The Hidden River in the Air:
How the Small Water Cycle Sustains Life

Sources: *WaterStories.com (Zach Weiss), Alpha Lo's Climate Water Project Substack, Didi Pershouse (Land and Leadership Initiative), Brock Dolman (OAEC Water Institute), Dr. Millán Millán, the Biotic Pump theory (Makarieva & Gorshkov), USGS Water Science School, Canada WaterPortal, Natural Resources Canada, Nature Communications, ScienceDaily.*
Further reading: *Ali Bin Shahid s Regenesis Substack (r3genesis.substack.com).*

Most of us learned about the water cycle in school: rain falls, rivers flow to the sea, water evaporates from the ocean, clouds form, and rain falls again. That picture is true but it's only half the story. There is a second, more intimate water cycle at work, one that happens entirely over land, driven not by oceans but by forests, soil, and the living world beneath our feet. Researchers and practitioners like Alpha Lo of the Climate Water Project and Zach Weiss of WaterStories.com call it the **small water cycle** — and understanding it may be one of the most important things we can do for our climate, our water supply, and the heat baking our cities.

A Tree Is a Pump, a Filter, and a Rain Maker

The small water cycle begins with a single, extraordinary act: a tree breathing out water. Evapotranspiration is the sum of all processes by which water moves from the land surface to the atmosphere via evaporation and transpiration. Transpiration occurs when plants take up liquid water from the soil and release water vapour into the air from their leaves. [1] According to the National Oceanic and Atmospheric Administration (NOAA), a large oak tree can transpire 151,416 litres of water per year [2] working out to roughly 413 litres on an average day. Larger trees move even more: a giant sequoia can transpire nearly 1,900 litres a day. [3] In Canada, this process is immense in scale. Anywhere from 20 to 90% of the precipitation that falls on forests returns to the atmosphere through evapotranspiration. The drinking water for two-thirds of Canadians comes from surface waters, including lakes and reservoirs, a large proportion of which originates in forested areas. [4]

That water doesn't just disappear into thin air, it carries passengers. Bacteria form small groups on the surface of plants and are lofted into the atmosphere [5] along with the water vapour. Once aloft, these microbes become the seeds of raindrops. The bacterium *Pseudomonas syringae*, found regularly in clouds, has proteins on its cell surface that nucleate the formation of ice, the precursor to most forms of precipitation. [6] In other words, the forest doesn't just release water upward, it sends up the biological instructions for turning that water back into rain.

Before water leaves via the leaves, the tree channels it downward. Rainwater runs along branches and down the trunk in a process called stemflow, directing a concentrated stream into the soil at the base which is precisely where the root system can capture it.

The Soil as a Living Sponge

What happens underground is as miraculous as what happens above. Healthy soil is not merely dirt, it is a living architecture. Author, educator, and soil health advocate Didi Pershouse, founder of the Land and Leadership Initiative, has popularized the concept of the "soil sponge": the living matrix that makes life on land possible. Her workshops engage farmers, policy makers, and communities in building working groups to reduce flooding and drought through changes in land management. [7]

The soil sponge is built by a community of organisms working in concert. Bacteria and earthworms exude a slime that binds soil particles together into a structure that provides pore space for air and water storage. Fungi grow threadlike structures called hyphae that form mats called mycelia distributing water over large areas. [9] Earthworm and other beings' burrows can persist long after the being has died and can be a major conduit for soil drainage, particularly under heavy rainfall. [10] The more intact this web of life, the more water the soil can absorb and hold, reducing both flood and drought. Compacted, degraded soils shed water as runoff; living soils drink it in.

As water filters slowly through layers of mineral and organic matter, it is also cleaned — toxins and pathogens broken down by microbial communities before the water reaches aquifers. Perhaps the most important ecosystem service that healthy soil performs is to capture and clean water. [11]

Forests Pull Rain Inland — and Cool Our Cities

Globally, about 65% of rain comes from the small water cycle, and 35% comes from the large ocean-driven cycle. [11] The late Spanish meteorologist Dr. Millán Millán spent decades investigating why living landscapes are so central to rainfall. Commissioned by the European Commission to find out why summer storms were disappearing across the western Mediterranean, he discovered that deforestation, land degradation, and the paving over of land were reducing evapotranspiration rates, and that without sufficient moisture rising from the land to combine with incoming ocean moisture, the humidity never crossed the saturation point needed for rainfall to form. His research influenced the European Commission to fund large-scale land restoration efforts to bring back the rain. [12] Russian physicists Anastassia Makarieva and Victor Gorshkov proposed a related concept, the biotic pump theory, suggesting that forest-evapotranspired water vapour condenses to create a pressure drop that draws in moisture-laden winds from the ocean, helping to carry rainfall deep into continental interiors. [13] Both lines of work point to the same conclusion: living landscapes are active rain-makers, not passive recipients.

This matters profoundly in cities. Urban areas replace trees and soil with asphalt and concrete surfaces that absorb heat rather than releasing it as cool water

vapour. The result is the urban heat island effect: cities run measurably hotter than their rural surroundings. Trees and vegetation lower surface and air temperatures through shade and evapotranspiration. Shaded surfaces may be 11–25°C cooler than peak temperatures of unshaded materials, and evapotranspiration alone can help reduce peak summer temperatures by 1–5°C. [14] A typical tree transpires around 100 litres of water per day, equivalent to the cooling power of two hotel air conditioners running all day. [15] In a country like Canada, where urban heat events are intensifying, every mature tree is infrastructure.

How We Broke the Cycle — and How We Can Restore It

Deforestation, wetland drainage, and the paving of vast areas have disrupted the small water cycle at a massive scale. Landscapes have been transformed from water-catchments into water-sheds, places that shed water as fast as possible rather than absorbing it. [16] The result is a reinforcing spiral: less vegetation means less evapotranspiration, less rain, drier soils, more heat, and even less vegetation. The Canada WaterPortal notes that human activities replacing forests with impermeable surfaces result in water that becomes runoff rather than infiltrating into the ground, and that the loss of forested areas not only interrupts the hydrologic cycle but also leads to heavy erosion. [18]

But this cycle can be reversed, often faster than we expect. The guiding principle was coined by Brock Dolman, conservation hydrologist and co-founder of the Occidental Arts and Ecology Center's Water Institute in California: *slow it, spread it, sink it, store it, share it.* [17] The idea is straightforward. We should slow water down before it escapes, give it time to sink into the soil sponge, and let the landscape hold it. Practitioners like Zach Weiss of WaterStories.com translate this into concrete actions: reforesting and revegetating landscapes, terracing hillsides, creating water retention bodies, and reconnecting waterways with their floodplains, all of which help land receive and hold seasonal rains. [16] The evidence that restoration works is compelling. In northwest China, the Loess Plateau, once considered the most eroded landscape on Earth was transformed through vegetation restoration and soil conservation, resulting in a 25% increase in vegetation cover. In 2004, the World Bank described it as "the world's largest and most successful water and soil conservation project." [19] In Rajasthan, India, Rajendra Singh, known as the Waterman of India, demonstrated what community-led water restoration can achieve. Working with over 1,000 villages, his organization Tarun Bharat Sangh built more than 8,600 johads, traditional crescent-shaped earthen dams for rainwater harvesting, recharging groundwater across the region. Groundwater tables rose by up to 6 metres in some areas. [20] As this work spread, 12 rivers were revived and have now become perennial. [21] Singh won the Stockholm Water Prize — often called the Nobel Prize for water — in 2015. Closer to home, British Columbia has committed $30 million to watershed restoration projects led and co-led by First Nations, with the goal of restoring ecosystem services and watershed health across the province. [22]

When working with water, people often see results after the first rainy season — the landscape stays green for longer and becomes more productive year after year. Huge transformations are possible within a decade. [16]

Each of us can participate, at whatever scale we have access to: plant a tree, build a rain garden, restore a verge, compost to feed the soil food web, depave a driveway. Every action that slows water and welcomes it back into the ground is a vote for the cycle that keeps our land alive.

Further Exploration

WaterStories.com | Climate Water Project (Alpha Lo) | Land and Leadership Initiative (Didi Pershouse)

Canada WaterPortal | Regenesis (Ali Bin Shahid)

References

[1] USGS Water Science School. ***"Evapotranspiration and the Water Cycle."*** https://www.usgs.gov/water-science-school/science/evapotranspiration-and-water-cycle

[2] NOAA Jetstream. ***"Learning Lesson: Leaf it to Me — Transpiration data."*** https://www.noaa.gov/jetstream/ll-leaf

[3] Princeton Tree Care. ***"10 Astounding Facts About Trees."*** https://princetontreecare.com/10-astounding-facts-about-trees/

[4] Natural Resources Canada. ***"Water and Forests — Evapotranspiration."*** https://natural-resources.canada.ca/forest-forestry/sustainable-forest-management/water

[5] Louisiana State University / ScienceDaily. ***"Evidence of Rain-making Bacteria Discovered in Atmosphere and Snow."*** https://www.sciencedaily.com/releases/2008/02/080228174801.htm

[6] American Chemical Society / C&EN. ***"Bacteria in Clouds — Pseudomonas syringae as ice nuclei."*** https://cen.acs.org/articles/86/i15/Bacteria-Clouds.html

[7] Didi Pershouse / Land and Leadership Initiative. ***"The Soil Sponge: the living matrix that makes life on land possible."*** https://lali.teachable.com/p/the-soil-sponge

[8] Piedmont Master Gardeners. ***"The Soil Food Web: Nature s Way to Build Healthy Soils."*** https://www.piedmontmastergardeners.org/article/the-soil-food-web-natures-way-to-build-healthy-soils/

[9] Covers & Co.. ***"Soil Food Web — Earthworm burrows and soil drainage."*** https://www.coversandco.ca/soilfoodweb

[10] Loudoun Wildlife Conservancy. ***"Supporting Biodiversity in the Soil Food Web — capturing and cleaning water."*** https://loudounwildlife.org/2019/02/supporting-biodiversity-in-the-soil-food-web/

[11] Alpha Lo, Climate Water Project Substack. ***"Slow Water — the small water cycle and hydraulic redistribution."*** https://climatewaterproject.substack.com/p/slow-water

[12] Alpha Lo, Climate Water Project Substack. ***"Millán Millán: he helped us understand rain."*** https://climatewaterproject.substack.com/p/millan-millan-he-helped-us-understand

[13] Climate Water Project Substack. ***"Biotic Pump: Anastasia Makarieva interview."*** https://climatewaterproject.substack.com/p/biotic-pump-anastasia-makarieva-interview

[14] US EPA (archived). ***"Using Trees and Vegetation to Reduce Heat Islands."*** https://19january2021snapshot.epa.gov/heatislands/using-trees-and-vegetation-reduce-heat-islands_.html

[15] Resilience.org. ***"Millán Millán and the Mystery of the Missing Mediterranean Storms — tree cooling equivalence."*** https://www.resilience.org/stories/2023-07-17/millan-millan-and-the-mystery-of-the-missing-mediterranean-storms/

[16] WaterStories.com. ***"The Revived Water Cycle — from water-sheds to water-catchments."*** https://www.waterstories.com/story/the-revived-water-cycle

[17] Occidental Arts and Ecology Center / Wikipedia. ***"Brock Dolman — Slow it, Spread it, Sink it, Store it, Share it."*** https://en.wikipedia.org/wiki/Occidental_Arts_and_Ecology_Center

[18] Canada WaterPortal. ***"Forest Hydrology — evapotranspiration and impervious surfaces."*** https://waterportal.ca/forest-hydrology/

[19] Active Sustainability. ***"How one of the world s most eroded landscapes came back to life — the Loess Plateau."*** https://www.activesustainability.com/environment/soil-conservation

[20] Grow Billion Trees. ***"Rajendra Singh: Waterman of India — johads and groundwater restoration."*** https://growbilliontrees.com/blogs/inspirational-stories/rajendra-singh-waterman-of-india-dedicated-his-life-for-water-conservation-efforts

[21] India Development Review. ***"Interview with Rajendra Singh on the importance of water conservation."*** https://idronline.org/idr-interviews-rajendra-singh/

[22] Water Canada. ***"Watershed restoration creates a healthier future for B.C.."*** https://www.watercanada.net/watershed-restoration-bc/