95 some hardwood seedlings (mostly aspen) and sprouts (mostly maple and white birch) had reached 1 m in height. Yet much of the area was still barren.

<u>Soil Profile</u>



Profile was bare on top except for a few sprigs of rock moss. The only recognizable litter was dead moss, some charred pine needles, and a few dead unburnt pine needles. A fairly solid mat of slightly decomposed humus like could be expected in a standing timber was observed in the decomposing layer with no sign of any current activity. No live small plant roots were seen in the profile and all tree roots were dead. Likewise, no live insects or seeds were found.

<u>Fungi Species</u>

None

<u>Study Area</u> Clear-cut (no-burn)

<u>Location</u> On south side of South Trail just east of South Ridge Road (just east of Firehole Flowage)

<u>Situation</u> The regrowth, following the 1990 clear-cutting of the area, offers a definite contrast to the recent (1991 and 1995) burn areas. Although, included in the study, a more uniform control area should have been selected. This area had a generally rocky terrain, considerable slope on some parts, and a swampy area. All sampling of soil and vegetation was, therefore, conducted on the upper right-hand part when approaching the area from the road. Stumps of various sizes showed signs of little decomposition after the five years. More decomposition might have occurred, except for the fact that the larger dimension wood apparently was piled and burned, destroying most of the existing wood-hosted fungi.

<u>Regeneration</u> Vegetation, which was extremely dense throughout the area, included such species as raspberries, bracken fern, wild strawberry, everlasting pearly, a red stemmed,red leafed vine unidentified, young birch and aspen (1 m), and sprouting maple (1 1/2-2 m). No young coniferous trees were observed in the part of the area surveyed.

<u>Soil Profile</u>

Primarily a good stand of wild strawberries existed on top of this soil profile although area had other species, see situation, above. Otherwise, only a very light layer of leaves comprised the litter layer. Roots of the surrounding vegetation were observed throughout the 10 cm "O" horizon. Decomposition of the top part of the "O" horizon was nearly complete.

<u>Fungi Species</u>

Tremetes versiolor
Coriolus versicolor
Guepintopsis alpina

Study Area Hardwood Regrowth

Location Just north and west of junction of Snare Meadow Road and Moosehorn Ridge Road. Adjacent to 1988 burn area.

Situation A large percentage of the trees in this study area were hardwoods. Their size compared to the size of the conifers, suggested that the area had been in the regrowth cycle of about 20 years or more. Numerous dead pieces of wood were observed, both standing and on the ground. Numerous dogbane plants were seen in this area, but much of the ground is simply barren due to a heavy layer of deciduous leaves.

Regeneration The broadleaf trees have reached 15-20 cm in diameter. The new growth of conifers is around 2 m in height and significant. There is no evidence that this area was ever burnt. Numerous large logs, downed trees, and some stumps exist. All original small debris is all decomposed. The natural cycle of growth-death-decomposition has begun anew. Frequent signs of fungi fruiting bodies emerging from dead and live tree trunks were observed.

Soil Profile

Primarily a mat of dead leaves covered the surface of the soil profile sample. A heavy mass of root material was found in the top 5 cm of the "O" horizon. This belonged to the shrub-type under story, not smaller plants. Some live roots were found throughout the profile. No visible sign of partially decomposed pieces of wood suggest that decomposition in recent years has assumed the natural process of litter-decomposing-decomposed to build the humus layer. A well-developed soil in the lower 7 cm of the "O" horizon was observed. One ant was found, but no live seeds.

Fungi Species

Collybia Dyophila
Amanita vaginata
Ondemansiella radiata
Phellinus igiarius
Daedaliopsis confragosa
Hydnum imbricatum
Cryptoporus volvatus

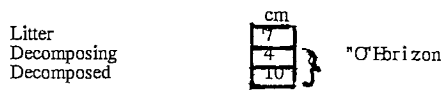
<u>Study Area</u> Wilderness Forest

<u>Location</u> Southwest of Two-Mile Meadow Pond in Wilderness Area

<u>Situation</u> The ground canopy species in this area are primarily bunchberries, spreading dogbane, sweet ferns and sheep laurel, creating a low canopy of 15 to 30 cm. The ground, in general, is covered 5-10 cm in depth, with non-decomposed pine needles, which serve as a fairly restrictive barrier to both plant and ground fungi growth. For this reason, a large percentage of the ground in this area is barren. Thus few fungi could be expected to find host material on the ground. The primary tree species were conifers.

<u>Regeneration</u> Not Applicable

<u>Soil Profile</u>



This area proved to be extremely rocky. The profile which was obtained had to be separated from numerous fist-sized rocks, The "O" horizon was deep. Peat-like soil, very rich in humus, was found all the way down to the lighter-colored clay-loam soil. A mass of sheep laurel and bracken fern roots extend throughout the decomposing and decomposed layers. In this profile there were 6 live seeds, 2 ants, and 1 spider.

<u>Fungi Species</u>

Leiccnum scabrum
Polyporus betulinus
Phellinus igniarius
Phellinus punctatus
Traneta versicolor
Coriotus versicolor

ATTACHMENT B: REFUGE FUNGI SPECIES LIST

The following list of fungi species is divided as follows:

Gilled (Basidiomycetes, etc.)

Boteles

Polypores

Slime Molds (Myxomycetes)

Tooth Fungi (Hydnum Basidiomycetes)

Jelly Fungi (Basidiomycetes)

Puffball (Gastromycetes)

Sac Fungi (Ascomycetes)

The format used to prepare the species list makes it possible to remove it from this report for alternative purposes.

FUNGI SPECIES LIST
MOOSEHORN NATIONAL WILDLIFE REFUGE

by
Dr. Walter G. Heid, Jr.

Gilled (Basidiomycetes, etc.)

Date Found	Botanical Name	Common Name	Refuge Location
5/31/95	Galera tenera	Conocybe tenera	Near Mahar Flowage
6/13/95	Pluteus cervinus	Deer Mushroom	Numerous locations
6/14/95	Pleurotus ostreatus	Oyster Mushroom	Near weather station off McConvey Road
6/14/95	Tricholoma ustaloideas	None	Near Headquarters
6/19/95	Amanita verna	None	Off 2-mile Meadow Road
6/19/95	Marasmius rotula	Pinwheel Mushroom	Near Seeley Pond
7/4/95	Lentinus lepideus	Scaly Sawgill	Near Headquarters
7/10/95	Pleurotus cornucopiae	Horn of Plenty	Near Snare Road woodcock trapline
7/20/95	Amanita vaginata	Gilded Grisette	Off Snare Rd, across from 1988 burn area
7/24/95	Amanita flavoconia	Yellow Wart	Near Dineen woodcock trapline
7/24/95	Mycena galericulata	Rosy-Gill Fairy Helmet	Off Mile Bridge Rd near McRae Flowage
7/24/95	Hygrophorus miniatus	Vermillion Mushroom	Near Dineen woodcock trapline

7/25/95	Clitocybe subconnexa	Clustered Funnelcap	Upper Goodall-Heath Flowage
8/1/95	Russula brevipes	Short-stalked White Russula	Near Headquarters
8/1/95	Amanita muscaria	Yellow-orange Fly Agaric	Numerous locations
8/2/95	Lactarius subpurpureus	Variegated Milky	Near 2-Mile Meadow woodcock trapline
8/2/95	Amanita flavor-ibescens	Yellow-Blusher	Near Boundary Flowage
8/7/95	Russula emetica	None	Beaver Trail woodcock trapline
8/7/95	Hygrophorus flavescens	Golden Waxy Cap	Near Cranberry Lake on 1984 burn area
8/8/95	Dudemansiella radicata	Deep Root	Near Boundary Flowage
8/8/95	Laccaria Laccata	Deceiver	On clear-cut study area near Firehole Flowage

<u>Boleteo</u>

Date found	Botanical Name	Common Name	Refuge Location
7/15/95	Boletus subtomentosus	None	Near Headquarters
7/24/95	Leccinum aurantiacum	Aspen Scaberstalk	Numerous locations
7/24/95	Austrobeletus betula	Birch bolete	Numerous locations

8/3/95	Boletellus russellii	Rusell's Bolete	Near Beaver Trail, woodcock trapline
8/2/95	Suillus granulatus	Dotted-stalk Suillus	Near Beaver Trail, woodcock trapline
8/2/95	Leccinum insigne	Aspen Scaberstalk	Near Beaver Trail woodcock trapline
8/7/95	Boletus parasiticus	Parasitic Bolete	Near Beaver Trail woodcock trapline
8/3/95	Leccinum scabrum	Common Scaber Stalk	On wilderness forest study area
9/6/95	Bolletus felleus	None	On 1984 burn area
9/6/95	Suillus placidus	None	On 1984 burn area

<u>Polypores</u>

Date found	Botanical Name	Common Name	Refuge Location
6/13/95	Pycnoporus cinnabarinus	Dragon's Blood	Near Upper Goodall-Heath Flowage
7/2/95	Fomes Fomentarius	Hoof Fungus	Numerous locations
7/11/95	Lenzites betulina	Birch Maze-gill	numerous locations
7/11/95	Trametes versicolor	Turkey-tail	Numerous locations
7/15/95	Phellinus igiarius	None	Numerous locations

7/15/95	Datronia mollis	None	Numerous locations
7/15/95	Cerrena unicolor	None	Numerous locations
7/15/95	Piptoporus betulinus	Birch Polypore	Numerous locations
6/19/95	Fomitopsis pinocola	Red Belt	Numerous locations
7/2/95	Coriolus versicolor	Turkey-tail	Numerous locations
7/2/95	Ammillaria strammea	Yellow Bracelet	Near Beaver Trail woodcock trapline
7/18/95	Heteroh basidion annosum	Conifer-base Polypore	Numerous locations
7/18/95	Cerrena unicolor	Mossy Maze Polypore	Numerous locations
8/9/95	Gleeoporus dichrous, also called Caloporus	None	Near Upper Goodall-Heath Flowage
8/13/95	Daedaliopsis confragosa	Curry Comb Bracket	On Hardwood Regrowth study area
8/15/95	Phalaeolus schweintzii	None	Near South Ridge Road
8/16/95	Gloephyllum sapiarium	Yellow-red Gill Polypore	Near 2 Mile Bridge Road
8/23/95	Polyporus squamosus	Dryad's Saddle	By Charlotte Road near entrance to blind
8/24/95	Tyromyces chioneus	White cheese Polypore	Near Beaver Trail woodcock trapline
8/25/95	Pexillus panunides	Stalkless Paxillus	Near headquarters

9/6/95	Phellinus punctatus	None	On wilderness study area
9/11/95	Cryptoporus volvatus	Veiled polypore	On Hardwood Regrowth study area

Myxomycete (Slime Mold)

Date found	Botanical Name	Common Name	Refuge Location
7/25/95	Dianema harveyi	None	Numerous locations
8/9/95	Hypomyces chrysospermus also called Apiocrea chrysosperme	None	Near Beaver Trail woodcock trapline
7/25/95	Apiosporina morbosa	Black Knot Fungus	Numerous locations

Hydnum (Tooth Fungi-Basidiomycetes)

Date found	Botanical Name	Common Name	Refuge Location
6/15/95	Scaber Hydnum	None	Off Beaver Trail woodcock trapline
9/11/95	Hydnum imbricatum	Scaley Tooth	On Hardwood Regrowth area study

Jelly Fungi (Basidiomycetes)

Date found	Botanical Name	Common Name	Refuge Location
7/2/95	Tremella lutescens	Sulphur Butter	Near Beaver Trail woodcock trapline

8/15/95	Guepintopsis alpina	Jelly Cup	On Clear Cut fungi study area

Puffball (Gastromycetes)

Date found	Botanical Name	Common Name	Refuge Location
7/25/95	Lyosperdon marginatum	Naked Puffball	Near Beaver Trail woodcock trapline
8/26/95	Lycoperdon pyriforme	Pear-shaped Puffball	Near Headquarters

Sac Fungi (Ascomycetes)

Date found	Botanical Name	Common Name	Refuge Location
5/31/95	Helvella esculenta	None	Near Mahar Flowage

ATTACHMENT C: CURTIS LETTER AND SPECIES LIST

1. Letter to Mr. W.R. Jones, Director, Moosehorn National Wildlife Refuge from Sybil A.S. Curtis, Dated January 18, 1966.
2. List of fungi gathered and identified during 1962-1965, Moosehorn Wildlife Sanctuary.

Mrs. John G. Curtis
Adamsville, R. I.

Jan. 18, 1966

Mr. W. R. Jones, Director
Moosehorn National Wildlife Refuge
Baring, Maine

Dear Mr. Jones:

In response to your request I submit a list of the fungi collected in my four visits to Moosehorn. The year 1963 was the best by far; 1965, alas, yielded practically nothing.

It has been a great pleasure to me to have spent what time I had to spare in Moosehorn, which is a remarkably fine area for collecting. I have found some rare species there, as well as two or three for which I have been able to find no names, and I strongly suspect that there are other unnamed species awaiting discovery. If a professional mycologist of my acquaintance ever gets around to examining some dried specimens I sent him in 1964, perhaps I shall have a few new names to add to the list.

Thanking you again for permitting me to collect in the Refuge, and hoping that I may do so again in a season of normal rainfall, I am

Sincerely yours,

Sybil A. S. Curtis

LIST OF FUNGI GATHERED AND IDENTIFIED DURING 1962-1965

MOOSEHORN WILDLIFE SANCTUARY

A S C O M Y C E T E S

PEZIZALES

PEZIZACEAE

Aleuria aurantia
Scutellinia scutellata

HELOTIACEAE

Chlorociboria aeruginascens
Helotium citrinum

GEOGLOSSACEAE

Cudonia circinans
" lutea
Leotia lubrica

HYPOCREALES

HYPOCREACEAE

Hypomyces lactifluorum

B A S I D I O M Y C E T E S

AGARICALES

THELEPHORACEAE

Craterellus cornucopioides
Thelephora terrestris

CLAVARIACEAE

Clavaria fumosa
" rosea
Clavariadelphus ligula
" pistillaris
Clavulina cinerea
" cristata
Clavulinopsis fusiformis
Lentaria mucida
Ramaria stricta

HYDNACEAE

Bankera mollis
Dentinum repandum, var. repandum
" " , var. album
Hericium coralloides
Hydnellum caeruleum
Sistotrema confluens

POLYPORACEAE

Coltrichia (Coltricia) perennis
Gloeoporus fumosus
Griphola (Grifola) sulphureus
Inonotus radiatus
Leptoporus caesius
Polyporus borealis
Trametes abietinus
" versicolor

BOLETACEAE

SUILLOIDEAE

Suillus acidus
" americanus
" granulatus, subsp. Snellii
" Grevillei
" hirtellus
" pictus
" piperatus
" placidus
" punctipes
" rubinellus
" subaureus

XEROCOMOIDEAE

Xerocomus badius
" illudens, subsp. illudens

BOLETOIDEAE

Boletus edulis
" impolitus

Leccinum aurantiacum
" chromapes
" scabrum
" " , subsp. niveum
" subglabripes

Pulveroboletus retipes

Tylopilus felleus

Xanthoconium affine

AGARICACEAE

Amanita citrina
" flavoconia
" muscaria
" parcivolvata
" rubescens
" strangulata
" vaginata, var. fulva
" " , var. livida

Cantharellus cibarius
" lutescens
" tubaeformis

Clitocybe clavipes
" infundibuliformis
" umbonatus

Clitopilus prunulus

Collybia acervata
" cirrhata
" dryophila
" maculata
" radicata

Cortinarius armillatus
" collinitus
" palaceus
" semisanguineus
" traganus

Crepidotus mollis

Hygrophorus cantharellus
" chlorophanus
" conicus
" laetus
" marginatus
" mineatus
" nitidus
" virgineus

Laccaria laccata

Lactarius affinis
" chrysorheus
" deceptivus
" deliciosus
" lignyotus
" mucidus
" piperatus

Lactarius (cont.)

" rimosellus
" torminosus
" trivialis
" turpis
" vellereus

Lepiota cristata

Marasmius cohaerens
" oreades

Mycena Leaiana
" pura

Panus rudis
" stypticus

Paxillus panuoides

Pholiota caperata
" spectabilis

Phylloporus rhodoxanthus

Pleurotus candidissimus

Pluteus admirabilis
" cervinus

Rhodophyllus lampropus
" pascuus
" salmoneus

Russula emetica
" fallax
" variata

Stropharia semiglobata

Tricholoma alboflavida
" aurantium
" sejunctum

SCLERODERMATALES

SCLERODERMATACEAE

Sphaerobolus stellatus

Note: List compiled from collections made by:
Dr. Kenneth A. Harrison, Kentville, Nova Scotia, Canada
Sybil A. S. Curtis, Adamsville, R. I.