Autumn Flibotte

Emma Levy

Fun with Fungi:

The Effect of Rainfall, Humidity, and Soil and Air Temperature on the Growth of the Mushrooms of the Cathance River Preserve

What are Mushrooms?

- A mushroom is actually the fruit of a fungus, produced above ground on soil or on trees, in some cases.
- The word mushroom is used to describe fungi that have a stem, a cap, and gills or pores on the cap-underside.
- Mushrooms have an average lifespan of about a week, and have different growing seasons and thrive in different conditions, depending on the species.
- Mushrooms are neither plant nor animal; they belong to a kingdom of their own (fungi), encompassing thousands of species. They are not a plant because they have no way of producing their own food, nor can they absorb nutrients from the sun as they have no mitochondria or chloroplasts. Fungi is surprisingly more closely related to animals than plants, due to this lack of photosynthesizing cellular organelles, as animals lack these as well.
- The most common theme of mushrooms found were mycorrhizal fungi; mushrooms that feed off of the nutrients of trees for survival. The two other types of mushrooms are saprophytic (lives in leaf litter, decaying logs, etc) and parasitic (thrives on and attacks trees, plants, and animals/humans in some cases)
- A mature forest is an area containing trees that are significantly larger and older than those in an immature forest. Mature trees have achieved most of their potential growth, while immature trees still have a more growing years to come.

*Autumn checking the soil temperature in the immature forest

* Mycorrhizal with gills

* Armillaria mellea

* Mycorrhizal with pores

* Lactarius chrysorrheus

* Cortinarius iodes

Purpose & Hypothesis:

Problem/Question: Determine what effects rainfall, humidity, and soil/air temperature have on the increase and decrease of numbers of mushrooms in an immature compared to a mature forest area.

Hypothesis: More mycorrhizal mushrooms will be found when the rainfall and humidity are greater, and the soil and air temperature are higher in both the immature and mature forest areas.

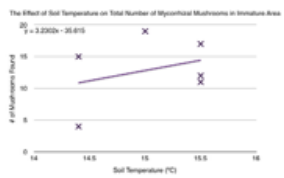
Procedure:

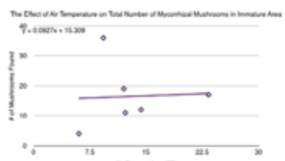
1. Mark a 10 meter by 10 meter square in a mixed forest area dominated primarily by immature trees at the Cathance River Preserve.
2. Record the soil temperature, in °C, using a soil thermometer.
3. Search for mushrooms in the area, and take samples of any mycorrhizal specimen found, placing them into wax or paper bags to be carried back to the Ecology Center. Note where the mushrooms were found growing - in the soil, by or on rotting logs, on tree trunks, etc.
4. Record observations of the weather, and of sights, sounds, smells, and other interesting things that are found or observed in the notebook.
5. Mark a second 10 meter by 10 meter square in a mixed forest dominated primarily by mature trees.
6. Repeat steps 2-3.
7. Find and record the amount of weekly rainfall, the current humidity, and the current air temperature from the Maine Weather Underground for Topsham.
8. Identify mushroom samples using field guides, or, if necessary, spore prints.

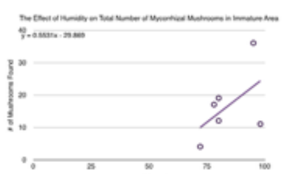
Graphs:

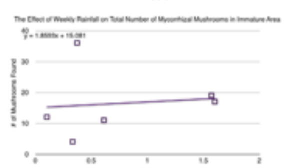
*The graphs for saprophytic mushrooms were not included on this poster, as this lab is studying the effect of immature compared to mature trees on mushroom growth, and the growth of saprophytic mushrooms does not discriminate based on tree type.

Immature Area:

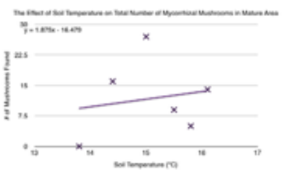


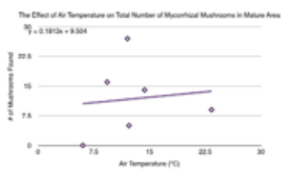


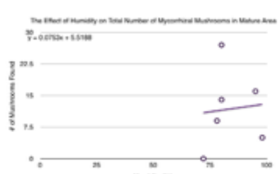




Mature Area:





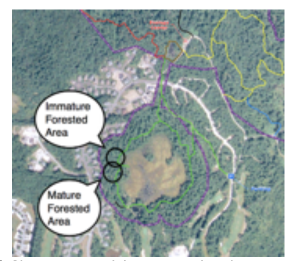


Acknowledgements:

Thanks to Cheryl St. Pierre for all her help in the field, and Cheryl Sleeper for her pictures, her help at the Ecology Center, and of course - her snacks!

Conclusions:

- The data for both the immature and mature forest areas supported the hypothesis. The graphs for soil and air temperature, humidity, and weekly rainfall all showed increasing trends.
- Although there were points on the graph that were not in keeping with this hypothesis, the general and overall trend of the data, as evidenced by the graphs, was positive; as the abiotic factor increased, so did the number of mushrooms found.
- It was discovered that, for the immature area, soil temperature had the greatest effect on the growth of mushrooms. Rainfall, however, had the greatest effect for the mature area.



* Close-up map of the areas under observation

*The researchers and Cheryl St. Pierre identifying mushroom samples back at the Ecology Center

Emma Levy &
Autumn Flibotte
November 12th, 2013
RED-1, 2

Title: The Effect of Rainfall, Humidity, Soil and Air Temperature on the Mushroom Population in Immature and Mature Forests at the Cathance River Preserve

Background:

Mycology (from the Greek word for "fungus") is the branch of biology concerned with the study of fungi, including their genetic and physical properties, medicinal qualities, their use in nutrition, as well as their dangers and toxicity, such as poisoning or infection. A mushroom is actually the fruit of a fungus, produced in the ground or soil or, in the case of symbiotic/ mycorrhizal fungi, on trees. The word mushroom is usually used to describe fungi that have a stem, a cap, and gills or pores on the underside of the cap. Mushrooms are neither plant nor animal; while they were initially classified as members of the kingdom Plantae - as they were believed to be nothing like animals or minerals, and therefore could only be plants - they were later found to have characteristics very different from the organisms within this kingdom. Fungi gain carbon by breaking down and absorbing materials around them, while plants gain it through photosynthesis, a process that mushrooms cannot replicate, as they have no mitochondria or chlorophyll. In addition, both plants and fungi have very different substructures, and fungi produce fruiting structures, known as mushrooms, that are unlike anything produced by plants. Mushrooms are actually a kingdom of their own, which encompasses thousands of species. Surprisingly, fungi are more closely related to animals than plants, due to this lack of photosynthesizing cellular organs, as animals lack these organs as well.

There are three types of fungi: the first being mycorrhizal fungi. This type of fungi has a symbiotic relationship with trees, meaning that both organisms provide nutrients for the other, as trees are more efficient in obtaining nutrients due to their large roots, and are therefore an excellent source of concentrated nutrients. The tree can live without the mushroom, but the mushroom cannot survive without the tree. The fungus absorbs carbohydrates and glucose through the tree and provides the tree with phosphate in return, bypassing the need for direct soil contact. Because mycorrhizal fungus have smaller roots in diameter, they are often resistant to microbial soil-borne pathogens.

The second type of fungi is saprophytic (from the Greek terms for “rotten material” and “plant”). This type of fungi thrives in low to medium temperatures, neutral acidic pH, and in the presence of water, but cannot survive in an entirely anaerobic environment. Known as lignicolous fungi, they aid in the decomposition of the logs or humus that they live on by breaking down proteins into amino acids, lipids into fatty acids and glycerol, and starch into its most simple form.

The third and least common type of fungi is parasitic. Parasitic fungi can cause extensive damage to agriculture and forests; Dutch Elm Disease and Rice Blast Fungus are two of many examples. Fungi can also severely affect humans, attacking eyes, nails, hair, and skin; ringworm and athlete’s foot are two examples. Some historical agricultural disasters have also been caused by parasitic fungi. An example of this is the Irish Potato Famine of the mid-1800s, which resulted from a lack of species diversity in the monoculture potato crop of the Irish peasants. A wet summer followed by a wet fall promoted the growth and the spread of the fungus across Irish potato fields, which spread quickly and wreaked havoc on the potatoes as they were grown so closely together and consisted of only a single species. The devastation of American Chestnuts was also a result of a lack of species diversity, and had a similarly severe effect on these types of trees all across America.

Mushroom reproduction occurs when mushrooms become a certain age and release spores from underneath their caps, and the spores are spread either by the wind or by insects and animals inadvertently transporting them. This causes a generally random dispersion pattern among populations of mushrooms, although they can only survive in ideal conditions. This means that the mushrooms that are dispersed in areas with abundant resources are more likely to survive and thrive in groups where there are several mushrooms, creating somewhat of a clumped dispersion pattern.

Mushrooms that have been found and identified in both of the areas under study at the Cathance River Preserve include the following: *Cortinarius iodes, Cortinarius alboviolaceus, Lactarius lignyotis, Lactarius aquifluus, Lactarius chrysorrheus, Suillus granulatus, Gymnopilus penetrans, Marasmius capillaris, Aminita citrina, Lycoperdon pyriforme, Clavicorona pyxidata, Laccaria laccata, Tricholoma sejunctum, Armillaria mellea, Hypholoma sublateritium,* and various unidentified samples of the *Cortinarius, Lactarius, Collybia, Russula, Pholioda,* and *Bolete* genera.

The *Cortinarius* genus is one of the largest and most diverse families of mushrooms. Spore prints of any of the nearly 2,000 different mushroom species within the *Cortinarius* family range from yellowish-brown to rusty-brown. The cap and stalk are firmly attached and cannot be easily separated with a clean break, the veil is often cobwebby, and the spores may be wrinkled, warty, or spiky. *Cortinarius iodes* have purple caps that develop yellowish-white spots or streaks when they reach maturity, and grow in a mycorrhizal association with the roots of deciduous trees. Both mature samples - with the yellowish-white spots - and immature samples - with smaller purple caps and no spots - have been found in the areas under study at the Cathance River Preserve. *Cortinarius alboviolaceus* have convex, silvery violet caps; twisted and club-shaped stems; and large, medium-spaced gills. Like others of their genus, they are mycorrhizal, and typically grow near deciduous trees, though they occasionally grow near conifers. The *Cortinarius* genus typically sprouts in the summer, but can also be found in the late spring or early autumn.

All mushrooms of the *Lactarius* genus have small to large caps that are firm but often delicate, and white to orange-yellow spore prints. When any part of the mushroom is cut or broken, a white, clear, or pale-colored milky substance is exuded. The color of the milk as well as the color of the spore print can be useful in identifying the species of the mushroom. *Lactarius lignyotus* have a dark brown, velvety cap with a small dent in the center, which is connected to a pale-brown stem. These mushrooms have spherical spores and exude white milk, and have a mycorrhizal association with the roots of conifers. *Lactarius aquifluus* are highly poisonous, and emit a strong, spicy smell. These mushrooms are relatively large, and become funnel-shaped as they mature. Their cap and stem are typically the same color - a yellow-ochre to gray-brown - and they exude a clear, watery milk. Similar to the species *lignyotus*, *aquifluus* grow in a mycorrhizal association with the roots of conifers and birches, and fruit in the late summer to early autumn. *Lactarius chrysorrheus* are also mycorrhizal, but grow near oaks as opposed to birches and conifers. Their caps are pale yellow, and they produce large amounts of white milk that turns yellow when exposed to the air.

Suillus genus mushrooms have large, soft, and thick caps, underneath which are found angular pores that are arranged in rows. The surface of the caps are very often sticky, which is the primary reason why the *Suillus* genus has been nicknamed the “Slipperycap” family. Spore prints of these mushrooms range from olive-brown to mildly yellowish-brown. *Suillus granulatus* have ringless stems with pointed bases and yellow spots, rusty-brown to yellow-orange convex caps, and fine, rounded yellow pores on the underside of the cap. They, too, are mycorrhizal, and grow near two-needled (red, jack, or scotch) pines in small to large clusters. Although they appear in both summer and autumn, they are most common in September.

Mushrooms of the *Gymnopilus* family have firm, yellow to orange tinted caps, that cannot be separated easily from their stems. They have gills, and produce spore prints that range from orange to grayish-orange to a bright yellowish-brown. *Gymnopilus* mushrooms are often nicknamed “Flamecaps”, for the bright colors of their spores and cap surfaces. *Gymnopilus penetrans*, although related to the *Cortinarius* family, are not mycorrhizal, and grow instead on dead and rotting wood. These mushrooms have convex to flattened caps that are tinted orange-brown and are typically smooth and dry. Their stems are pale yellow, as are their gills, which also have rusty flecks. The *penetrans* species typically appear in small groups or singularly, during the late summer and into the autumn.

The *Marasmius* family have small to medium caps that cannot be easily separated from their stems, which are typically thin but tough. Mushrooms of this genus have white to pale yellow spore prints. The *Marasmius capillaris* species have thin, small, white, convex caps with dry, dull, smooth surfaces, that are yellowish-white or brown when mature, and darker when immature. The cap is typically attached with a collar around the thin black stalk, and on its underside are widely spaced, white tinted gills. They grow in large clusters on decaying wood or the leaf litter of deciduous trees. *Marasmius capillaris* have been found in large numbers in both forested areas under observation at the Cathance River Preserve, although they have been found more frequently and more abundantly in the immature forest. They tend to appear in greater numbers when the humidity and rainfall of the past week are higher, and sprout from the spring to the autumn.

Mushrooms of the genus *Amanita* have large gills with white spores that are not attached to the mushroom stem, which typically has a ring of scales or powder on its center. The cap color of *Amanitas* varies from species to species, but is universally capable of being easily separated from the stem. For their highly poisonous nature, they have been nicknamed the “Deathcap” family. The species *Amanita citrina* has a medium-sized, shiny yellow, rounded cap, that is attached to a thin white stalk that has a large bulb at its base. These mushrooms often smell like raw potatoes, and have gills that are free from but close to the stem, that change from pale yellow to white with maturity. The *Amanita* genus sprouts in the late summer and autumn.

The genus *Lycoperdon*, or “Puffball”, are small to medium in size, and are often stalkless. The cap consists of a thin, rounded skin, or casing, that contains the mushroom’s spores. The spore powder, which is yellow-green in color, escapes through an apical pore in the casing when the mushroom is stepped on or otherwise squashed. The outer surface of the spore casing often forms spines, warts, or velvety scales. *Lycoperdon pyriforme* mushrooms are very easily identified, for their upside-down pear shape, their smooth surface when mature, their spiny surface when immature, and the white cords that are found at its base. These types of mushrooms are saprotrophic, growing primarily on rotten deciduous wood, but occasionally at the bases of conifers. They are most often found in large, clustered groups, but can also be found growing singularly. They fruit during the fall, but their spore cases often survive through the year.

Clavicorona pyxidata or “Crown Coral” mushrooms are medium to large in size, and grow as dull-yellow, coral-like masses with many separate branches. The ends of these branches are indented and ringed with smaller branches, or branchlets, and their surfaces are smooth. Both the branches and the stem of the mushroom are typically pale yellow at immaturity, and darken as they grow. Their spore prints are white, and they often emit an odor of raw potatoes. These mushrooms grow both singularly and in clusters, and can be found on decaying stumps or deciduous logs. They typically sprout in the early summer and into the autumn.

The *Laccaria* genus includes mushrooms that are small to medium in size, with white spore prints that are often tinted with purple. Their caps are not easily separated from the stem, which can be thin to thick, is often fibrous, and does not have rings. The gills of these mushrooms are waxy, and range from flesh-colored to purple-tinted. Mushrooms within this family are hygrophanous; that is, their colors fade with age. The *Laccaria laccata* species, otherwise known as the "Common Laccaria", appears in diverse shades of pink-brown, and has dry, velvety or scaly caps, that are often toothed at the edges or indented at the center. These mushrooms have strong, fibrous stems; thick, well-spaced, pink gills; and spherical spores. They grow in a mycorrhizal association with both conifers and deciduous trees, typically in wooded areas or under willows in marshy areas. They occur in groups, most commonly in moist soil, during the late spring into early autumn.

Mushrooms of the genus *Tricholoma* are medium to large in size, with white to pale-yellow spore prints. Their caps are fleshy, and the gills are notched around the peak of the stem, which is solid and fleshy, attached to the cap at its center, and slightly fibrous. Mushrooms of the *Tricholoma sejunctum* species have green or brown caps that are moist and convex, and are greasy with dark fibers during wet weather. The stem is initially white, but gains yellow tints with age, and is pointed at the base. Their gills are notched and are colored creamy white or pale gray. These mushrooms grow in small groups or clusters, between summer and autumn. For their poisonous nature, they are called the “False Edible *Tricholoma*”, as they look similar to another mushroom of their genus that is edible. *Tricholoma sejunctum*, on the other hand, can cause severe nausea if eaten.

The genus *Armillaria* of mushroom produces medium-to-large fungi, usually colored white to yellow to grayish-brown. Gills of these mushrooms, found on the underside of the cap, attach to the stem, and the stalks do not separate easily from the caps. The species *Armillaria mellea*, also known as the “Honey Mushroom”, is the only parasitic mushroom to be found in either plot under study in this lab at the Cathance River Preserve. Their caps are slightly convex at the peak, but generally flat in shape, and are typically tinged yellow-brown to pale brown-orange. The stems are slender, and colored a pale yellow-orange. Gills of these mushrooms are well-spaced and attached to the stalk, often colored white to pinkish-brown. The “Honey Mushroom” only appears in the fall, at very specific times, and grows almost exclusively in clusters. The stems originate from one body, and are all joined at the base.

Mushrooms of the *Hypholoma sublateritium* species, also known as “Brick Caps”, are quite large, and often can be identified by this feature, as well as the brick-red color of its cap and the lack of green in its gills. The cap is convex, and the stem is fibrous and fades from reddish-brown at the base to pale yellow at the top. It is mycorrhizal, and typically appears in clusters at the bases of deciduous stumps or roots.

Various mushrooms of the *Collybia, Russula,* and *Pholiota* families were found in both areas under study, but the researchers were incapable of identifying these samples fully, down to their specific species. The *Collybia* genus of mushroom includes specimens that are small to medium in size, that primarily produce white spore prints, though rarely they can be yellow- or pink-tinted. These mushrooms are thin-fleshed, with gills and thin, fleshy, often hairy stalks. The edges of their caps are curled inwards initially, but flatten out with age. The *Russula* genus includes medium to large sized mushrooms, that produce spore prints colored white to orange-yellow. Their thickly-fleshed yet brittle caps that crumble when touched are attached firmly to their thick stalks, that can range from fragile to tough, and hollow to stuffed. Finally, the *Pholiota* species contains mushrooms that produce yellow-brown spore prints. Their caps can range from small to large, and the underside of them houses brown gills. The stalk of these specimens has either a membranous ring or a fibrous, scaly area.

Although no specific information on the amounts of moisture that are most favorable to each mushroom genus could be found, a general idea of the growth periods of each of the three types of mushroom was. It was discovered that mushrooms growing in mycorrhizal associations with trees most often grow two-three weeks after a rain; mushrooms growing in a saprophytic association with trees typically sprout about one week after a rain; and parasitic mushrooms do not generally have a preference, as they fruit when others do, with little to no dependence on moisture. However, the above is only true when rain has been periodic and weekly. When a long period of dry weather has just occurred, a good inch of rain is required to have an effect on the growth of both mycorrhizal and saprophytic mushrooms.

Works Consulted

Arora, David. *Mushrooms Demystified: A Comprehensive Guide to the Fleshy Fungi*. Berkeley: Ten Speed, 1986. Print.

Barron, George L. *Mushrooms of Northeast North America : Midwest to New England*. Edmonton, AB: Lone Pine Pub., 1999. Print.

Könemann. *Pocket Guide to Mushrooms.* N.p.: Gardners, 2005. Print.

Lincoff, Gary, and Carol Nehring. *National Audubon Society Field Guide to North American Mushrooms*. New York: Knopf, 1997. Print.

McKnight, Kent H., and Vera B. McKnight. *A Field Guide to Mushrooms, North America*. Boston: Houghton Mifflin, 1998. Print.

Phillips, Roger, Geoffrey Kibby, and Nicky Foy. *Mushrooms of North America*. Boston: Little, Brown, 1991. Print.

Problem/Question:

Determine what effects rainfall, humidity, and soil and air temperature have on the increase and decrease of numbers of mushrooms in an immature forest area compared to a mature forest area.

Hypothesis:

More mycorrhizal mushrooms will be found when the rainfall and humidity are greater, and the soil and air temperature are higher in both the immature and mature forested areas.

Safety Considerations:

- Always be cautious of eye/face-level branches, and make sure to hold back any branches for the person walking behind you.
- Walk carefully and at a moderate to slow pace; walkways can be very slippery, and bridges are often slick after heavy rains.
- Always carry the soil thermometer downwards at your side to prevent possible injury; its tip is surprisingly sharp.
- Wash hands thoroughly after touching mushrooms as a preventative and precautionary measure, as one will probably be handling mushrooms that are poisonous to humans when ingested.

Procedure

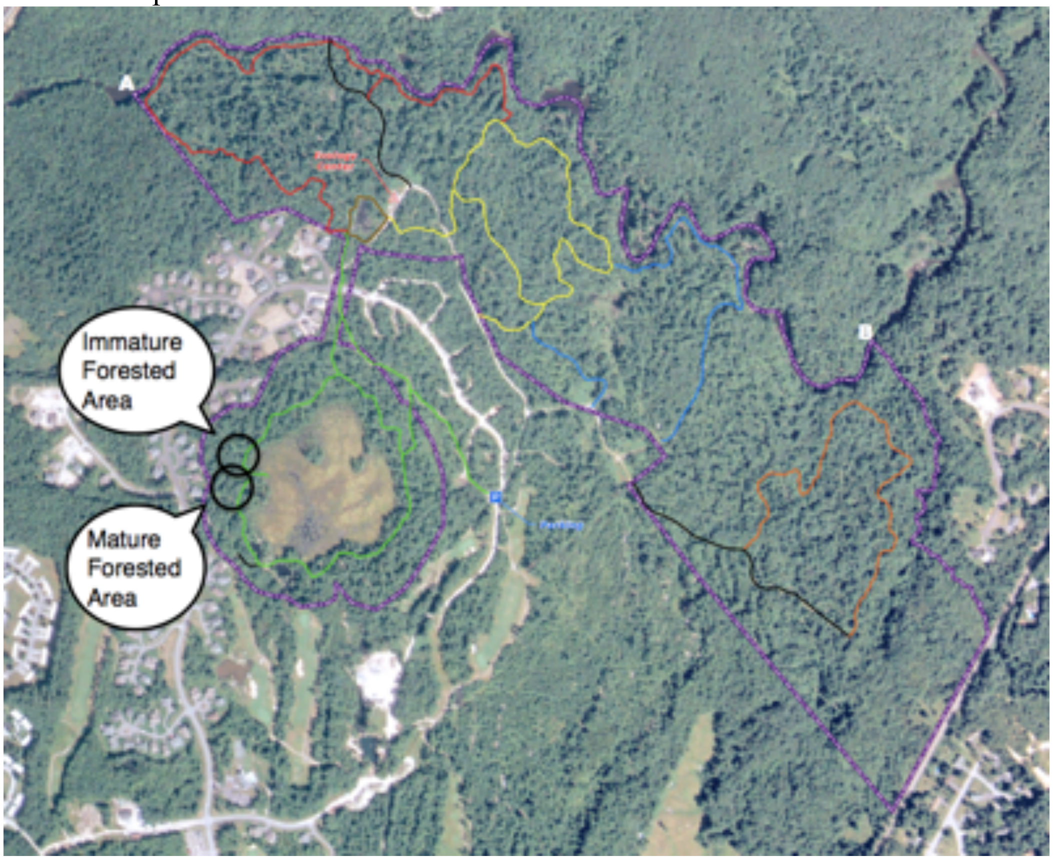
1. Mark a 10 meter by 10 meter square in a mixed forest area dominated primarily by immature trees at the Cathance River Preserve.
2. Go to each of the marked corners and record the GPS coordinates, which are:
   - N 43º 57.134' W 069º 57.168'
   - N 43º 57.139' W 069º 57.176'
   - N 43º 57.134' W 069º 57.178'
   - N 43º 57.133' W 069º 57.177'
3. Record the soil temperature, in ºC, using a soil thermometer.
4. Search for mushrooms in the area, and take samples of any mycorrhizal specimen found, placing them into wax or paper bags to be carried back to the Ecology Center. Note where the mushrooms were found growing - in the soil, by or on rotting logs, on tree trunks, etc. It is not necessary to take samples of saprophytic mushrooms, as this lab is studying the effect of immature compared to mature trees on mushroom growth, and the growth of saprophytic mushrooms does not discriminate based on tree type.
5. Mark a second 10 meter by 10 meter square in a mixed forest dominated primarily by mature trees.
6. Go to each of the marked corners and record the GPS coordinates, which are:
   - N 43º 57.086' W 069º 57.198'
   - N 43º 57.088' W 069º 57.197'
   - N 43º 57. 096' W 069º 57.197'
   - N 43º 57.095' W 069º 57. 196'
7. Repeat steps 3-4.
8. Find and record the amount of weekly rainfall, the current humidity, and the current air temperature from the Maine Weather Underground for Topsham.
9. Identify mushroom samples using field guides, or, if necessary, spore prints. Field guides that were used include (*Citations are listed in the* <u>*Works Consulted*</u> *section*):
   - <u>National Audubon Society Field Guide to North American Mushrooms</u> - By Gary Lincoff and Carol Nehring
   - <u>Mushrooms Demystified: A Comprehensive Guide to the Fleshy Fungi</u> - by David Arora
   - <u>Mushrooms of Northeast North America: Midwest to New England</u> - by George L. Barron
   - <u>Pocket Guide to Mushrooms</u> - by Könemann
   - <u>A Field Guide to Mushrooms</u> - by Kent H. McKnight / Vera B. McKnight
   - <u>Mushrooms of North America</u> - by Roger Phillips, Geoffrey Kibby, and Nicky Fox
10. Spore prints can be made using the following steps:
    a. Choose mature, healthy, and relatively intact mushrooms as subjects for the spore prints.
    b. Cut the stems from the mushrooms so they will lie flat.
    c. Place samples in the middle of two pieces of overlapped paper, one black and one white.
    d. Place a wet paper towel over the mushroom cap and let it sit. Check papers for spore prints next class.
    e. Match spore prints with specific mushrooms, using field guides (listed above).

12. Repeat steps 1-7 five times weekly at the Cathance River Preserve.

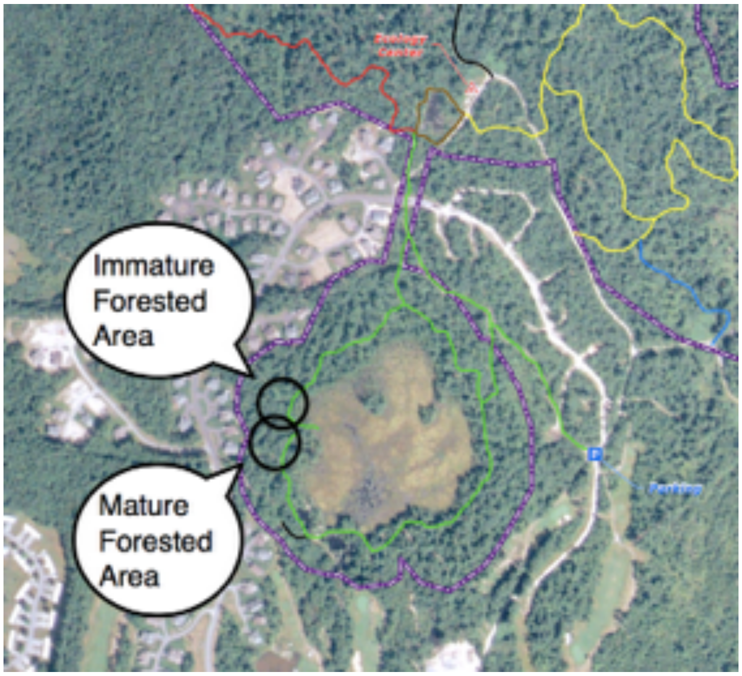
13. Repeat steps 8-10 at home or at Mt. Ararat.

Maps of Areas under Observation:

General Map of Areas:



Close-up Map of Areas;



Observations:

General Observations about the Sites:

Trees found growing in the immature forest area (measurements indicate the circumference of the tree at shoulder height, or at about 4-5 feet off the ground):

- 14 hemlocks, from (2' 10.25" or 86.995 cm.) - (4.75" or 12.065 cm.)
- 2 oaks (1' 4.5" or 41.91 cm.), (1' or 30.48 cm.)
- 14 firs, from (1' 9.25" or 53.975 cm.) - (circumference: 3.5" or 8.89 cm. height: 4' 3" or 129.54 cm.)

Trees found growing in the mature forest area:

- Several small maples
- 1 mature fir (1' 10" or 55.88 cm.)
- 3 immature firs
- 6 mature hemlocks, from (4' 1.5" or 125.73 cm.) - (2' 0.25" or 61.595 cm.)
- 1 immature oak (7.25" or 18.415 cm.)
- 3 mature oaks, from (3' 11.5" or 120.65 cm.) - (2' 7.25" or 79.375 cm.)

October 10th:

The day was sunny and colder than it has been - it was almost below freezing last night - but there was still no frost on the ground and the weather began to warm the as the day progressed. It rained heavily last Monday, three days ago, but only the lowest-lying areas in both forests were relatively wet; the majority of the ground was dry. The leaves of the deciduous trees have started to change - the colors are very bright this year, as a result of the wet summer and the wet beginning to this fall - and many have fallen. Since they litter the ground so heavily, especially in the mature forest, they may be obscuring mushrooms growing from the soil from view. Another explanation for the small amount of mushrooms found within the boundaries of the mature forested area, and the large amount found just outside the borders, is the fact that the roots of the trees in the mature forest extend far beyond the area boundaries. The mushrooms need the roots of these trees to survive, and therefore will more likely be found in the areas where they can reach these roots. Something interesting to note was that many needles on the conifers in both areas are also beginning to change colors. To some extent, this is supposed to happen, but there seem to be more orange needles than usual. Is this a sign of a cold and snowy winter to come? Lastly, several clusters of a previously-unseen type of mushroom, Armillari mellea or the "Honey" mushroom, were observed in the immature forest area, presumably because this is the time of the year in which these mushrooms grow.

October 18th:

The air was relatively cool and the sky was overcast initially this morning. Although it wasn't raining, there was some light mist and the trees were dripping from the rain that fell last night. Halfway through our observations, while the mature forest was being checked, the clouds began to clear and the sun broke through, and the temperature began to warm slightly soon after. The weather has been very dry recently - the last rain was two Mondays ago, or 11 days ago - and even though it rained last night and some time into this morning, not enough time had elapsed for the moisture to have an effect on the growth of the mushrooms in either forest area. Even more deciduous tree leaves had fallen, especially in the mature forest, possibly obscuring mushrooms growing out of the soil beneath the leaf litter and contributing to the small amount of specimens that were found in the mature forest. Other factors that added to this unanticipated result could have been, as stated before, the fact that the tree roots in the mature forest extend far beyond the area's boundaries, the lack of species diversity in the trees in the mature forest, and the weather that has recently been colder and drier. Something interesting to note was that a reddish-pink adult wood frog was found in the sunnier area of the mature forest. The frog leaped away from us initially, but froze and did not move after hopping only 2-3 times, even when he was touched. Was this a result of the cold? We left a log next to him so we would know where he was (he blended in with the leaf litter and could have easily been stepped on), and found him later underneath the log, presumably searching for warmth.

October 24th:

The day was again sunny and the coldest yet - it was nearly below freezing early this morning. Frost has still yet to appear. Most deciduous trees have lost the majority of their leaves, except the oaks, the leaves of which are just beginning to turn brown and fall. Even more fallen leaves were blanketing the ground in both forested areas, which again may have been the cause of the small amounts of mushrooms we found. Other factors that could have contributed to this result include the reduced amount of daylight that reaches the ground as the days progressively get shorter, or the sudden drop in both soil and air temperatures over the past few days. Rainfall has also been relatively low recently, and as most mushrooms favor highly moist soil, this could have also been a contributing factor. Since low numbers of mushrooms were found in both the immature and mature forest areas today, and very few were seen along the paths, this leads us to believe that the conditions in the areas themselves had little to no effect on this unanticipated result. Something interesting to note: the branch of a young red maple in the immature forest was completely stripped of bark. The tree is located at least thirty feet off the trail, and therefore was most likely not harmed by a human. Could a squirrel or a bird have peeled off the bark for a nest? Or was this more likely done by a porcupine?

Data Table:

Mushrooms Found and Abiotic Factors Observed in Mature Forest at Cathance River Preserve

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
9/20	16.1 ºC	14.3 ºC	80%	0.1 cm.	6	Immature Cortinarius iodes	Soil	Mycorrhizal
					2	Mature Cortinarius iodes	Soil	Mycorrhizal
					1	White-brown of Cortinarius species	Soil	Mycorrhizal
					2	Orange-brown of Cortinarius species	Soil	Mycorrhizal
					1	Lactarius lignyotis (Milky Cap)	Soil	Mycorrhizal
					1	Suillus granulatus	Soil	Mycorrhizal

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
					1	Orange-tan of Colybia species	Soil	Mycorrhizal
9/26	15 ºC	12 ºC	80%	1.57 cm.	1	White-brown of Cortinarius species	Soil	Mycorrhizal
					4	Red of Russula species	Soil	Mycorrhizal
					3	Yellow-brown of Cortinarius species	Soil	Mycorrhizal
					8	Cortinarius iodes	Soil	Mycorrhizal
					Approx. 25	Small white-brown of Pholioda species	Trunk of Young Maple	Mycorrhizal
					5	White-brown w/ speckled cap and milk-choc. colored gills, of Cortinarius species	Soil	Mycorrhizal
					3	Yellow-white, unidentifiable species	Soil	Mycorrhizal
					1	White of Russula species	Soil	Mycorrhizal
					2	Immature orange-brown of Cortinarius species	Soil, under rotting log	Mycorrhizal
10/2	15.5 ºC	23.3 ºC	78%	1.6 cm.	5	Red of Russula species	Soil	Mycorrhizal
					1	Red of Russula species, pa-rasitized by Hypomyces luteovirens	Soil	Mycorrhizal

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
					3	Pinkish-white of Russula species	Soil	Mycorrhizal
10/10	14.4 ºC	9.27 ºC	95%	0.37 in.	7	Red of Russula species	Soil	Mycorrhizal
					4	White of Russula species, immature	Soil	Mycorrhizal
					2	Cortinarius albobiolaciuus	Soil	Mycorrhizal
					3	Red of Russula species, parasitized by Hypomyces luteovirens	Soil, found in a cluster	Mycorrhizal
10/18	15.8 ºC	12.2 ºC	98%	0.61 cm.	2	Old, shriveled red of Russula species from last week	Soil	Mycorrhizal
					3	Old red of Russula species from last week, parasitized by Hypomyces luteovirens	Soil	Mycorrhizal
10/24	13.8 ºC	6 ºC	72%	0.33 cm.	2	Gymnopilus penetrans	Rotting Log	Saprophytic

Mushrooms Found and Abiotic Factors Observed in Immature Forest at Cathance River Preserve

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
9/20	15.5 ºC	14.3 ºC	80%	0.1 cm.	1	Gymnopilus penetrans	Rotting log	Saprophytic

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
					Approx. 100	Marasmius capillaris	Leaf litter	Saprophytic
					1	Amanita citrina	Soil	Mycorrhizal
					1	Unidentified red-brown	Soil, near rotting log	Mycorrhizal
					1	Tan with pores of Bolete species	Soil	Mycorrhizal
					1	Unidentified white-tan	Soil	Mycorrhizal
					1	Lactarius aquaflous	Soil	Mycorrhizal
					3	Unidentified scaly, layered brown	Soil	Mycorrhizal
					1	Lycoperdon pyriforme (Puffball)	Soil	Mycorrhizal
					1	Clavicorona pyxidata	Soil	Mycorrhizal
					1	Purple-tinted Cortinarius species	Soil	Mycorrhizal
					1	Pink of Russulla species	Soil	Mycorrhizal
9/26	15 ºC	12 ºC	80%	1.57 cm.	Approx. 100	Marasmius capillaris	Leaf litter	Saprophytic
					2	Brown with purple tint and white gills of Russula species	Soil at base of rotting stump	Mycorrhizal
					2	Laccaria laccata	Soil	Mycorrhizal
					1	Lycoperdon pyriforme (Puffball)	Soil	Mycorrhizal

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
					1	White-brown, gilled, old, shriveled, unidentifiable	Soil	Mycorrhizal
					1	Amanita citrina	Soil	Mycorrhizal
					2	Cortinarius iodes	Soil	Mycorrhizal
					4	Toothed brown-red, unidentifiable	Soil	Mycorrhizal
					6	Russula species	Mossy area in soil	Mycorrhizal
					2	Tan of Cortinarius species	Soil	Mycorrhizal
10/2	15.5 ºC	23.3 ºC	78%	1.6 cm.	7	Red of Russula species from last week, mature	Mossy area in soil	Mycorrhizal
					2	Tricholoma sejunctum	Soil	Mycorrhizal
					1	Cortinarius iodes	Soil	Mycorrhizal
					2	Brown Cortinarius	Soil	Mycorrhizal
					2	Orange-tan Lactarius	Soil	Mycorrhizal
					1	Purple of Russula species	Soil	Mycorrhizal
					Approx. 20	Marasmius capillaris	Leaf litter	Saprophytic
					1	Purple-gray Lactarius, with white milk	Mossy area in soil	Mycorrhizal

Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
					1	Orange spiky Lycoperdon pyriforme (puffball) from last week, mature	Mossy area in soil	Mycorrhizal
10/10	14.4 ºC	9.27 ºC	95%	0.37 in.	3	Red of Russula species	Soil	Mycorrhizal
					19	Armillari mellea ("Honey Mushroom")	Soil, found in 3 separate clumps of 9, 3, and 7	Parasitic
					7	Armillari mellea ("Honey Mushroom")	Found in 2 separate clumps: 4 coming out of bark of oak tree, 3 coming out of base of tree	Parasitic
					3	Pale yellow Amanita Citrina	Soil	Mycorrhizal
					2	Laccaria laccata	1 in mossy soil, 1 in soil	Mycorrhizal
					Approx. 20	Marasmius capillaris	Leaf litter	Saprophytic
					1	Pink-orange Lactarius chrysorneus, produced white milk that turned yellow when exposed	Soil	Mycorrhizal
					1	Small brown shriveled Cortinarius	Soil	Mycorrhizal
10/18	15.5 ºC	12.2 ºC	98%	0.61 cm.	4	Amanita citrina	Soil	Mycorrhizal

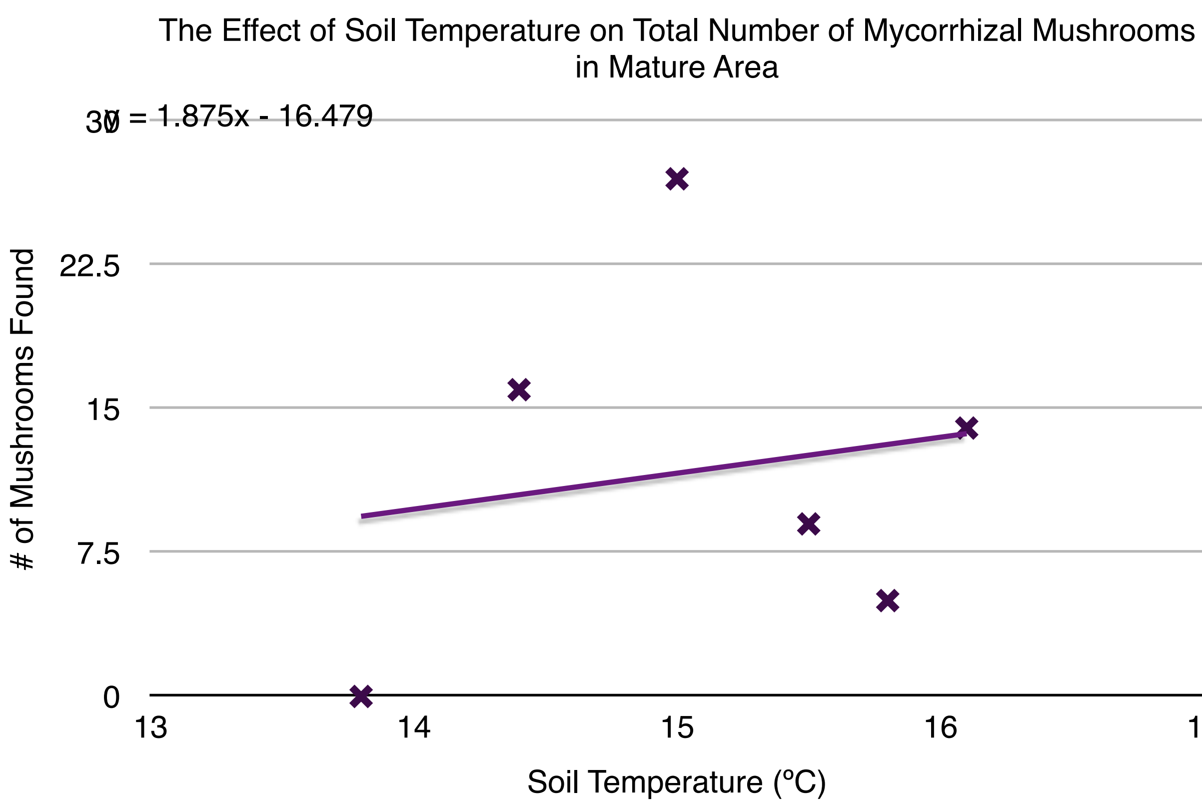
Date	Soil temp	Air temp	Humidity	Rainfall in last 7 days	# of Mush-rooms Found	Mushroom Type	Associated Environment next to Mushroom	Fungi Type (Mycorrhizal, Saprophytic, Parasitic)
					1	Purple-brown of Cortinarius species	Soil	Mycorrhizal
					Approx. 500	Marasmius capillarius	Leaf litter	Saprophytic
					2	Red of Russula species	Soil	Mycorrhizal
					1	Brown of Cortinarius species	Growing out of soil at base of immature hemlock	Mycorrhizal
					1	Armillari mellea ("Honey Mushroom")	Growing out of trunk of immature spruce	Parasitic
					2	Hypholoma sublateritium ("Brick-Cap")	Soil	Mycorrhizal
10/ 24	14.4 ºC	6 ºC	72%	0.33 cm.	2	Shriveled, old Amanita Citrina from last week	Soil	Mycorrhizal
					1	Shriveled, old red of Russula species from last week	Soil	Mycorrhizal
					1	Red of Russula species	Soil by rotting log	Mycorrhizal

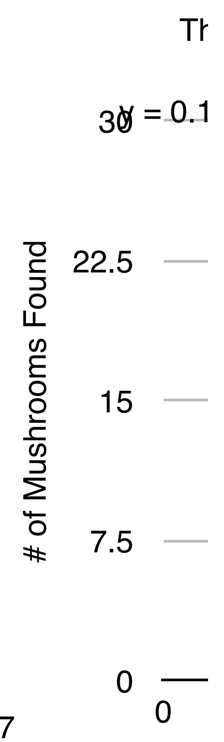
Calculations:
The soil temperature thermometer and rainfall calculator that were used during this lab only provided measurements in the U.S. Standard System, and these needed to be converted into metric units for the purposes of this lab.

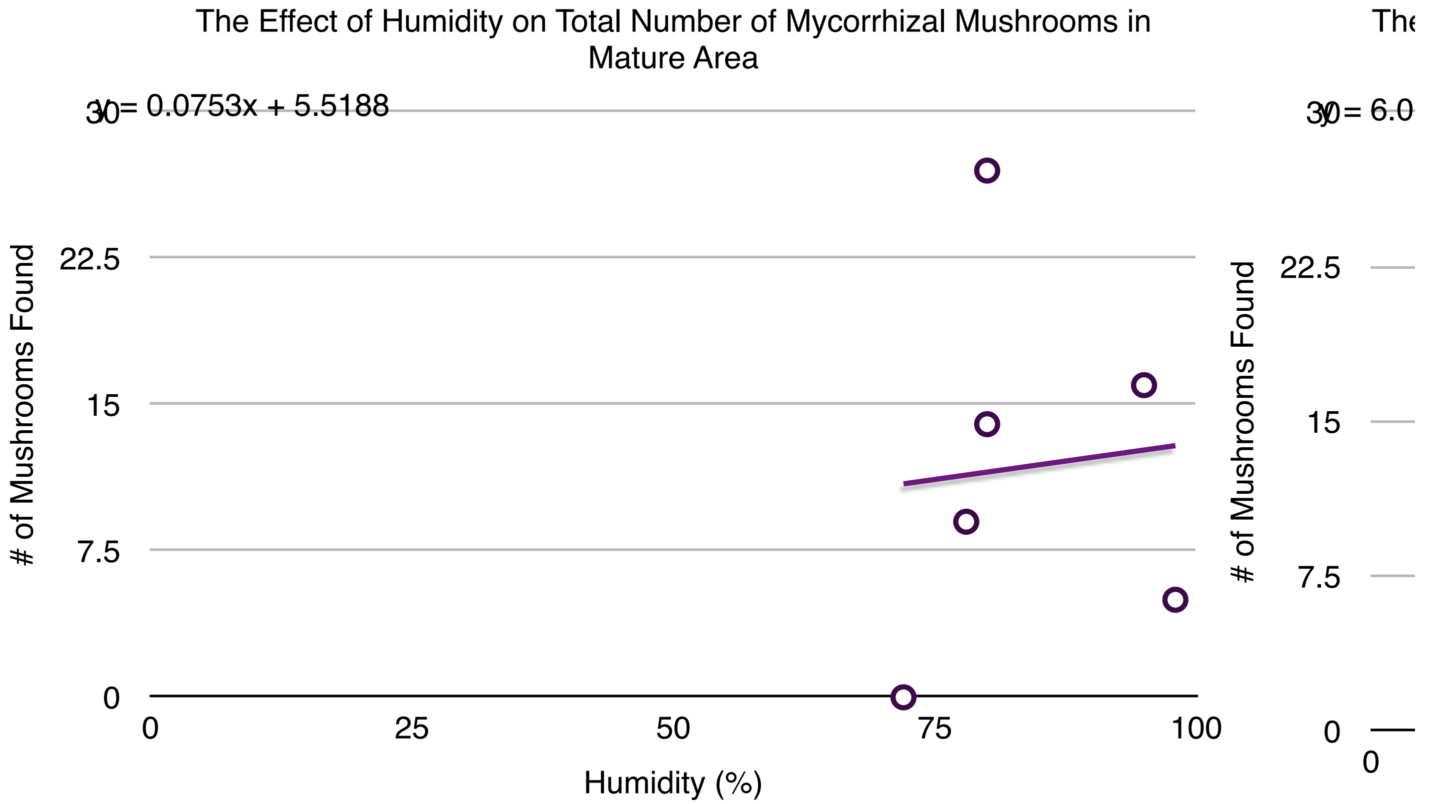
To convert degrees Fahrenheit to degrees Celsius:
$ºC = 5/9 \times (ºF - 32)$

To convert inches to centimeters:
# of cm. = # of in. x (2.54 cm. / # of in.)

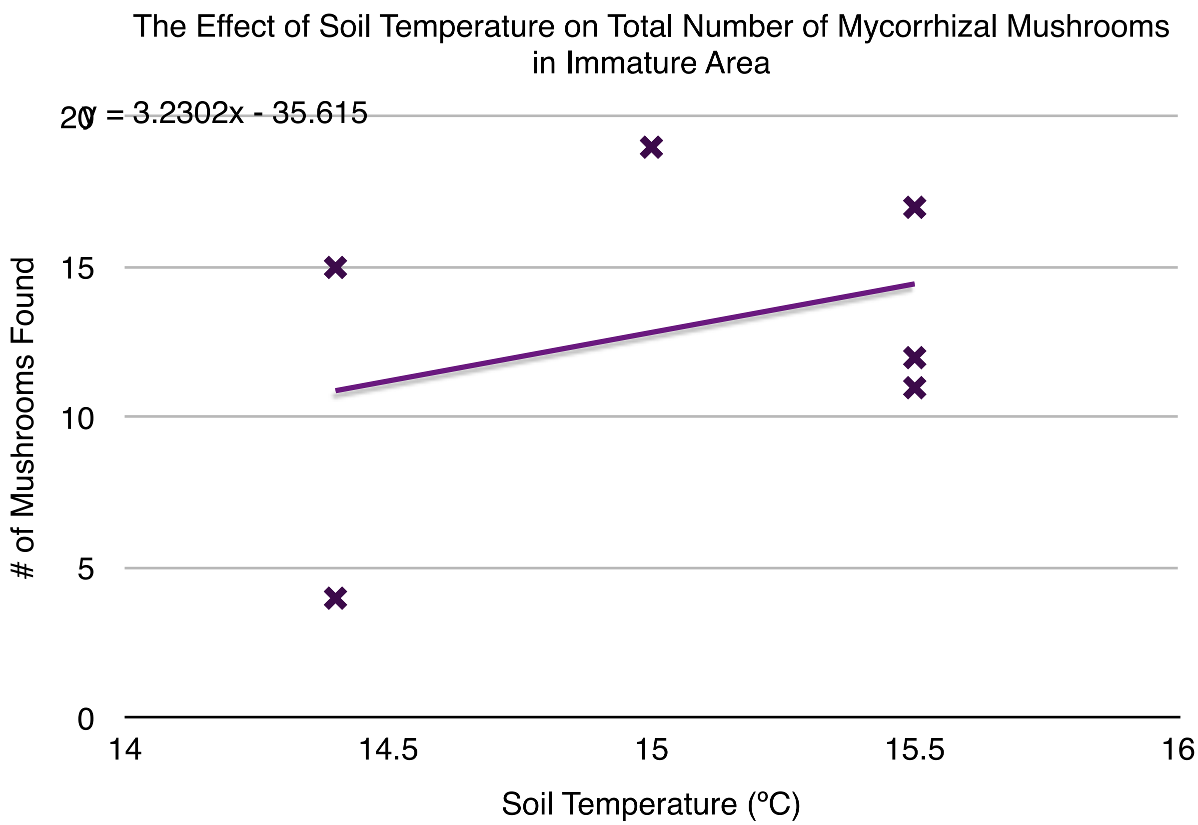
Graphs:



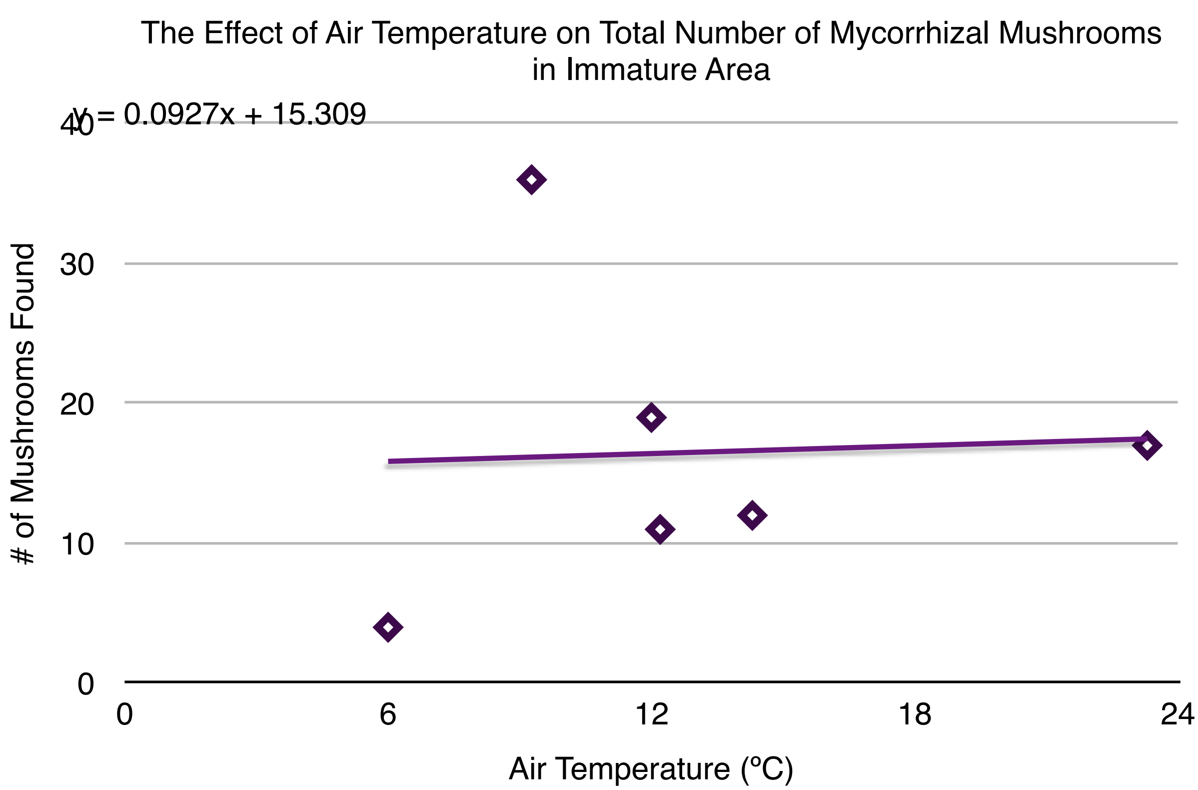




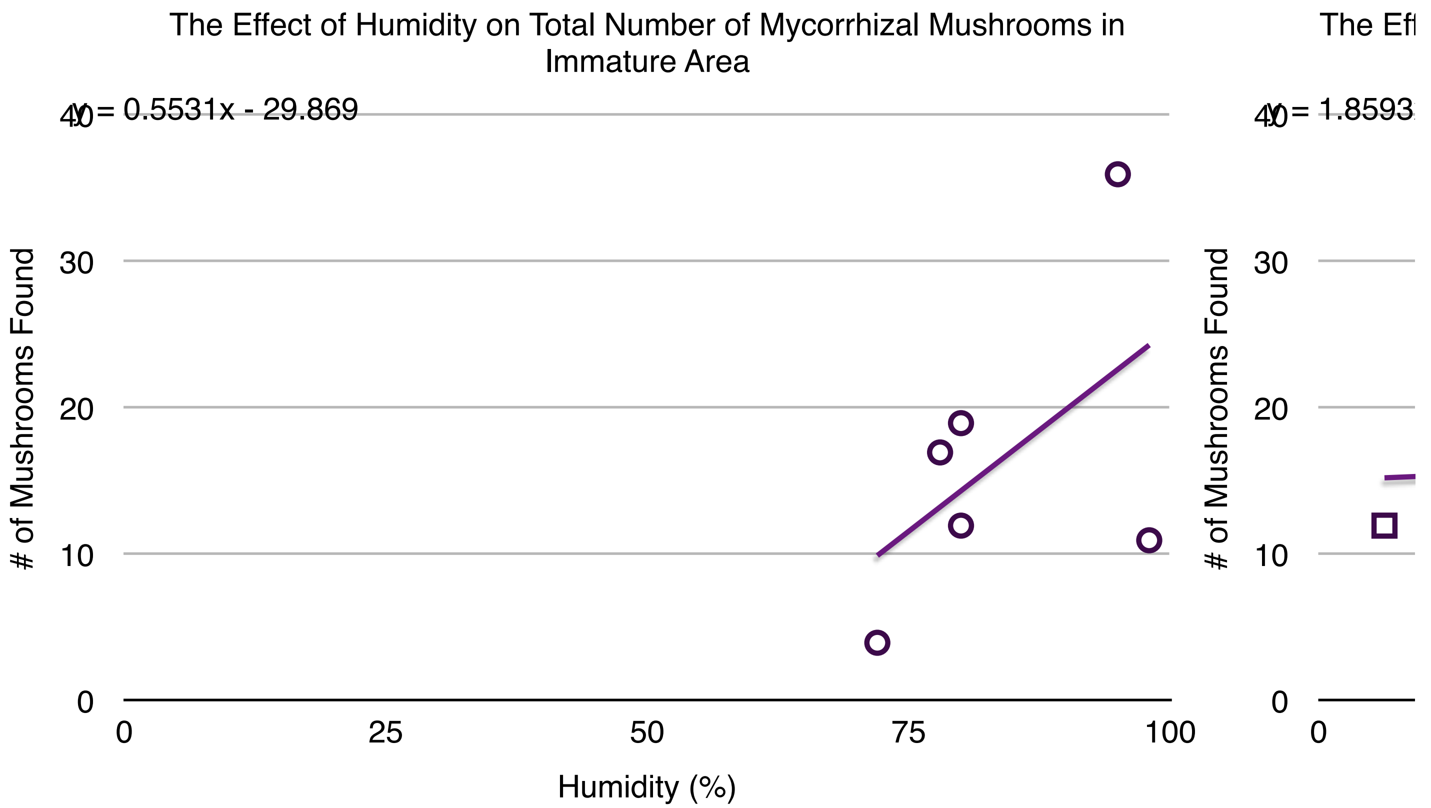
The Effect of Humidity on Total Number of Mycorrhizal Mushrooms in Mature Area
y = 0.0753x + 5.5188
# of Mushrooms Found
Humidity (%)
0
7.5
15
22.5
30
0
25
50
75
100
The
y = 6.0
# of Mushrooms Found

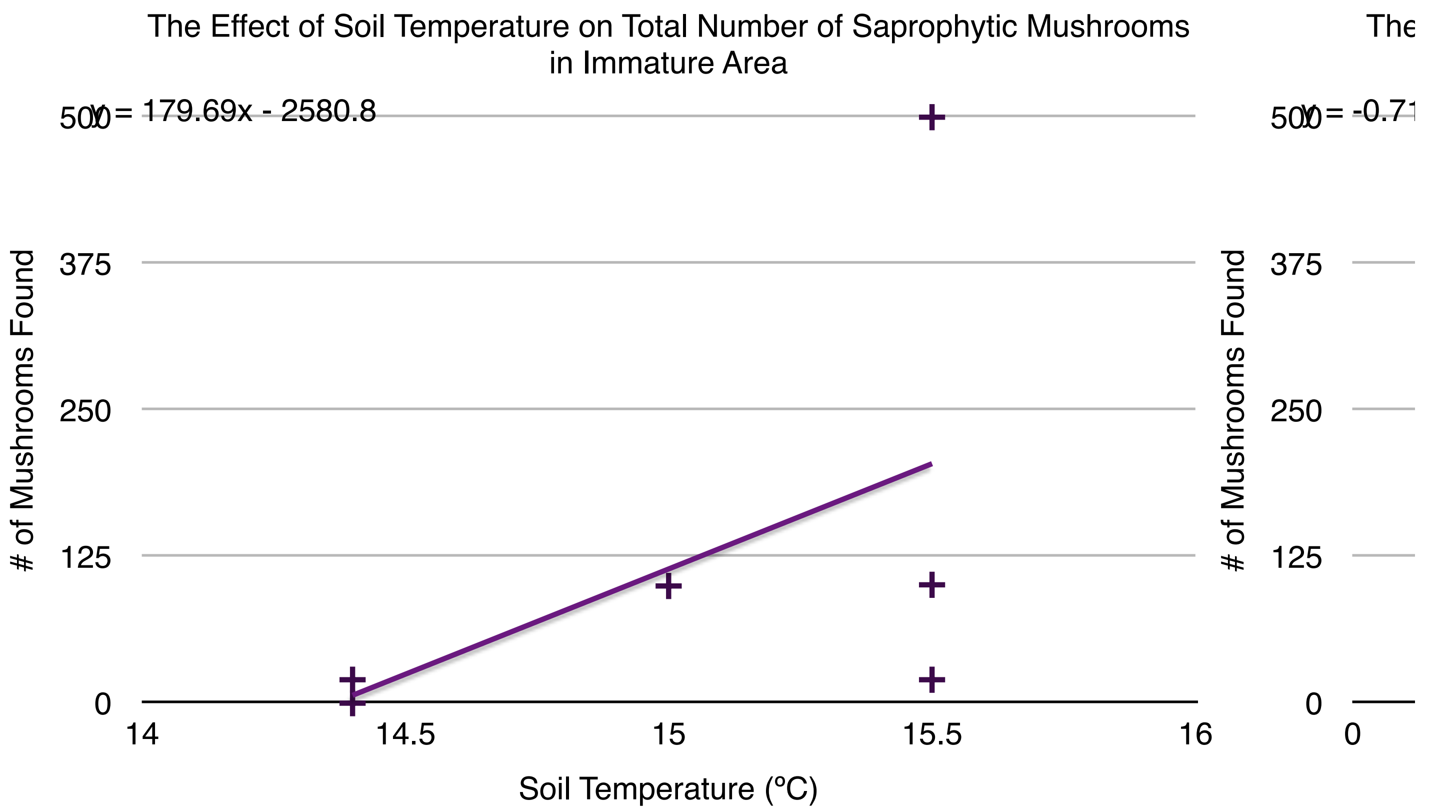


The Effect of Soil Temperature on Total Number of Mycorrhizal Mushrooms in Immature Area
y = 3.2302x - 35.615
# of Mushrooms Found
0
5
10
15
20
14
14.5
15
15.5
16
Soil Temperature (ºC)



The Effect of Air Temperature on Total Number of Mycorrhizal Mushrooms in Immature Area
y = 0.0927x + 15.309
# of Mushrooms Found
0
10
20
30
40
0
6
12
18
24
Air Temperature (ºC)


The Effect of Humidity on Total Number of Mycorrhizal Mushrooms in Immature Area
y = 0.5531x - 29.869
# of Mushrooms Found
Humidity (%)
0
10
20
30
40
0
25
50
75
100
The Eff
y = 1.8593
# of Mushrooms Found
0
10
20
30
40
0



Data Analysis:

For the mature forested area, increases in air temperature, soil temperature, humidity, and weekly amount of rainfall caused corresponding increases in the numbers of mycorrhizal mushrooms found. While there were results that did not follow this general trend in the data - for example, when the soil temperature decreased from 16.1ºC to 15ºC, the amount of mushrooms found increased by 13, which was not in keeping with the rest of the data recorded - on average, both the numbers of mushrooms found and the abiotic factors measured increased correspondingly, as evidenced by the above graphs. For example, the amount of mushrooms found was highest when the soil temperature was 15ºC - which was not the highest temperature recorded, but was within that range - and was at its lowest, zero, when the soil temperature was lowest, at 13.8ºC. Similarly, when air temperature was at its highest, 23.3ºC, the amount of mushrooms found was close but not nearly at its peak, while the lowest air temperature recorded also yielded the lowest amount of mushrooms found. The effects of humidity followed a very similar trend, with its lowest level corresponding to the lowest amount of mushrooms found, and its highest level corresponding to the nearly-highest amount of mushrooms found. However, rainfall followed a different path, its highest levels yielding the nearly-highest levels of mushrooms, but the lowest number of mushrooms only occurring with the second-highest amount of rainfall.

The immature forested area was discovered to show general increases in the growth of mycorrhizal mushrooms with increases in air temperature, humidity, and weekly rainfall. Increases in soil temperature, too, were found in cause corresponding increases in the growth of mycorrhizal mushrooms. This was in doubt initially, however, as there was a data point on the graph comparing soil temperature and the growth of mycorrhizal mushrooms in the immature forest that was much larger than any other. The soil temperature for this point was 14.4ºC, the lowest temperature ever recorded here. However, this number also yielded the highest number of mushrooms ever recorded: 36. This was discovered to be the result of an error. *Armillaria mellea* were found that day in five large clumps, with varying numbers of fruiting bodies per clump. Instead of counting the number of mushrooms as the number of clumps found, the researchers counted the number of individual fruiting bodies. When the graph was adjusted to fit this data, a much more plausible and explainable data point resulted.

Similar to the results recorded in the mature forest, the highest levels of soil temperature, air temperature, and humidity in the immature forest yielded the nearly-highest amounts of mycorrhizal mushrooms, while their lowest levels corresponded to the lowest amounts of mushrooms. Rainfall, however, similarly had its highest numbers yield the nearly-highest amounts of mushrooms, but its lowest numbers only gave the nearly-lowest amounts of mushrooms, not the absolute lowest.

In the mature forest, only one saprophytic mushroom was recorded in the entire six weeks that the plots were checked, and could therefore not be represented by a graph. However, there were enough saprobes found in the immature forest to warrant a graphical representation of them. The graphs of the saprobes are very different from those of the mycorrhizal mushrooms; the number of samples found increased rapidly with increases in soil temperature and humidity, and actually began to decrease with increases in the other abiotic factors, weekly rainfall and air temperature.

Conclusions:

The majority of mushrooms found and recorded in both forests were mycorrhizal. There were very few parasitic and saprophytic mushrooms found in the immature area, but there were even fewer found in the mature forest; there was only one saprophytic mushroom recorded in the mature forest in the six weeks the areas were under observation, and was only recorded then because no other specimens could be found. However, just because saprophytic mushrooms were only recorded once in the mature forest does not mean that they were found only once. There were several occasions in which saprobes were found on rotting logs or stumps, but could not be specifically identified and were discarded, as the types of trees in the area had no bearing on their growth, and the entire point of this lab was to study the effects of mature compared to immature trees on the growth of mushrooms. However, the fact remains that, even with the numbers of saprobes found aside, there was certainly a greater diversity of saprophytic and parasitic mushrooms found in the immature forest compared to the mature forest. *Gymnopilus penetrans* were found in both areas, but other saprobes such as *Marasmius capillaris*, and a parasite known as *Armillari mellea*, or "Honey mushroom", were found only in the immature forest.

According to the trend lines shown on each of the graphs for the mature forest, rainfall, out of all four of the abiotic factors tested, seemed to have the greatest effect on mycorrhizal mushroom growth. The slope of its trend line, or best-fit line, was just over six. Soil temperature had the second-greatest effect, with its trend line at a slope of 1.875. Air temperature had the third-greatest effect, with a slope of 0.1813, and humidity had the least effect of all four factors, with a trend line at a slope of only 0.0753. In the immature forest, however, the slope of the trend line for soil temperature, 3.23, was the greatest of all four abiotic factors, even though it was actually initially believed to have a negative effect on the growth of mycorrhizal mushrooms (see Data Analysis for explanation for this). Rainfall was next, with a slope of about 1.8593, and humidity had the third-greatest effect, with a slope of only 0.5531. Air temperature had the least effect on mushroom growth, with a slope of only 0.0927.

Although predictions of the abiotic factors that would have the greatest, least-greatest, and so on, effects on mycorrhizal mushroom were not made in this particular lab, a general prediction of their effects was. The researchers' hypothesis stated that increases in all abiotic factors under study in this lab - the amount of weekly rainfall, and current humidity, soil and air temperature - would cause corresponding increases in the number of mycorrhizal mushrooms found, and this was correct. Every one of the graphs comparing mycorrhizal mushrooms to each of the abiotic factors for both forest areas had positive slopes, showing that as the abiotic factor increased, more mushrooms were found. Although there were outlying points and points not in keeping with the rest of the data collected, the general trend of the data was positive for every one of the graphs, and therefore was also in support of the researchers' hypothesis.

Though not discussed in the hypothesis, and rendered unnecessary in the procedure, large and obvious growths of saprophytic mushrooms were recorded, when they could be found, in the immature forest area. In contrast to the graphs of mycorrhizal mushrooms, which were very constant and in keeping with the hypothesis, the slopes of the graphs for saprophytic mushrooms in the immature forest were extremely varied. Soil temperature by far had the greatest effect on the growth of saprobes; the slope of its graph was just over 179. Humidity had the second-greatest effect, with a slope of 12.139, and air temperature had the third-greatest effect, actually causing a slight decrease in the growth of mushrooms with a slope of -0.7111. Rainfall had the least effect out of all the abiotic factors tested; with a slope of -25.098, it caused rapid decrease in growth of mushrooms as it increased, suggesting that saprobes prefer drier conditions.

Many possible sources of error in this lab have already been mentioned in the <u>Observations</u> section, and include the falling of leaves and needles in the autumn that coated the ground and possibly obscured mushrooms from view, and the fact that the borders of the plots were not clearly and obviously marked - there were only small tags on branches to mark the borders, that were difficult to see and difficult to discern the exact line between - often making it difficult to determine whether or not a mushroom was within the boundaries of the area. The roots of the mature forest are also extended far beyond the boundaries of the plot, and as mycorrhizal mushrooms grow near or over the roots and bases of trees, and depend on trees for survival, the majority of mushrooms in that area were found without the borders. The soil temperature was as accurate as it could be; a large thermometer was used, so it was relatively easy to discern where the needle fell between notches, and was therefore relatively easy to get an accurate reading. The measures of weekly rainfall were also as accurate as possible, as they were taken from the weather station at the Cathance River Preserve. However, the measures of air temperature and humidity may have been the source of some mild errors. These were also taken from the Cathance River Preserve's weather stations, and the accuracy of these is not doubted. However, the exact time that the plots were checked was needed to gain an accurate measure of temperature and humidity, and an exact time was not always available; the general range of time in which the researchers visited was always known, but the time down to minutes was not. There may have been slight errors in the measures of air temperature and humidity as a result of this, but these most likely did not have a profound effect on the results, as it was simply a matter of recording 98% humidity as opposed to 95%, for example. Another possible source of error could have included the fact that the amount of sunlight reaching the forest was uneven, particularly between the two areas. The immature trees had been planted, or at least grew, fairly close to each other, shading most of the forest floor for most of the day. In the mature forest, although the branches are bigger and there are more leaves, the trees were less densely packed, so more sunlight reached the ground. This difference in sunlight may have been a factor in the number and kind of mushrooms collected and identified.

The error mentioned in the data analysis above concerning the recording of four mushrooms one day and 36 the next, even when the soil temperature remained the same, was not exactly an error, per se. It was simply the fact that *Armillari mellea*, or "Honey" mushrooms, were found for the first time that season on the day that 36 samples were recorded. These mycorrhizal mushrooms grow in clusters of around seven-to-ten, each of which originates from one single fruiting body. Counting a cluster of seven "Honey" mushrooms as seven separate mushrooms is therefore the incorrect way of going about this; a more accurate method would be to count the clusters themselves, instead of the individual mushrooms within them. When the fruiting bodies were counted as opposed to the individuals, the number of mushrooms found that day was much lower, more in keeping with the rest of the data, and much more explainable.

A final source of error occurred in the graphs of the saprophytic mushrooms. Only two types of saprobes were found during the entire study at the Cathance River Preserve: *Gymnopilus penetrans*, and *Marasmius capillaris*. The former was not the source of error in this case; they grow singularly on rotting logs or stumps, and were recorded whenever they were found without difficulty. The latter, however, is a saprobe that grows differently than any other mushroom found in either the immature or mature forest area during this study. *Marasmius capillaris* are mushrooms about the size of a fingernail, and grow in clusters of tens-to-hundreds on the forest floor. Unlike mycorrhizal mushrooms, they do not depend on the roots of trees to grow, nor do they depend on rotting logs or stumps as saprobes such as *Gymnopilus penetrans* do. Instead, these mushrooms grow off of the leaf litter on the forest floor. There were far too many to get very accurate measures of their numbers, so estimates were recorded instead. Similar to the problem mentioned above regarding the clustered growth of *Armillari mellea*, *Marasmius capillaris* cannot be counted by the number of individual mushrooms that sprout above the soil. They should be counted by cluster, and as this was not done, numbers such as 100 and 500 were added to the graphs, which severely affected the trend lines and therefore the results.

One suggestion for improvement or change to the procedure of this experiment, if done again, would be that the boundaries for the area being studied to be broader by about 10 more feet. This would help to factor in the long roots of the mature forest trees, which was a common source of error in this particular lab, as mentioned above. Another possible change to this experiment would be to focus on how specific abiotic factors have an effect on different categories of mushrooms other than mycorrhizal; for example, how rainfall and soil temperature have an effect on saprophytic mushrooms, or parasitic. In the lab previous to this one, the effects of hardwood compared to softwood trees was studied, while the difference between mature and immature forested areas was studied in this particular lab. The effect of low-ground versus high-ground on the growth of mushrooms could also be studied in later years, as well as open and sunny areas compared to shady and tree-covered areas. One final addition to the procedure of this study, if done again, is that soil samples could be taken to find the nutrient concentration and specific levels in areas where there are mushrooms present, as well as where mushrooms are not present and hypothesize which nutrients are ideal for mushrooms and in what levels.