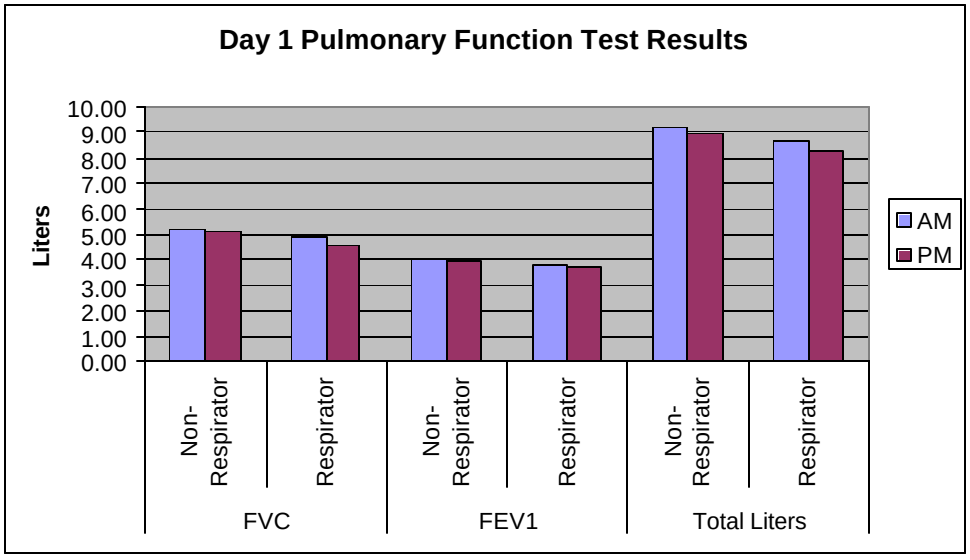
Table 9: General Pulmonary Function Results

	Normal	Restriction	Obstruction
Day 1 Morning (8 participants)	4	1	3
Day 1 Evening (8 participants)	6	0	2
Day 2 Morning (7 participants)	5	1	1

The normal reading may be misleading for it takes into account the number of years that the participant has been smoking, if relevant, and the adjusts the "normal" value for that individual. On the spirometry read-out it offers an approximate "lung age" for smokers and then based on that age assigns a general interpretation of normal, detection of restriction or obstruction. Four of the 15 normal readings were assigned a corresponding lung age based on the level that the user smokes.

Table 10: Day 1 Pulmonary Function Results



In Table 10, it is observed that all groups decreased from pre to post shift pulmonary function when comparing the best, or highest, value for FVC, FEV1, and Total Liters. Even though there is a decrease across all categories in Table 10, it is clear from the Table 9, it can be derived that the participants' pulmonary function improved

resulting in more normal readings in the afternoon. One reasonable explanation for the improvement from pre to post PFTs was a learning curve occurred within the participants' ability to perform the test properly. Only one of the participants had experience taking a pulmonary function test at a different employment institution. If this learning effect was in fact why the participants' PFTs improved, then the second day of pulmonary function tests are probably a more accurate read on the crews' actual pulmonary ability. Also, it is important to note that the 8 participants on the first day are not the exact same group of individuals tested on the second day.

4.6 Fungal Spore Exposure

The analysis to determine the amount and type fungal spores that had accumulated on the poly carbonate filters during this study was executed by the Environmental Analysis Associates, Inc. The pumps were set to an airflow rate of one liter per minute, which was the airflow selected in other studies including one performed in Sweden with farmers (Malmberg et al., 1993). The farmers were being observed for their response to microorganisms exposure much like this study.

The first day of data collection there were only three pumps that were running throughout the shift. The average total mold spore count among the three participants was 2866.56 CFU per cubic meter on the first day of data collection. On the second day of data collection, seven pumps were running on participants collecting exposures. Many of the exposures on the first day were found again on the exposures for the second day. A summary, including means and standard deviations, of the total exposures spanning across both days is as follows:

Table 11: Spore Counts per Meter Cubed

	Mean	Standard Deviation
Total Mold Spores (cts/m^3)	1264.20	606.11
Alternaria	83.50	12.87
Aspergillus/Penicillium-types	109.00	45.00
Ascospores	122.50	66.71
Basidiospores	58.63	23.00
Botrytis	16.00	1.00
Cladosporium	632.20	363.03
Epicoccum	33.00	8.69
Nigrospora	23.40	3.75
Pithomyces	22.67	5.67
Rusts	20.60	3.85
Smuts/Myxomycetes	168.44	84.04
Stachybotrys	18.00	0.00
Torula	17.00	0.58
Trichocladium Uniseptatum	17.00	0.00
Pestalotia	95.00	0.00
Other Hyaline Fungi	165.25	81.62
Other Brown Fungi	118.70	52.43
Small Brown Round	44.33	14.95
Hyphae Fragments	525.70	126.31
Algal Spores	34.50	0.50

Table 12: Total Colony Forming Units per Meter Cubed

	Mean	Standard Deviation
Total CFU/m3	1227.38	678.22
Acremonium	57.50	19.05
Alternaria	277.00	0.00
Aspergillus fumigatus-like	63.67	26.85
Aspergillus species	63.67	26.85
Aureobasidium	15.00	5.00
Botrytis	109.33	83.87
Cladosporium	756.88	510.22
Curvularia	10.00	0.00
Drechslera/Bipolaris	10.00	0.00
Paecilomyces	218.33	158.92
Penicillium	99.00	28.48
Rhodotorula	20.00	0.00
Unidentified Asomycete	10.00	0.00
Yeast-like	38.00	15.81
Sterile mycelia	74.67	39.36

The difference in the two measures of colony forming unit (CFU) and counts (cts), both per cubic meter, is that the cts takes into account both alive and dead spores and CFUs are just live spores. Initially, the laboratory determined the number of counts per cubic meter when the samples were received. Once the cts for the samples were recorded the samples were then observed for growth of live spores. The observations were designated as CFUs. For this study both were relevant numbers, for both live and dead spores may cause respiratory irritation and may trigger allergic responses in an individual. Spores that are alive are more invasive and some can cause infection, where as the dead spores are simply annoyances to the immune system generating allergic response to remove the dead spores from the body.

In an article published in 2000, by Robbins, Swenson, Neally, Gots, and Kelman, a critical review was performed of the health effects associated with many of the mycotoxins of fungi found in this study of landscape workers. The article touches on *Aspergillus*, *Fusarium*, *Stachybotrys chartarum*, *Memmoniella echinata*, *Penicillium*, and *Alternaria* and how these select mycotoxins can affect the body (Robbins et al., 2000).

In this critical review one study by Malmberg, found that the exposure to airborne fungi must be in the range of 10^{10} spores/m^3 in order to generate an acute effect in humans. Levels in this landscaping study were not in that range for any of the fungal spores that were found present in the participants' breathable space (Robbins et al., 2000).

4.6.1 Aspergillus

The *Aspergillus* species have different levels of toxicity, mainly *A. flavus, A. niger,* and *A. parasiticus* are the more harmful. The samples from both days do not show any quantifiable exposures to *A. flavus* nor *A. niger,* which the laboratory did look for. The days of data collection were too cool for the *A. flavus* to grow and thrive, so the lack of this species was expected. *A. flavus* requires temperatures in the high seventies to middle eighties in order to grow (Robbins et al., 2000).

Aspergillus fumigatus was found on the samples with a measure of 60 CFU/m^3 on the first day and 1.4 CFU/m^3 on the second day. The differences in the amounts observed on the two different days may be dependent on the manner in which the wood mulch had been stored. The species of *aspergillus* is linked to respiratory irritation and allergies (Flannigan et al., 2001). In a grain dust study published in 1974 a link was established between what they called 'house dust' or *aspergillus fumigatus* and asthma in individuals with a previous heighten sensitivity (Warren et al., 1974).

Aspergillus produces mycotoxins called aflatoxins were are known culprits to many animals including humans. Aflatoxins are described as "…acutely toxic, immunosuppressive, mutagenic, teratogenic and carcinogenic…" (Peracia et al., 1999). These aflatoxins can be found at low levels in many foods (i.e. peanuts; wheat; in products from animals, such as milk and eggs, that have ingested aflatoxins from contaminate feed). Other than ingesting contaminated food sources, another route of entry is inhalation. When these mycotoxins are inhaled at significant levels and duration the primarily cause teratogenic and carcinogenic effects in the animal. The liver is the most targeted organ for the cancer to afflict. Also, those that suffer from liver cancer due to exposure tend to develop hepatitis B (Robbins et al., 2000).

4.6.2 Stachybotrys

On the second day of data collection 2.6 cts/m^3 were found on average across all workers, but when looking at the raw data (Appendix C) it is noted that only one of the filters tested positive for *stachybotrys*. On that one filter, there was a count of 18 per cubic meter. In a study to learn more about the effects of inhaling mycotoxins, mice were used and exposed to *S. chartarum*. There was not any inflammation in the mice that were exposed to 10^3 number of spores of a weak strain of *S. chartarum*. Exposure to the harsher strain in the study with mice, the 10^3 number of spores caused some inflammation is the respiratory system of the mice. The levels in this landscaping study are substantially less and based on the study involving mice, the exposure probably did not cause an acute respiratory response in the landscape workers (Robbins et al., 2000).

Stachybotrys is commonly found in agriculture settings where there is the presence of moldy straw, but can also be found in other industries. Humans that are exposed to a significant amount of *stachybotrys* suffer from respiratory difficulty, fever, and sinus irritation (Robbins et al., 2000). Michael Gray is a medical doctor that has established a database of patients from 1987 to present time who have been exposed to and suffering from mold toxicity. Through his work he has determined that fungal spores like stachybotrys are confirmed to cause airway obstruction in individuals exposed to a significant amount of the fungal spores for their respiratory system (Gray, 2002).

4.6.3 Penicillium

Throughout the first day there was an average measure of 72.7 cts/m^3 *Aspergillus/Penicillium* type molds found across the three working pump filters. As for colonies formed from the first day filters on the first dilution is 29.7 CFU/m^3 and on the first dilution on the samples from the second day of data collection the average measure across the samples is 58 CFU/m^3. The ailments most closely associated with *penicillium* exposures are teratogenic effects. There are also some animal studies that suggest that exposure can cause liver damage is humans (Robbins et al., 2000).

4.6.4 Alternaria and Cladosporium

There was an average of 83.3 cts/m^3 of *alternaria* observed on the samples from the samples from March 17th and 92.3 CFU/m^3 after the first dilution. On March 28th the average measurement for cts/m^3 was 59.7 and after the first dilution an average of 32.9 CFU/m^3. *Alternaria* is known to generate an allergic response in some exposed individuals, but is not conclusively associated with other diseases (Robbins et al., 2000).

Cladosporium much like *Alternaria*, is an airborne conidia and commonly found outdoors. On the March 17th the filters collected 1891.7 cts/m^3 (1704.7 CFU/m^3) versus March 28th when only 92.4 cts/m^3 (134.4 CFU/m^3) were collected, which is unusual since the airborne numbers tend to decrease after it rains. *Cladosporium* is a known allergen and can aggravate asthmatic conditions in individuals suffering from asthma (Alexopoulos et al., 1996).

4.7 Endotoxin Exposure

Aerotech Laboratories, Inc. was employed to analyze the samples for endotoxins. The Kinetic Chromogenic method was used to determine the level of endotoxin that the workers were exposed to during there shift. The complete analysis can be observed in Appendix D of this paper.

The endotoxin exposures from the first day were minimal. Only one of the three functioning pumps showed any accumulation of endotoxin and that amount was small. This lack of accumulation may be due to the moisture in the air and the wet mulch suppressing the dust from the mulch.

On the first day of data collection only one filter proved positive for endotoxin exposure. The exposure that the individual experienced was 1.58 EU/m^3 (2.74 EU/filter). The average measurements from March 28th are summarized the table below:

Table 13: Endotoxin Exposure

	Average
EU/Filter	3.96
EU/cubic meter	2.68

Cassette P3-E contained a filter spacer instead of a filter and is not considered in the calculations