

The Chatfield Mushroom Degradation Trial –

The largest demonstration of fungal remediation in the US to date

- Jeffrey Ravage, CUSP, COCO



HISTORY- In the spring of 2020, the Coalition for the Upper South Platte (CUSP), Coalitions and Collaboratives (COCO), Denver Botanic Gardens (DBG), the Chatfield Storage Reallocation Project, and the Colorado Mycological Society (CMS) jointly began a test of industrial scale fungal remediation at the Denver Botanic Gardens Chatfield Farms. With the consent of the Army Corps of Engineers, this project deposited ~81 tons of wood chips in a large windrow, 100 meters in length. CUSP’s North Fork Watershed Coordinator, Jeff Ravage, used his then experimental technique of fungal degradation (Ravage and Czaplicki 2020) to attempt the wholesale decay of this massive pile. Work the previous winter at CUSP’s facilities and at the labs at Mile High Fungi in Conifer, Co, had trained and amplified 50 bags of natively collected wood rotting mushrooms. This mushroom spawn was inserted into the pile with the help of dozens of volunteers from the Denver touring company of “Up with People”, as well as members of the CMS and other interested persons. Thus, began the largest test of myco-remediation at the time in the United States.



Monitoring at Chatfield

The pile was monitored for three- and one-half years to measure progress and document the chip’s progress. This report chronicles the results.

METHODS- Wood for the pile came both from the Chatfield reallocation project (Cottonwood) and from a post and pole mill in Evergreen, Colorado (Ponderosa and lodgepole pine). The Chatfield chips, by-products of a massive project to raise the shoreline of the Chatfield reservoir, had been inadvertently mixed with large amounts of dirt, the one contaminant that could stop wood-rotting mushrooms from doing their job. These deliveries were regrettably stopped and only the pure wood from Evergreen was considered for this experiment.

When the pile was constructed, steel spikes were driven into the ground every ten feet to mark data collection points. There were 22 spikes placed along the 210' of un-contaminated pile. Measurements of pile height and width were made at each point, once a year for the following years. Samples of the raw woodchips were taken to measure baseline friability, the chip's structural strength when rubbed against a standard ¼" screen, and the chip's chemical characteristics. These samples were also used for archival and chemical analysis.

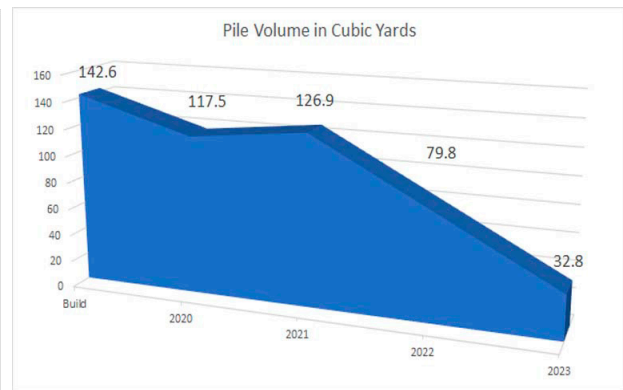
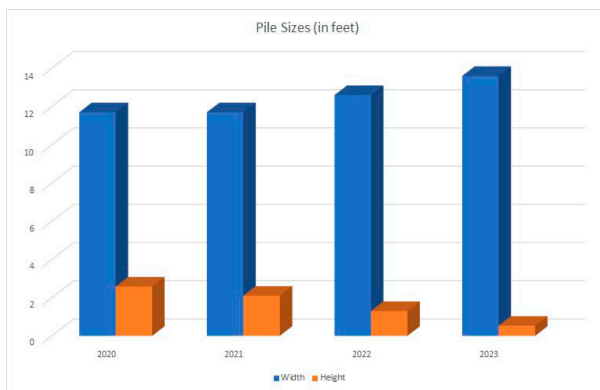


Pile Before



Pile After

RESULTS- The initial pile measurements were 210' in length with an average width of 11.7' and average height of 2.58'. The bulk volume was 142.6 cubic yards, with an estimated weight of 81 tons. The final measurements showed an expanded width of 13.6' and an average height of 0.53'. This equates to 32.8 cubic yards and approximately 12.4 tons. The pile had experienced an average 77% reduction in volume, and an 85% reduction in mass.



We use friability as a proxy measurement of decay. Friability is tested by a simple screen test. One volumetric liter of substrate was agitated against a ¼" screen for two minutes. The resulting material was measured as the fraction that passes through the screen versus the amount that is

retained (too tough to be abraded). Test of the sample wood chips retained over 86% of the material and passed just over 13%. This was our baseline measurement. Our finished compost passed between 86% and 98% of the material (n=6).



DECOMPOSITION BY SPECIES-

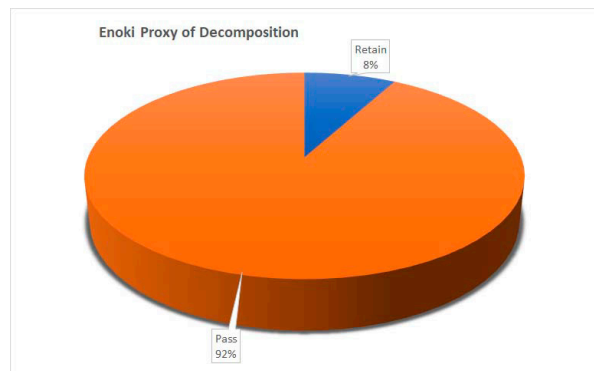
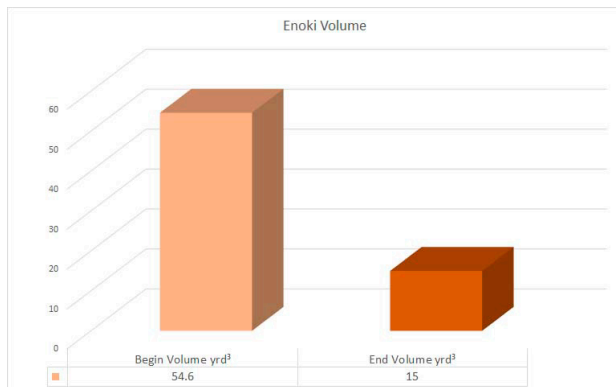
This test used four species of locally collected, lab conditioned mushrooms. All results are calculated using the base relative density of raw wood chip of 0.677, as measured on delivery. Each individual species has differing specific densities as noted in their section. These densities were standardized and carbon densities were calculated in terms of bone dry tons.

←210' →

North ←46' →	←49' →	←58' →	←58' → South
Flammulina velutipes	Trametes versicolor	Ganoderma applanatum	Pleurotus ostreatus
Enoki	Turkey tail	Artist's Conk	Oyster mushroom
Bags @ 3.5' on center	Bags @ 3.7' on center	Bags @ 4.8' on center	Bags @ 4.8' on center

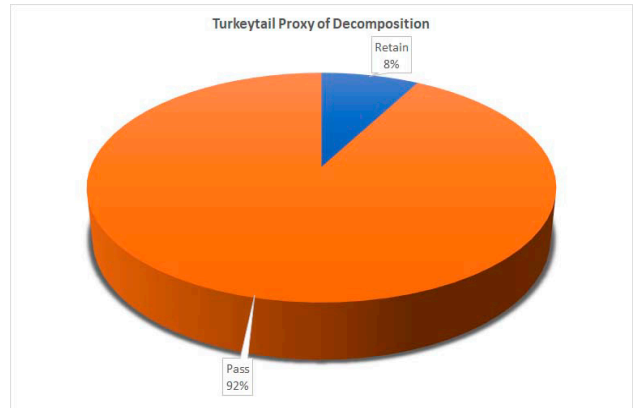
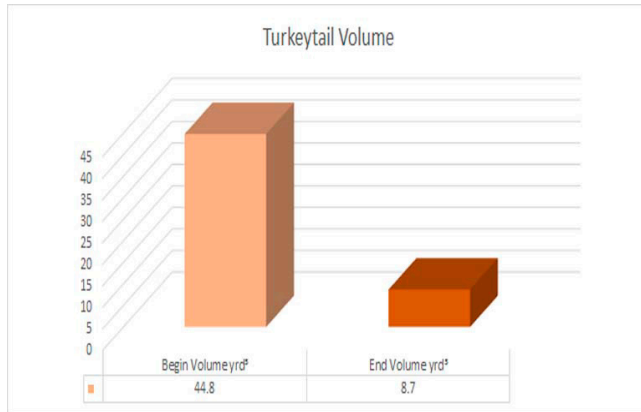
Chatfield pile layout as built

.Flammulina velutipes -the Velvet foot mushroom aka, Enoki (Strain designated: Fvelu2020CUSP01-WC) -collected in Fort Collins, Colorado. Enoki is a white-rotter.ⁱⁱ Post decay compost standard density: 0.231



In this test run, the Enoki achieved a 72.60% reduction in pile volume and a 91% reduction in mass. Its segment had a starting length of 46' ft, a height of 3.3' and a width of 15.1'. The end measurements were 46' in length, 0.94' in height and 14.1' in width on average. The estimated starting weight was 31.1 tons, with an ending weight of 2.91 tons.

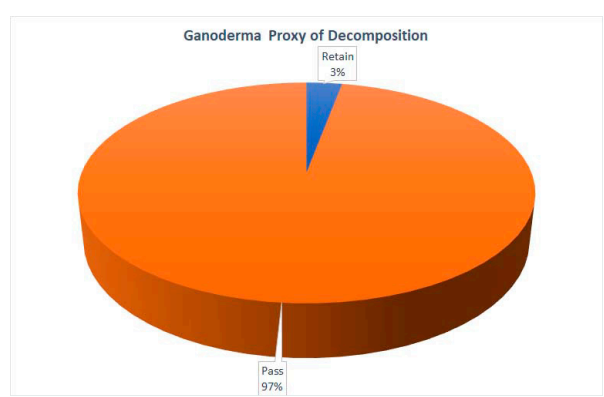
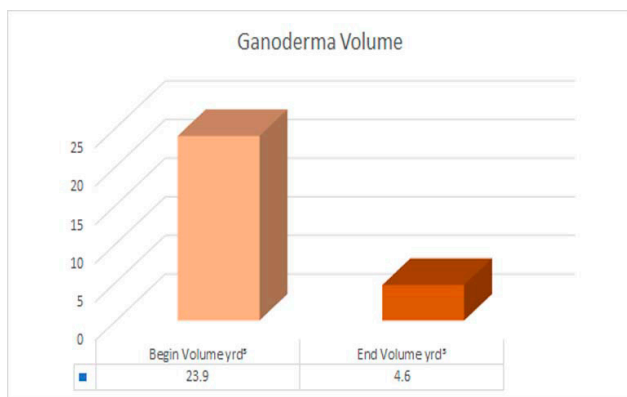
Trametes versicolor -the Turkey tail mushroom (Strain designated Tversi2019CUSP01-WC) - collected in Lakewood, Colorado. Turkey tail is a white rotter. Compost standard density: 0.393



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In this test run, the Turkey tail achieved an 81% reduction in pile volume and an 89% reduction in mass. Its segment had a starting length of 49' ft, a height of 2.72' and a width of 12.9'. The end measurements were 49' in length, 0.41' in height and 14.3' in width on average. This segment began with a weight of 25.5 tons and finished at 2.9 tons.

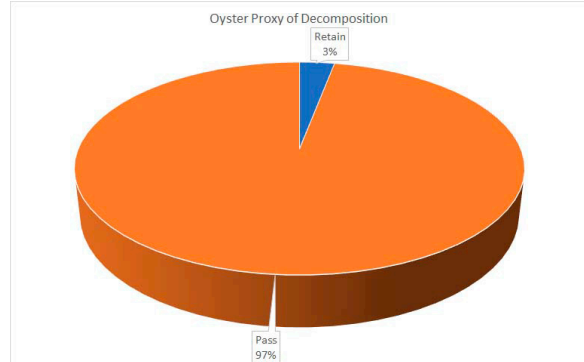
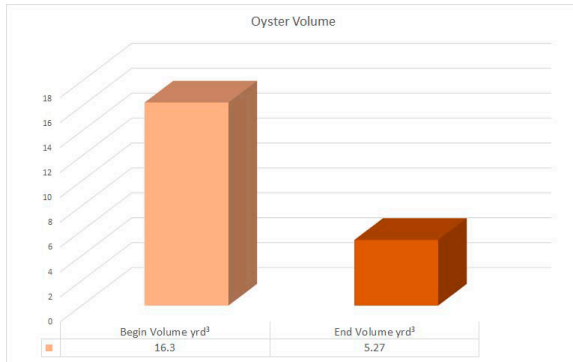
Ganoderma applanatum -the Artist's bracket mushroom (Strain designated: Gapp2021CUSP01-WC) -collected near Conifer, Colorado. The Artist's bracket is a brown rot mushroom.ⁱⁱⁱ Compost standard density: 0.367



In this test run, the Artist's conk achieved an 81% reduction in pile volume and a 90% reduction

in mass. Its segment had a starting length of 58' ft, a height of 2.1' and a width of 10'. The end measurements were 58' in length, 0.35' in height and 12.7' in width on average. The starting weight was 13.6 tons and ending weight was 1.4 tons.

Pleurotus ostreatus -the Oyster mushroom (Strain designated: Post2019CUSP01-WC) - collected near Conifer, Colorado. Oyster mushrooms are white rotters. The compost standard density: 0.379



In this test run, the Oyster achieved a 77% reduction in pile volume and an 88% reduction in mass. Its segment had a starting length of 58' ft, a height of 1.9' and a width of 8'. The end measurements were 58' in length, 0.39' in height and 12.6' in width on average. The starting weight was 10.9 tons and the end weight was 1.4 tons.

CONCLUSIONS- Unattended piles of woody waste can linger in Colorado's mountainous climate for 20 to 50 years (Wagener 1972). The speed at which we can remove this material from the fire cycle and return it to the soil cycle is the primary goal of our investigations. This is our fourth test of fungal decomposition in a forestry or remediation context. It is our second trial with industrial levels of tonnage. This pile would represent the waste material generated by 10-20 acres of forest mitigation.

Our best performing strains were the Turkey tail and the Artist's conk. The Ganoderma is the only species that is a native rotter of conifers. Turkey tail and Enoki are generally found on hardwoods, and the Oyster is a denizen of cottonwoods. We have continually demonstrated the ability of lignicolous saprophytes (wood rotting mushrooms) to cross over to different wood types when properly pre-conditioned. These results are completely consistent with our previous findings. Trained wood rotting mushrooms can rapidly decompose forestry waste and convert it into a valuable soil amendment. Our work will continue in partnership with CUSP and COCO as we move directly into the implementation phase. We are accepting inquiries for projects for 2024 and 2025 at this time. We are also now experimenting with the carbon capture potentials of this technique as well as expanding into post-fire and petroleum-based pollution scenarios.



Decomposed woodchips (mushroom compost)



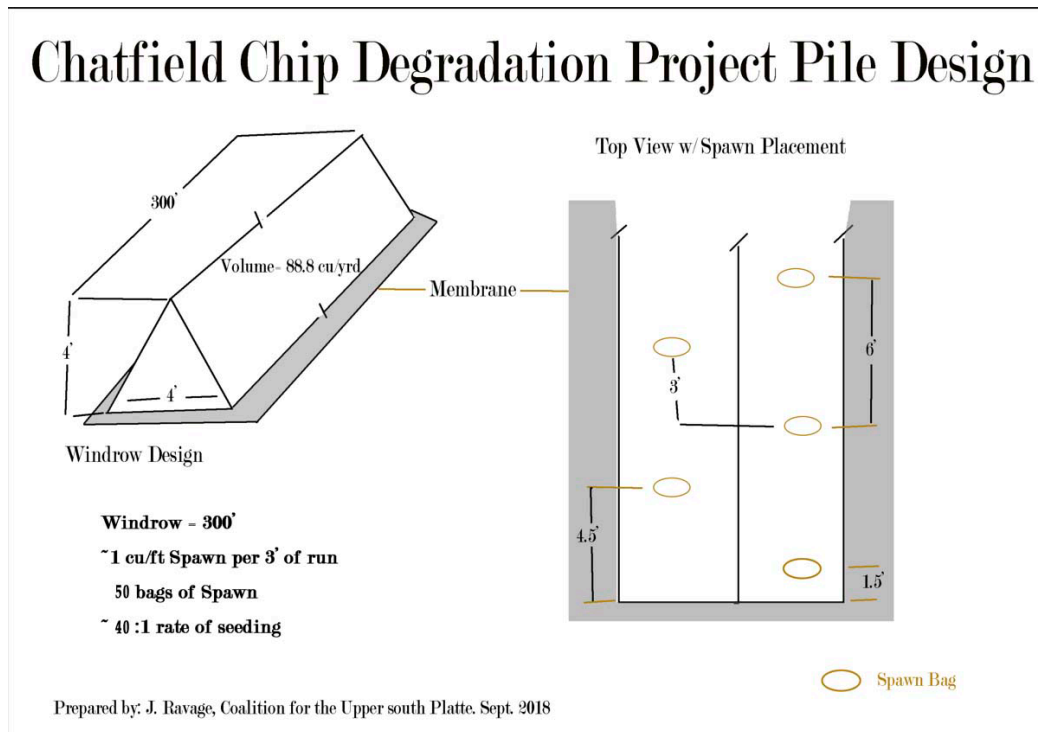
Mycelial bonding of wood chips

Many thanks to all the organizations involved: CUSP, COCO, DBG, the Chatfield reallocation team, Colorado Mycological Society, Jefferson County Open Space, Mile High Fungi, Aurora Water, Up with People, and the nearly 100 volunteers who have helped at some stage in this project.



Up with people volunteers

Appendix One Design Drawings.



Citations:

Ravage, Jeffrey, and Lauren C'zaplicki. 2020. "The Fungal Degradation of the Woody By-products of Forest Management Activities." *cusp.ws*. https://cusp.ws/wp-content/uploads/2023/03/FungalDegradation_RG_prepub..pdf.

Wagener, W. 1972. *Logging slash: it's breakdown and decay at two forests in northern California*. Berkeley, Ca: Pacific SW. Forest & Range Experimental Station, USDA Forest Service.

ⁱ All measurements for this project were made using the metric system. They have been converted in this paper for a wider audience.

ⁱⁱ White rotters consume primarily lignin in the wood, leaving behind the white strands of cellulose.

ⁱⁱⁱ Brown rotters consume cellulose leaving behind the lignin. This is the characteristic cuboidal brown rot often seen in the forest.