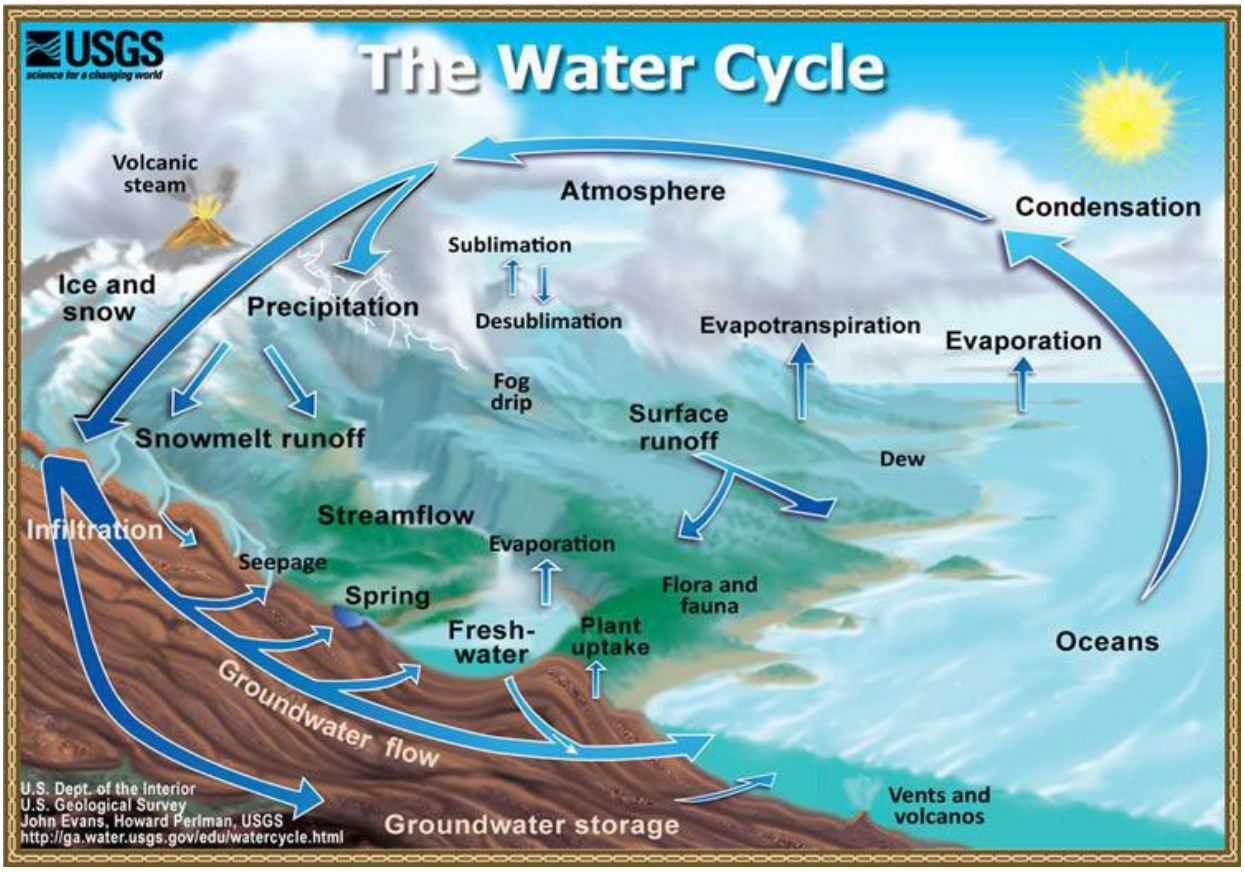
Old Growth Forest Nature: The Biotic Water Pump

The Biotic Pump Theory

A warming and drying global climate has many people concerned. Some believe it's just a natural phenomenon. Some believe it's caused by man's activities. Others don't believe in it at all. What is the truth? Well, certainly there are some parts of the planet that has become deserts, and others that are headed that way. We hear about carbon and greenhouse gases like CO_2. But it's becoming more widely known that the greenhouse effect is only part of the climate story. For at least half century it has been known that what we do to the land has as much of an effect on climate as climate does on the land. But that part of the story has been largely ignored.

If you were a creature living under the sea, the last thing you'd be thinking about would be how to find water. On land, it's a different story. There's only one way to get fresh water delivered to land. It comes to us on the wind. Sea breezes carry water vapour that can fall as rain or snow. But things are not quite that simple, or reliable. Earth receives energy from the sun, which is converted to heat at the surface. Atmospheric greenhouse gases trap some of the heat emitted by the surface and redirect it back toward Earth, warming it further. CO_2 is the greenhouse gas we hear most about today. But atmospheric water vapour is a far more abundant greenhouse gas and is responsible for a major part of the greenhouse effect. Scientist say global temperatures have risen steadily since the industrial revolution of the 19th century. There is what's called the large water, or hydrological cycle, where water vapour is carried over continents on the wind fromoceans. At some point that water vapor may condense and fall as precipitation onto the land. The water eventually cycles back to the oceans, and



the cycle repeats.

In the 1990's, the Atmospheric Physicist Millan Millan studied the reason why the almost-daily summer storms had disappeared from his Western Mediterranean home region during his lifetime. The air that comes in from the sea gets heated, but it also gets more moisture, and eventually it reaches a condensation point and you have the summer storm developing over the slopes sometime in the afternoon. That cycle would go on almost every day. That keeps the soil moist and the following day that moist soil would contribute to the vegetation transpiring, and puts moisture in the atmosphere again, and what you see is the same amount of water going around and around for many days in the summer.

Most of the western Mediterranean used to be covered with marshes as far as 2000 years ago, and as people filled in the coastal marshes and there was industrialization with power plants and oil refineries and housing, the amount of water that is driven inland with the sea breeze goes down and the frequency of the storms goes down. After you have cut all the forest, and built along the coast, then you don't get enough water vapour now to the top of the mountains, and of course the storms don't develop. There's not enough moisture to compensate for the amount of heating the air sustains as it moves inland.

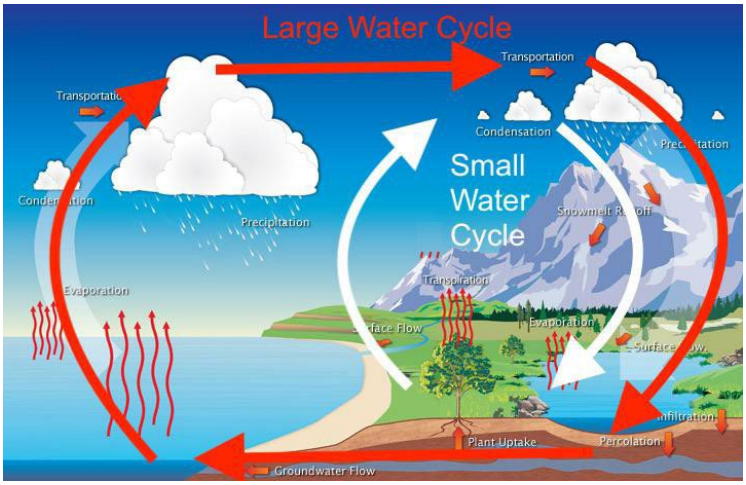
Deforestation, filling of coastal marshes, industrialization, and development destroyed the local hydrologic cycle and dried up the land. That was why the summer rains had disappeared. This was the second half of the climate story; greenhouse gases were the first half, and land cover change was the second.

But in the 1990's Millan's findings were not well accepted by climate modelers and politicians. Climate modelers could not easily incorporate land cover into their models, so they focused on greenhouse gas CO_2. And politicians did not want to get involved in the contentious issue on how land was altered or used.

As the sun comes up and warms the land mass, heated air rises, drawing in moist, cooler air from the sea or even large lakes. As the air moves over the land, heat emitted from the surface warms it and causes it to rise into the atmosphere, where some of its water vapour will condense into clouds and fall as precipitation. When water vapour condenses it occupies less space than before, resulting in lower pressure. Air from higher pressure areas move into equalize the pressure, thereby drawing more air from over the sea.

However, because that incoming air has been heated, it can now hold additional water vapour, and its initial vapour content may not be high enough to reach the dew point and condense. So, its water vapour content must be increased in order for it to condense. If that doesn't happen, little or no rain will fall over that area, and the water vapor will be carried away with the wind to some other place. Where does the additional water vapour come from? From the source that nature has provided…the forest.

Millan Millan found that the sea breezes carried water vapour onshore, and historically, the forest had transpired enough additional water vapour each summer day to allow condensation, and clouds to form, then an afternoon storm would drop water back on the forest. It was a local feedback loop over the forest that recycled the same water over and over all summer.



It's known as the small, or local, water cycle, in which about half of the rain that falls on land is this local recycled water. Farther inland, the percentage is even higher, because, with a contiguous forest cover, wind carries the transpiration-precipitation across the land. But coastal deforestation had interrupted the forest belt and had eliminated the local water cycle.

You change the surface or the land use cover…and you immediately change that cycle. Land cover is the driver of the second leg of climate change. Everywhere that you change the land use around any coast, that part of the water cycle that was driven by the sea breezes on that coast changes.

This was first presented in San Diego, California, in 1997. And the head of the US Forest Service at the time said…if what you say applies in California, we will have serious problems with forest fires in about 25 years. That was said in 1997.

In California you have lost the local precipitation in the summer afternoons, the ground has dried up, people have built in the forest and now the ground is much drier than it used to be before, and it becomes a fire trap. When you had forest, and soils, you had a huge amount of water trapped in the soils and in the forest. As we have changed land use, all the water that was in the soils in the forest is somewhere else.

California line fire 2024

What you would like to do is make sure that the water vapour goes back to where it was 100 years ago, or even better a few hundred years ago before they deforested all the places in Africa, and Asia, and now in the United States. All that water is now somewhere else. Anytime that you disturb the hydrological cycle you're creating a real monster. It's a monster because it contributes to further loss of soil moisture, which means more droughts and higher temperatures, which in turn effect our climate, agriculture, ecosystems and way of life.

How does it all work? Plant foliage has microscopic pores called stomata. During photosynthesis, these pores open to take in CO2 molecules from the air. Sunlight shining on the foliage provides the energy to build carbohydrate molecules from the CO2 and water. The plant uses these sugars to build more of itself. Some oxygen is released to the air and water is released as vapour. That's why old forest are superheros. they have evolved to transpire a lot of water into the air during photosynthesis, raising the humidity level high enough so that condensation can happen in the atmosphere over land and precipitation can occur. This is the Biotic Pump. Large contiguous, old forests in effect pump water across the land via the repeating cycle of transpiration and precipitation.

Atmospheric physicist Anastassia Markarieva co-authored the Biotic Pump theory, which describes the vital role that old, natural forest play in maintaining the supply of inland water, and in moderating our climate. The Biotic Pump is the mechanism by which the forest can regulate their own moisture supply. By regulating the rate of evapotranspiration, forest can actually induce the ascending air motion. And when there is ascending air motion there will be also horizontal inflow of air. This process is turned to local geophysical conditions it can lead to the moisture import from water bodies like the ocean or a big lake, so the forest will be supplying itself with water. We have more and more data about how forest produce certain substances that act as so-called cloud condensation nuclei which help and facilitate cloud formation.

Microscopic particles such as, spores, bacteria, pollen, and terpenes are released from the forest into the air, providing surfaces on which water vapour molecules can condense into clouds. And when there are clouds, they reflect a lot of sunlight and can lower the temperature and facilitate condensation. By controlling clouds, the forest can switch condensation by controlling temperature. Clouds both cool and warm the earth because first they can reflect sunlight so there is less energy reaching the earth's surface and its cooler. On the other hand, clouds capture thermal radiation of the earth's surface and partially redirects it back to the surface, they enhance the greenhouse effect. And depending on the type of the cloud the net effect will be either warming or cooling.

Imagine a forest that has all this repertoire of producing all types of clouds which warm and cool. Using these as levers it can maintain any desired temperature, to induce condensation, to optimize the conditions for all the organisms which live in the forest. The forest has mastered the laws of physics, as for example birds mastered the laws of aerodynamics to be able to fly. The forest has mastered the laws of atmospheric physics to regulate its environment and climate. And given this delicate balance between negative and positive influences on warming and cooling, it is of utmost importance that these mechanisms are enhanced in a native forest, the natural forest that has this capacity to regulate these processes. Because when we arbitrarily change what is in the forest by cutting trees, by logging, by fires, we decouple these mechanisms, and forests' ability to stabilize environmental and climatic conditions deteriorate.

Critically important in the local water cycle is adequate mature forest cover and the ability of the forest soil to retain water. How does it do that? It all started from rock. Rock is slowly and continuously being eroded into smaller chunks and particles. Mountain have been ground into gravel by glaciers. Cycles of freezing and thawing, crack rock. Flowing water abrades it. Tree roots can exert enough expansion pressure to facture boulders. And the release of acids by lichen and mosses dissolve it. These processes produce inorganic mineral soil. In the forest fallen leaves, twigs, branches, logs, and animal remains accumulate. As soon as this material hits the ground, an army of decomposers quickly goes to work on it. Saprophytic fungi and slime molds break down wood. Various creatures dine on and digest dead plant material. Microbes decompose it into nutrients needed to grow new plants. Together these organisms

create and maintain the forest floor duff layer- organic material in various states of decomposition which sits atop the mineral soil. This is the primary rooting zone for all forest plants, including trees. The decomposing material becomes intermingled with mineral soil through the activities of various burrowing creatures, forming a compost-like matrix that is highly absorbent. Logs in the shade of the canopy remain water soaked for decades as they slowly break down. If you don't have good soil, you don't have good forests. The soil behaves like a sponge that stores the water.

Some water goes into the ground; some water goes into the vegetation; from the vegetation it goes into the atmosphere that goes into the summer storm, that goes back into the soil. You have a huge amount of water doing a local job. As soon as you alter all that, eventually that water ends up where it shouldn't be. You cannot separate soil from forest, because good forest is sustained by good soil and if you change the soil use, you're changing automatically the forest and the water cycle. Whatever disturbance you introduce, it doesn't matter how small-scale it would only propagate to the larger scales.

Wet logs become seed beds for new plants, shelter and food for uncounted organisms, and are virtually fireproof as well. The whole of the forest floor is a gigantic sponge, soaking up rainfall, keeping vegetation watered, recharging aquafers, preventing runoff, erosion, and flooding, and slowly releasing just the right amount of purified water to maintain streams and rivers. Water is also continuously being drained from land because land is above sea level, so gravity drains away water that is not held in spongy soil, plants, lakes, and ponds. Streams and rivers return it to the sea.

If we stop the import of moisture via the atmosphere, all the rivers would steal the water from the continents in just a few years. So, there must be a continuous process returning water to land, because land is losing water due to gravity, being elevated above the ocean. Imagine when the forest began to invade the land they were bringing this biotic pump with them, and as the forest marched inland, they brought this moisture inflow with themselves. When we have a large contiguous forest, it brings moisture even further inland.

In 1972 there was a book that was published by the Massachusetts Institute of Technology called ''inadvertent Climate Modification'' and they talked about two drivers for the climate change… the greenhouse gasses, and the second leg was the land cover changes, because they alter the hydrological cycle immediately. As soon as you cut a piece of forest or you build a road, the small water cycle is immediately changed by a bit. But it's not too little when you start adding a little more and a little more and eventually you hit a tipping point. And after you cross that point your local precipitation disappears. Then you only have the largest scale precipitation. Your original water cycle begins to be changed as soon as you change soil use, which includes forest and soil.

Soil loses water whenever plants are photosynthesizing, or rivers are flowing. There has to be a reliable feedback loop to replenish and maintain the supply of fresh water; that is a small water cycle. And what provides it? A forest. The older and more natural the forest is, the better. That's because the ability of the soil sponge to absorb and hold water is reliant on the presence of the entire complement of plants, fungus, and animal organisms naturally found in any given forested area. Loss of that wide diversity, or any degradation of the forest begins the downward trend toward desertification. It may be small and unnoticeable at first, but once passed the tipping point, it is a very rapid descent.

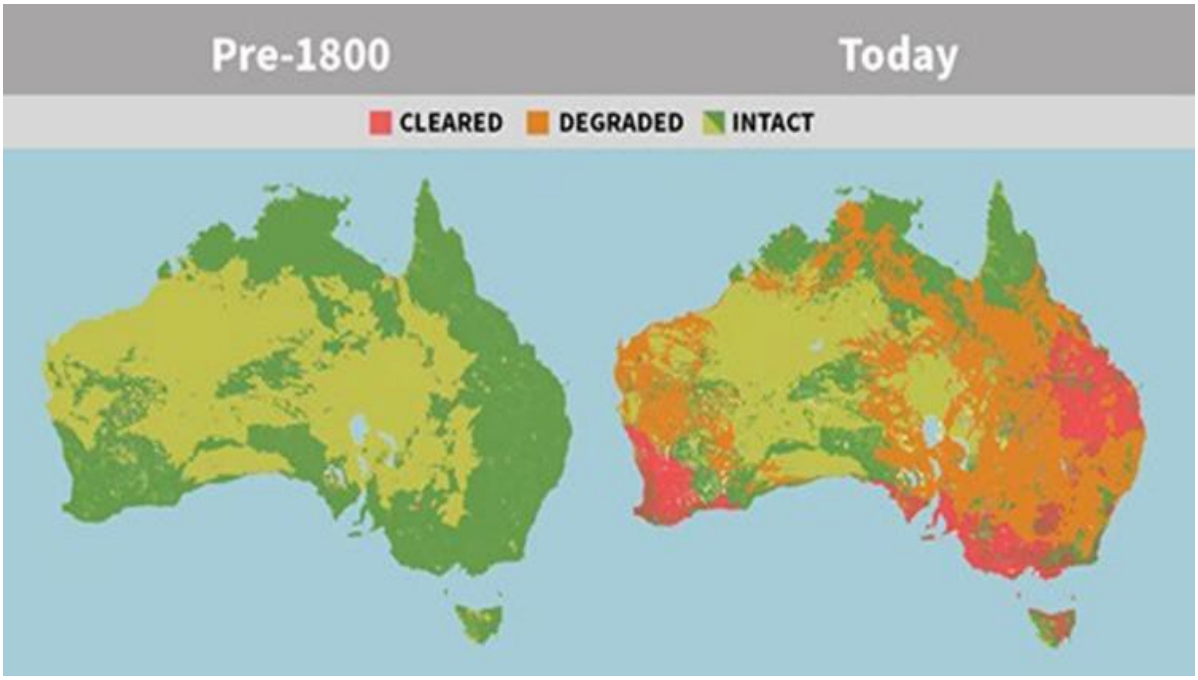
Photosynthesis is a remarkable and elegant biological process, first evolved by green algae. Carbon is the primary constituent of life on Earth. As CO_2 is drawn in by vegetation and, via the energy of

sunlight, combined with water from the soil to build more plant structure. Water vapour and oxygen is released into the air during the process. All plant and animal life eventually dies. On land the reverse of photosynthesis process, called oxidation or respiration, takes in oxygen to break down the dead organic biomass back into CO_2 and water. This process can happen very quickly, such as when the biomass is burned, or the forest canopy is removed; in that case CO_2 and water vapour are immediately released to the atmosphere, where they don't contribute directly to building life. But an old. Natural forest is a delicately balanced ecosystem where biomass is decomposed slowly, at the same rate it is synthesized. A lot of organic carbon and water are incorporated into the soil sponge, the layer where new plant life can be generated. It's a store of water and carbon, as well as nitrogen from decomposed proteins. The sponge provides countless tiny voids where water is held, and mineral soil particles can be dissolved to supply other needed elements. Soil particles are bound together by organic adhesives and tree roots, preventing erosion. In old growth forest, you don't see streams loaded with mud; that occurs where the forest has been removed or degraded, or where there is insufficient vegetation with perennial roots. If the soil is healthy, it can store a lot of water, and there is less possibility of runoff. You increase the runoff when the soil has become weak because you have interrupted the smaller cycle. The soil gets damaged, the sponge dries up, it cannot store water, and if you have a large storm, it eventually gets rid of the soil, and you have a mudflow. When the soil sponge is compromised or destroyed, land dries out and begins the slide to desert conditions. That's part of the degeneration cycle that you trigger when you alter the land surface. You lose the local storms and you're open to more damage by the larger water systems.

It's critical that there is adequate, vibrant, mature forest cover to constantly maintain the soil sponge and the local water cycle. When forest cover is reduced or removed, the local feedback loop is compromised or eliminated, rainfall diminishes, and the land becomes drier. Vegetation dries out. Stream flows decline and water bodies dry up. There's only one way to prevent or reverse that slide towards desert conditions that is to have adequate natural, mature forest cover to maintain the water cycle. There is simply no other way to keep the soil sponge intact and the land hydrated. Young, early successional forest is not as effective at this job as a very old forest is, likewise, neither is tree plantations. Younger, smaller trees typically don't have the robust crown structure of older, larger trees, nor the capacity to transpire the right amount of moisture at the right time. Old trees are well adapted and have already survived a wide range of environmental conditions. They have well-developed, deep root systems that can access a deeper underground water table during drier times, keeping transpiration rates high and the feedback loop working. Young trees do not have yet deep root systems, so they cannot access a deep-water table when needed. Furthermore, old, unmanaged forests has a deeper organic duff layer, with a greater amount and diversity of organisms that constitute the soil sponge. Old natural forests are the pinnacle of what nature has evolved to make Earth the livable planet that it is.

With this biotic pump concept in mind, we can actually understand several enigmas in human history, for example the fact that how Australia had once a very rich vegetation became such a big desert. This happened approximately the same time when the first human settlers came to the continent. If they were making fires in the coastal areas where they were settling at the very beginning, they could just cut the pump off to the inner forest from the ocean, by making areas without vegetation. That would disrupt the moisture flow and then the inner forest would dry out very, very quickly, because the freshwater amount on the land is very small, on a geological time scale, and it could evaporate or run down to the sea in just a few years. In that case we would have seen a desertification of the entire continent nearly instantaneously.

There is a natural fire dynamic in a forest, fires occur naturally but are relatively infrequent. But then you add logging, and the tree stands become even aged, and young, and they have a much higher flammability. At a certain point the threshold is passed, and the ecosystem is put on the self-degradation trajectory and never recovers. There's no recovery at all, and they call this a landscape trap. The landscape is trapped into a drier, depauperate state. Here in the northern hemisphere, we have this temperate and boreal forest belt in Canada, USA (Alaska) and then in Russia, which spreads along the main flow of major weather patterns. In a way we are all connected by this flow. If something happens in Siberia for example and there are big fires and big disruptions, we can have disruptions in this weather pattern. And we will have something like a heat wave, and it continues for a long time, and we have extreme temperatures. These disruptions can actually be related to what we are doing to our forest. If we take care of this forest belt that connects us all, we could actually get rid of these disruptions, or make them much less destructive.



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In the boreal forest of Russia, we can see dramatic difference between precipitation patterns in winter and summer. We have this predominate wind direction from west to east across Eurasia, and, in winter when the forest is dormant… so there is no photosynthesis we can see that precipitation declines sharply from west to east, there is no biotic control of this process. And as the air travel along the continent, it loses moisture, and less and less moisture comes to the east. Then in spring and summer, when the forest awakes and begins to photosynthesize, we see a totally different picture of precipitation that is uniform all

across the Eurasia, like 7,000 kilometers. During this time the forest draws moisture from all the oceans, not just the Atlantic, but also the Pacific and the Arctic ocean. We can see this biotic control of moisture transport, manifested as uniform, practically independent of distance from the ocean. The forest gets the moisture that it requires for normal functioning. If we can compare this to Australia, which doesn't have extensive forest cover, we will see that there…whether there is a wet season or a dry season…we see the decline of precipitation inland independent of the absolute of moisture. There is no regulation of moisture imported into the inner part of the continent. What is important to bear in mind is that the presence of a natural forest that have evolved in a particular region, is that this forest will buffer water cycle extremes. They not only draw moisture inland, but they also do it in a stable and non-chaotic but in a very uniform manner, buffering any extremes that could have happened. With the loss of the local water cycle, water vapour is carried away by the winds, eventually building up and falling somewhere else, but in a more erratic pattern, with more violent storms and floods. Soil on slopes are no longer bound to the substrate by deep roots. Flood waters cannot penetrate parched earth and will rapidly wash away soils, causing erosion, landslides, and muddy rivers. A long cycle of droughts and floods take hold. And the remaining drought-stricken vegetation invites fires. This scenario is playing out in many places, including Canada, California, Chile, and the Amazon.

In Chile's central valley there's a story similar to what happened in Millan Millan's Western Mediterranean region. Santiago, once a lush, fertile valley at the foot of the Andes, watered by seepage from the mountains, is now a paved-over city of 8 million people. The water table used to be about 8 meters down; it's now almost 80 meters down. Forest influence precipitation downwind for hundreds of miles farther inland, in effect becoming a pump that delivers water across a continent. But, according to Millan Millan, as soon as we alter the land cover, even in a small area, by reducing vegetation, or negatively affecting the biota of the soil community, or developing and paving, we immediately affect the precipitation downwind. That is regardless of whether we affect one larger area, or a collection of small ones. It all adds up.

Greenhouse gases spread around the globe, and tend to affect Earth uniformly and gradually over a period of time; but they are only half of the climate story. Altering land cover has an immediate effect on the local temperature and water cycle; further changes to land cover eventually brings us to the point where the local water cycle is destroyed, regional cycles are affected, and only larger scale precipitation occurs. This is the other half of the climate story.

It was known about fifty years ago but has been largely ignored since CO_2 became the focus of attention. Is climate change real? Is it caused by man's activities? If you've ever driven away from a city to a forested area on a hot summer day, you've no doubt noticed that it's much cooler in the forest. Not only is the forest shady, but it cools itself by transpiring water, much like perspiring cools us; the vaporized water carries latent heat energy up into the atmosphere.

Climate regulating forests are natural forest that have evolved this capacity to regulate climate, maintaining a certain homeostasis of certain climate conditions, including the water cycle. Forest can only function normally and efficiently in terms of climate regulation when they have the structure that has been proved by many millions of years of evolution, during which they have evolved this capacity to be stable and to perpetuate in time, together with their climate.

The kind of forest that is capable of maintaining not only itself over time, but the precious water supply, is the forest that has evolved in a given region for thousands of years. Only that kind of forest has the genetic makeup that has been shaped by time to adapt and flourish there. Wisdom suggests we should allow nature to manage as much global forest land as possible without our intervention. That's how our environment came to be, but it has been steadily degraded by our increasing levels of extraction, manipulation, and outright deforestation, all of which is leading to warming, drying, and desert conditions, with more erratic weather patterns. We should embrace "proforestation" wherever possible, which means letting existing forest grow to their full potential without human manipulation, where natural processes have played out as they have for millions of years. Proforestation best enables the biotic pump to bring and keep fresh water on land, and to regulate our climate.

Although we humans constitute .01% of all living biomass on Earth, we've eliminated half of all plant life, and over 80% of all wild mammals. A third of Earth's forest and half of its biomass are gone. More forest acreage falls every day. Putting solar panels on roof tops is worthwhile. But clearing hundreds of acres of forest for a solar farm is counterproductive. As we remove or exploit more and more old, natural forest around the globe, we destroy the mechanism that millions of years of evolution brought about to produce the conditions we find habitable. The entire forest, including all plants, fungi, and animals, is a wondrously integrated, functioning, whole body that provides the climate that we depend on for life as we know it.

After a four-decade career, Millan Millan (1941-2024) an atmosphere physicist passed away in January 2024. Though many of those years, he was disappointed that the findings of his atmospheric research were ignored by most people who might have been able to effect change. But in recent years, he was gratified to see more attention given to his work, which is now becoming much more appreciated. And scientists such as Anastassia Makarieva and others are now furthering the knowledge of how forests are the foundation of terrestrial life on Earth. We wish them great success.

The Biotic Pump Theory Applied to British Columbia

While specific, detailed studies *directly* applying the Biotic Pump Theory (BPT) to British Columbia might be scarce in general searches, BC's vast, moisture-rich coastal and interior forests, like the ancient temperate rainforests and boreal forests, are prime examples of ecosystems where BPT principles *should* apply, driving moisture inland, influencing regional climate, and making BC vulnerable to forest loss impacts like drier conditions, highlighting why intact forests are critical for BC's water cycles, as supported by general climate impact reports.

Key Concepts of Biotic Pump Theory (BPT) & BC Relevance

- Forests as Wind Generators: BPT suggests forests create low-pressure zones through transpiration and condensation, actively pulling moist ocean air inland, creating "Atmospheric rivers" (moisture-laden winds).
- Moisture Transport: This process moves significant moisture far from the coast, sustaining rainfall deep within continents, which is vital for BC's interior.

- Forest Health = Climate Stability: Intact, large forests (like BC's) maximize this effect, ensuring consistent rainfall and preventing overheating; deforestation reverses this, leading to drier, hotter conditions.

Evidence & Implications for BC

- BC's Ecosystems Fit the Model: BC's extensive coniferous forests (Douglas Fir, Spruce, Cedar) are excellent transpiring systems, perfectly positioned to benefit from and contribute to biotic pumping from the Pacific.
- Climate Change Impacts Align with BPT Warnings: Reports for BC note increased fire, drought, and pest outbreaks linked to climate change. BPT explains *why*: forest loss reduces the moisture pump, causing drier conditions and making forests more vulnerable to disturbances, creating feedback loops.
- "Atmospheric Rivers" to BC Interior: The moisture from the Pacific, pumped inland by BC's forests, is essential for the interior's water supply, impacting ecosystems far from the coast.

While the Biotic Pump Theory—proposed by Victor Gorshkov and Anastassia Makarieva—is most frequently associated with large tropical basins like the Amazon, its application to British Columbia (BC) emphasizes the critical role of its vast old-growth forests in maintaining regional hydrological cycles and drawing moisture from the Pacific Ocean.

Application to British Columbia

- Moisture Transport**:** The theory suggests that BC’s contiguous old-growth forests act as a "biotic water pump" by transpiring massive amounts of water vapor during photosynthesis. This high humidity triggers condensation, creating a low-pressure zone that sucks in moist air from the Pacific Ocean.
- Inland Water Supply: This mechanism is viewed as essential for maintaining water supplies in BC’s interior. Without these forested pathways, moisture from the coast might not penetrate as deeply inland, leading to drier conditions in the interior.
- Climate Moderation: The continuous cycle of transpiration and precipitation helps moderate BC's climate, particularly during summer, by recycling water locally in what is known as the "small water cycle".

Local Impacts and Risks

- Deforestation Impacts: Large-scale disturbances—such as industrial logging or wildfires—threaten to disrupt this "pump". If the forest canopy is significantly reduced, the resulting drop in transpiration can weaken the pressure gradient, potentially leading to a permanent shift toward more arid regional climates.
- Role of Old-Growth: Proponents of the theory argue that old-growth forests are more efficient "pumps" than younger plantations because of their immense surface area and complex canopy layers, which maximize evapotranspiration.
- Recent Discussions: In 2025, concerns were raised regarding BC's forest management, specifically the harvest of old-growth trees for wood pellets, which critics argue undermines the forest's ability to regulate the regional water cycle via the biotic pump.

Scientific Context

- Theoretical Status: The biotic pump remains a controversial theory in mainstream meteorology. While proponents argue it provides more accurate wind velocity values than standard models, critics contend that traditional differential heating (convection) is sufficient to explain BC's rainfall

patterns.

- Local Data Integration: Some studies in BC utilize tools like the BC MetPortal and data from the Pacific Climate Impacts Consortium (PCIC) to track shifts in precipitation and evaporation, which are key variables for testing the biotic pump's local effects.
- Where to Find More Information: Look for research by scientists like Dr. Anastassia Makarieva (co-developer of BPT) and Dr. Peter Link: B. Reich on forest hydrology, as well as reports from BC government sources and Biodiversity BC discussing forest impacts, which implicitly support BPT principles. While there is no specific large-scale "biotic pump" study dedicated exclusively to British Columbia (BC), the theory's core principles directly intersect with BC's unique coastal forest ecosystems and their role in regional hydrology.

Relevance to British Columbia

- Coastal Forest Suction: The theory posits that continuous coastal forests create a "suction effect". In BC, the vast old-growth coastal temperate rainforests could theoretically act as this initial pump, drawing moist Pacific air inland through high levels of evapotranspiration.
- Atmospheric Rivers: BC frequently experiences atmospheric rivers—massive corridors of moisture that bring heavy rain. Proponents of the biotic pump theory argue that forests are not passive recipients of these rivers but active drivers that help pull this moisture deep into continental interiors.
- Inland Moisture Transport: The theory suggests that in forested regions, rainfall does not decrease as you move inland. This is relevant to BC's geography, where moisture must travel from the coast across mountain ranges to the interior.
- Climate Resilience: Research in Metro Vancouver highlights that coastal forests provide critical environmental services, including maintaining safe drinking water for over 2.5 million people. The biotic pump theory suggests that preserving these forests is essential for stabilizing this regional water cycle against climate change.

Core Mechanisms of the Biotic Pump. The theory, developed by Anastassia Makarieva and Victor Gorshkov, outlines how forests actively generate weather:

- Pressure Drop: When water vapor transpirated by trees condenses into clouds, it creates a **local** drop in atmospheric pressure.
- Wind Induction: This low-pressure zone "sucks" in moist air from high-pressure areas over the ocean, creating wind that transports moisture inland.
- Rain Nucleation: Forests release volatile organic compounds and microbes that act as cloud condensation nuclei, further facilitating precipitation.
- Scientific Status: The biotic pump remains a controversial hypothesis. While supported by some physicists and ecologists, critics argue that standard meteorological models based on differential heating are sufficient to explain wind and rainfall patterns. Nevertheless, recent discussions in 2025 emphasize its potential for redefining forest management and climate modeling.

Bob Harvey
March 16, 2026