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THE FOREST GRAVEYARD: THE IMPORTANCE OF DEAD TREES, BARK, AND WATER

Anna Klamerus-Iwan[1*], *Ewa Błońska*[2], *Jarosław Lasota*[2] *and John T. Van Stan*[3]

[1] *Department of Forest Utilization, Engineering and Forest Technology, Faculty of Forestry, University of Agriculture, Krakow, Poland*

[2] *Department of Ecology and Silviculture, Faculty of Forestry, University of Agriculture, Krakow, Poland*

[3] *Department of Biological, Geological, and Environmental Sciences, Cleveland State University, Cleveland, OH, United States*

YOUNG REVIEWER:

SILAS

AGE: 11

The forest floor is the forest's graveyard. There, broken branches and fallen trunks are laid to rest. However, this deadwood still has an important role to play. New deadwood is still covered in bark—a tissue that protects a living tree's insides from the outside world. The bark makes it difficult for water to enter the dead tree. It repels the rain and dew, as if the dead tree still needs this protection. Since deadwood cannot rebuild its bark, the bark slowly breaks down over time. As the bark decomposes, rain and dew are no longer repelled, and the deadwood begins to store more and more water. Recent findings show that, as its bark disappears, the amount of water that can be stored by deadwood changes significantly. This role of deadwood on the forest's water cycle has consequences for soils and the organisms living in deadwood.

WELCOME TO THE FOREST'S GRAVEYARD

DEADWOOD

Wood lying on the forest floor, including dead roots and stumps ≥10 cm in diameter.

DECOMPOSITION

The process of "rotting," in which dead materials are broken down to become soils.

WATER CYCLE

The continuous movement of water on, above and below the surface of the Earth.

When you go hiking in the woods, you probably stick to the trail. After all, the trail is very well trimmed, there are few leaves or branches to walk through, and there are no fallen trunks to climb over (hopefully)! Let us walk off the trail for now, and wade through the fallen leaves, branches, and trunks. Here, we find ourselves in the forest's graveyard, where the branchy skeletons of dead trees poke their limbs through the decaying leaves. Forest scientists call these tree skeletons **deadwood**, and they have long been interested in understanding how deadwood decomposes. During **decomposition**, deadwood is eaten by microbes and insects and eventually becomes soil [1]. Before deadwood can become a true feast for the forest graveyard organisms, the bark that protected the trees during their lives must be broken down. This is no easy task for these wood-hungry critters, as bark can contain chemical compounds that protect living trees from some of the same organisms now trying to digest it [2]. These compounds can also make it hard for water to enter the deadwood—a beverage that wood-hungry critters crave as they eat. Recent research is looking into how deadwood affects the **water cycle**, and the consequences for forest soils.

DEADWOOD IN THE FOREST'S GRAVEYARD

Deadwood is an important part of forests. It affects the cycling of nutrients, including the capture and long-term storage of carbon. Natural forests can have between 40 and 120 cubic meters of deadwood in a single hectare (10,000 square meters, or an area roughly the size of a rugby field). But forests managed by humans can have much less—as little as 5 cubic meters of deadwood in a hectare—because forest managers typically remove a lot of deadwood. For comparison, a single elephant's volume is about 5 cubic meters, making these deadwood volumes equal to approximately 1–24 elephants-worth in a single hectare of forest! Not all deadwood is the same. Different tree species tend to decompose differently, because their deadwood can have unique physical and chemical traits that affect its durability. So, deadwood can be as diverse as the living trees of the forest! The structure of deadwood also changes as bark and wood decompose, which can change the deadwood's water-absorbing properties (Figure 1).

The nature and timing of these decomposition changes appear to depend on the hardness of the wood. For example, fir and aspen are soft (and therefore easy to decompose), but harder woods (like hornbeam and oak) resist decomposition and are well-suited for building structures or outdoor furniture. Softer woods lose their bark relatively quickly, in approximately 10 years, while harder woods can keep their bark for up to 100 years. Rainwater must pass through the forest graveyard to recharge the soils and groundwater from

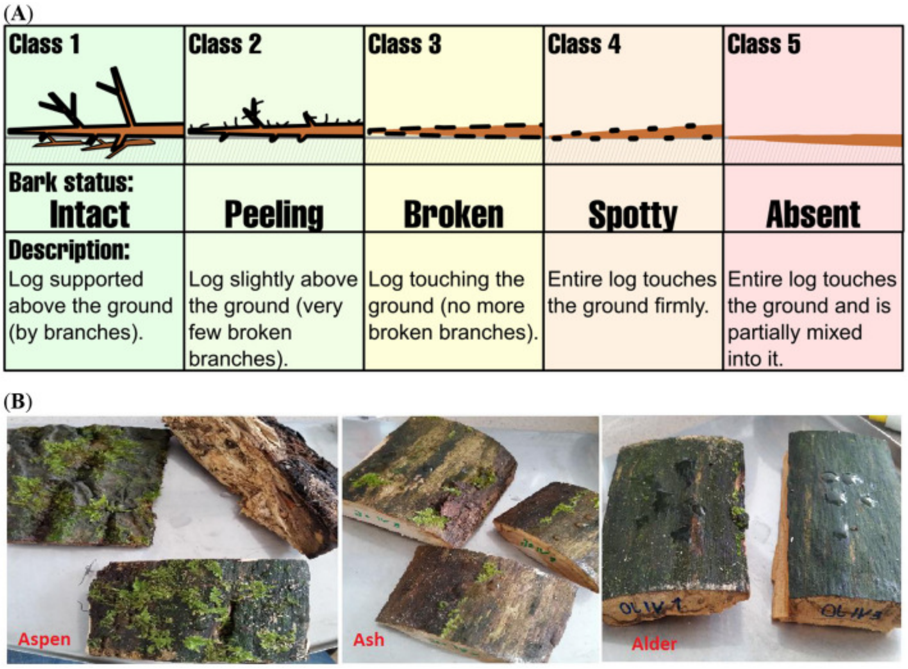

Figure 1

Figure 1

(A) The five classes of decomposition for deadwood. The status of the bark and of the wood is different for each class (Figure credit [3]). **(B)** Examples of wood of different hardness, all in the fourth stage of decomposition. Different types of wood differ significantly in porosity, which affects the amount of water they can hold.

which living plants drink. Given the amount, diversity, and types of deadwood, it is important for forest scientists to see if water-related properties (like the amount of water deadwood can absorb and store) change meaningfully for deadwood of different tree species as they decompose.

WHAT HAVE WE DONE SO FAR?

So far, we have studied the water properties of deadwood from a forest in central Poland, the Czarna Rózga Forest Reserve, and we have examined diverse species including silver fir, European hornbeam, ash, alder, and aspen. The samples that were tested represent the final three decomposition classes shown in Figure 1A. Measuring the amount of water that a log in the woods can absorb from the rain would be very challenging! For example, if you wanted to weigh a long chunk of deadwood multiple times during a storm, how would you get a scale underneath? How would you power that scale in the woods, under the forest canopy where even solar panels have a tough time generating energy? Finally, how would you keep the deadwood intact, since most deadwood over class 3 can fall apart when lifted?

We tried to avoid these and other challenges by exposing samples of deadwood to simulated rainfall in a laboratory in Krakow, Poland (Figure 2). This way, the **water-storage capacity** of a small chunk of deadwood could be estimated as the difference between the amount of water used to simulate rainfall over the wood sample and the water that is recovered, meaning not absorbed by the deadwood. We also

WATER-STORAGE CAPACITY

The largest amount of water a surface or material can hold.

Figure 2

Figure 2

(A) A scale with a mesh platform is used to analyse the amount of water taken up by deadwood samples. **(B)** Water is sprinkled over the deadwood sample to simulate rainfall (Photo credit: Anna Klamerus-Iwan).

investigated how much water could soak into the wood, by soaking deadwood in water and measuring its weight change over 66 h, until the weight no longer increased. With these data, the **absorbability** was estimated as the difference in weight between a deadwood sample saturated with water and a dry sample.

ABSORBABILITY

The ability of a material to take up water.

HOW DOES WATER STORAGE CHANGE AS THE BARK ON DEADWOOD DISAPPEARS?

Our research suggests that: (1) deadwood is an important, large, water-storage container in forests; and (2) the water-storage capacity and absorbability of deadwood depends both on the species and the degree of wood decomposition [3, 4]. For the forest we studied, a single cubic meter of deadwood could hold approximately 55 L of rainwater—that is about 240 juice boxes! Since natural forests can have 40–120 cubic meters of deadwood in a single hectare, that is 9,600–28,800 juice boxes of rainwater storage over an area the size of a rugby field! This means that the deadwood in the forest's graveyard can suck up more water in a single storm than your class typically drinks in a week. We found that different species' deadwood stores different amounts of water, showing that forest biodiversity has an impact on a forest's precipitation water storage and humidity, even after tree death! The low-density deadwood of fir trees was the thirstiest, while dense deadwood of the hardy hornbeam was the least thirsty.

As all deadwood decomposes, the number of holes throughout—called **porosity**—can increase as the graveyard residents find ways to enter and eat (Figure 1B). As porosity increases, there is more potential space into which water can penetrate, resulting in higher water-storage capacity and absorbability. Thus, most deadwood in the final class of decomposition, regardless of the tree species, has a great potential to store water. For deadwood with a bark "lid" still clinging on (class 3 deadwood), the bark surface reduced the water-storage capacity. For example, deadwood with just a partial bark lid, for any species studied, could store only three-fifths of what class 5 deadwood could store,

POROSITY

A measure of the "empty" spaces in a material.

Figure 3

Figure 3
Forests with different deadwood density (Photo credits: Ewa Błońska and Jarosław Lasota).

on average [5]. After a long, dry period, when the bark gets very dry, bark's effect on decreasing the water-storage capacity of deadwood becomes even greater. For all study species, the average water-storage capacity for deadwood with some very dry bark was only one-quarter of what deadwood could store without bark! So, the biodiversity of the forest's deadwood, its porosity, the presence of bark, and how dry this bark gets all contribute to the amount of rainwater the forest graveyard can store (Figure 3).

WHY DOES THE WATER IN DEADWOOD MATTER?

Forest scientists are very interested in how deadwood and its bark interact with the water cycle. This is because the deadwood that rests within forest graveyards appears to be an important water-storage container. The presence of bark can act like a lid that covers these containers. With or without bark, a single deadwood log can store hundreds of liters of water each year.

Deadwood water storage matters because it keeps a portion of rainfall from becoming **runoff**. Since stormwater runoff is good at picking up soil particles and carrying them away, the water storage

RUNOFF
Rainwater that flows over the land as surface, rather than being absorbed into the ground or evaporating.

in deadwood may also help prevent local soil erosion. Deadwood is as diverse as the living forest itself. Therefore, any new-fallen log or branch will bring its species' unique bark features to the forest floor with it—affecting how much water can be stored. This means that the biodiversity of a forest could affect the graveyard's water storage. As the diverse deadwood decomposes and the logs lose their lids, however, diversity ceases to matter as much in terms of water absorption and retention. These findings indicate that, by regulating the quantity and species composition of deadwood, we can actively influence the way stormwaters are stored and drained through forest ecosystems. Managing deadwood may also be useful to create local "micro" habitats where moisture can be maintained. Moist micro-habitats are particularly important in times when water becomes scarce. Overall, deadwood is an essential element of forest ecosystems that is a source of nutrients and serves a very important role in the maintenance of biodiversity. Deadwood are microhabitats which, thanks to the combination of shapes, wood species and degrees of decomposition, enable rain waters to persist and be available to multiple organisms even when it is not raining.

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Klamerus-Iwan, A., Błońska, E., and Lasota, J. 2020. Interspecific variability of water storage capacity and absorbability of deadwood. *Forests*. 11:575. doi: 10.3390/f11050575

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWER

SILAS, AGE: 11

My name is Silas. I like to draw, build with LEGOs, and do stop-motion. I am reading Calvin and Hobbes. My favorite video game is Minecraft. My favorite art mediums are pencil and pastel. I have a brother and sister. My favorite Star Wars movie is The Empire Strikes Back. When I grow up, I want to be a filmmaker. My favorite song is Eleanor Rigby by The Beatles. I hope that we can end this pandemic so we can visit our friends and family.

AUTHORS

ANNA KLAMERUS-IWAN

Anna Klamerus-Iwan works at the Faculty of Forestry at the University of Agriculture in Krakow, Poland. She is an ecohydrologist investigating how living and non-living factors affect water-storage capacity of tree crowns, bark, and topsoil. *annaklamerus.iwan@gmail.com

EWA BŁOŃSKA

Ewa Błońska works at the Faculty of Forestry at the University of Agriculture in Krakow, Poland. Ewa is a soil scientist investigating soil microbial activity and the deadwood-soil relationship.

JAROSŁAW LASOTA

Jarosław Lasota works at the Faculty of Forestry at the University of Agriculture in Krakow, Poland. He is a soil scientist investigating the soil-plant relationship and the effects of pollution on the soil.

JOHN T. VAN STAN

John Van Stan is an ecohydrologist interested in what happens when plants and water meet during storms—rain, snow, sleet, or otherwise. He enjoys researching the roles that wet plants play in our Earth's energy balance, nutrient cycles, and landscape ecology. He is currently an associate professor at Cleveland State University, where he leads the Wet Plant Lab.