BIOPRECIPITATION

A PRACTICAL GUIDE TO IMPROVE BIOPRECIPITATION OVER LANDSCAPES

Healthy ecosystems play a crucial role in producing precipitation by maintaining the water cycle through various mechanisms. Forests, including tropical rainforests, temperate forests, and boreal forests, are significant contributors. These forests absorb and release water vapor, aiding cloud formation and subsequent precipitation. Wetlands such as marshes, swamps, and bogs store water and gradually release it into the atmosphere via evaporation and transpiration, enhancing local precipitation patterns. Grasslands, including savannas and prairies, also contribute to the water cycle through these processes, though to a lesser extent than forests. Coastal mangrove forests help maintain local humidity levels and influence precipitation through evapotranspiration processes. Even urban green spaces, with abundant vegetation, can contribute to localized increases in precipitation.

Marine ecosystems are equally vital. Oceans, which cover about 71% of the Earth's surface, are major sources of atmospheric moisture. Seawater evaporation adds water vapor to the atmosphere, which eventually cools and condenses to form clouds and precipitation. Coral reefs maintain healthy marine environments and contribute to local humidity and cloud formation, impacting coastal precipitation patterns. Seagrass beds facilitate the exchange of gases and water vapor between the ocean and the atmosphere, influencing local weather patterns and precipitation. Coastal mangroves, as previously mentioned, also play a role in maintaining humidity and impacting precipitation through evapotranspiration.

Together, these terrestrial and marine ecosystems are integral to the global water cycle and significantly impact weather and precipitation patterns both locally and globally.

FORESTS BRING THE RAIN

Forests create and manage rainfall over land. The biotic pump function of large forested areas plays a crucial role in transporting atmospheric moisture from oceanic regions to continental interiors, where it can get recycled as much as 7 times in the case of the largest tropical forest on Earth, the Amazon Rainforest. Forests can influence regional climate patterns and precipitation distribution by creating low-pressure areas through the processes of evapotranspiration (where plants release water vapor during photosynthesis through their leaves into the atmosphere), and through subsequent cloud-forming, whereby the abrupt volume change as water vapor condenses, brings about a sharp pressure reduction. The hydrological cycle involving evapotranspiration followed by cloud-forming, therefore, affects air temperature, wind patterns and, by the absorption of solar energy at the Earth's surface, enables cooling locally by as much as 10 degrees centigrade. All this, underscores the importance of forests in managing hydrological cycles and climate regulation. Indeed, forests and precipitation share a mutual relationship where precipitation influences forest growth and density, while forests contribute to local and regional precipitation patterns through evapotranspiration and cloud formation.

Identifying "acupuncture points" in the landscape for planting trees to enhance the biotic pump effect as effectively as possible involves targeting areas that can significantly impact moisture transport and atmospheric circulation patterns. These strategic locations should ideally have a large percentage of forest cover in ways that strengthen the inland flow of moisture. While comprehensive studies to pinpoint exact locations do not exist, some general principles can guide where these areas might be:

GUIDELINES FOR LANDSCAPE RESTORATION WITH THE RAIN MANAGEMENT CAPACITY OF FORESTS IN MIND

1. Degraded Lands Near Water Sources: Restoring forests on degraded lands, especially those close to oceans, seas, and large lakes, can help initiate moisture flow from these water bodies into continental interiors. Depending on the prevailing winds, a coastal area of at least 10 kilometers inland with at least 80% canopy cover would be a great start in most places.

2. Riparian Zones: Areas along rivers and streams are critical for maintaining connectivity between distant ecosystems, acting as corridors for moisture and species movement. For the health of a watershed, the source areas of rivers and tributaries need to have good native vegetation cover and need to be protected. The same holds true of hedgerows as natural corridors for species movement and as safe areas that species can restock agricultural lands from. When designing planting schemes it is desirable to build in planted corridors to create interconnectivity between environments, this is particularly important when one tries to integrate urban and rural landscapes.

3. Windward Sides of Mountains: Planting trees on the windward sides of mountains can enhance orographic rainfall (rainfall increased by mountains blocking moist air). This can be particularly effective in regions downwind from oceans, where moist air masses are lifted over the mountains, cooling and condensing to form rain. This can also lead to large amounts of precipitation, needing additional water management measures to protect against flooding. If the mountains are not too high, making sure the mountain tops are covered is crucial to pull the moisture to the Lee Side of the Mountains.

4. Deforested Areas within Rainfall Catchments: Targeting areas within important rainfall catchment zones that have been heavily deforested can restore the natural hydrological

functions and enhance rainfall infiltration and storage. Open spots in forested areas are not a problem as long as they don't exceed the size of a square kilometer. Canopy cover is related to the amount of annual precipitation

5. Ecological Edges: Areas where forests meet other ecosystems, such as savannas or grasslands, can be key points for expanding forest cover to modify local climate and moisture patterns. This can quite often be done by reviving existing tree trunks in the soils.

6. Pass Overs in mountainous areas: These lower areas, if thickly wooded, will help pull low hanging clouds through valleys and over pass overs to the lee side where more forest should be available to help the further pull down-slope.

7. Forest Bands: This needs to be better understood, but in the Amazon the recycling of rain happens every few hundred kilometers, so from the coast inwards, if you have a healthy first mangrove + terrestrial forest cover on shore, bands of open areas can be alternated with bands of forests that should then be at least 30 km wide.

8. Urban Peripheries: Expanding and connecting green spaces around urban areas can help in creating moisture corridors into inland areas, potentially reducing urban heat island effects and improving regional climate.

9. Forests can mitigate cyclones: Strategic reforestation around the Indian subcontinent and on the West-African coast could mitigate the formation and strength of cyclones![1][2][3][4]

CAUTIONARY RULES

1. As a rule of thumb, we should only reforest where there once were forests, though that can go back as far as 11000 years ago, since the start of the Holocene, the era that followed the last ice-age, but more practically we could look at the situation since the colonial era. The transition to the Holocene would have seen an expansion of forested areas in for instance the areas of current Spain and Pakistan, influenced by warmer climates and more seasonal rains. Human activity since then has led to gradual and later massive deforestation for agriculture, human settlements, mining and infrastructure, drying out these regions again.

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[1] New satellite-based maps of mangrove heights

[2] Evapotranspiration Characteristics Distinct to Mangrove Ecosystems Are Revealed by Multiple-Site Observations and a Modified Two-Source Model.

[3] Monsoonal Influence on Evapotranspiration of the Tropical Mangrove Forest in Northeast India

[4] The evapotranspiration rate of the mangrove forest in Eastern Thailand

2. We do not plant trees, we plant or assist the regeneration of forests or multi-species agroforests, and definitely not monoculture stands, as these impoverish rather than enrich the environment. The approach to follow is to ensure the restoration of resilient ecosystems that can support a wide range of species, offer more sustainable and robust ecosystem services, support more biodiversity and better withstand environmental pressures, including insect infestations, nutrient deficiencies and are naturally productive in creating healthy soils.

A healthy forest weaves a community of species, from trees and shrubs, to mosses and lichens, birds mammals, reptiles and amphibians all participating in seed dispersal together with the pollinators and other insects, while the soil's microorganisms and decomposers recycle dead matter into nutrients, fueling plant growth and maintaining soil health. This community orchestrates the nutrient and water cycles, with trees drawing up water and returning it to the air for cooling, ensuring the forest's vitality and resilience, embodying a self-sustaining oasis of biodiversity. A healthy forest is holistic cooperation between species, leading to the right conditions for life to thrive.

3. Well-managed agroforestry systems mimic natural forests by establishing a layered vegetation structure with a diversity of plant species, creating habitats for a wide range of wildlife and fostering biodiversity similar to that found in untouched woodlands. By such means, we can enhance soil health through natural nutrient cycling, thanks to the decomposition of organic matter and the action of nitrogen-fixing plants. Meanwhile, such composite vegetation helps regulate water cycles, by improving soils with, consequently, better retention of groundwater, all of which feeds back on tree growth and the leaf area index. The improvements are all positive, benefitting evapotranspiration, cloud-forming and the generation of climatically-beneficial small water cycles. The biodiversity of a mature agroforestry system adjacent to or connected with a healthy natural forest, has a biodiversity index at least 60 per cent that of an adjacent forest.

In drier, savanna-type areas, agroforestry adapts to the open grasslands interspersed with scattered trees, integrating trees, crops, and livestock in a sustainable mosaic that mirrors the natural ecosystem. These systems feature scattered tree cover for shade, fruit, honey and timber, alongside grass and crop integration for rotational grazing and cultivation. Such integrated systems enhance soil fertility and water efficiency. Silvo-pastoral practices merge livestock rearing with tree cultivation, an approach that fosters resilient communities and landscapes that thrive in these areas, with the body-mass growth of grazing animals increasing by at least 50%.

4. The right tree in the right place: In landscape restoration projects, applying the principle of "the right tree in the right place" involves a careful assessment of site conditions, ecological roles, and historical vegetation to select tree species that are mostly (not necessarily all) native and ecologically adapted, enhancing biodiversity and ecosystem resilience. It requires considering climate adaptability, disease and pest resistance, and engaging local communities to align restoration goals with ecosystem services, cultural values and economic production and contributing to biodiversity and contributing to habitat connectivity.

This also means that the degree of canopy cover needs to be attuned to what is possible in that area with regards to the whole picture on water cycle management.

5. While not applicable always and everywhere, we need to adhere to the general rule: slow down outflow. Slowing down the runoff of rainfall is crucial to keep a landscape healthy because it enhances water infiltration into the soil, which replenishes groundwater, reduces soil erosion, and supports plant growth, thereby maintaining the overall ecological balance and agricultural productivity and enhances the recycling via the atmospheric water cycle. The interaction between sufficiently moisturized soils and filled aquifers and the capacity to photosynthesize, produce sufficient aerosols and hence cool and create precipitation needs to be understood when designing regenerative landscapes, giving water sufficient chance to seep into soils and aquifers.

6. All of the above means that our remaining mature original growth ecologies are vitally important resources as diversified gene pools to draw on when we attempt to re-establish fully functioning woodlands or savannas. Transplanting more mature trees with the largest possible root balls including the surrounding soil with all of its microorganisms can provide a full spectrum seeding of diversified ecologies which will grow and evolve very much faster.

This link lists scientific work on the biotic pump and how forests bring and manage rain:

Scientific literature how Forests Bring the Rain

''Our work suggests that forests may protect continental regions from extreme storms. Both the formation and maintenance of cyclones appear to depend on sufficient supplies of water vapor. Extensive forests draw away moisture over the land. When cyclones do form near the coast of continental West Africa, they do so at a latitude where sufficient water vapor is available, that is, between that of wet forests and dry deserts (deserts yield only dry air), where the desiccating effect of neither dominates. This helps explain why these oceanic storms form in two belts 10°–20° north and south of the equator.''[5]

Implementing forest restoration, reforestation and agroforestry on former open land in these strategic locations requires some understanding of regional ecology, climate patterns, and hydrology, including streams, rivers, lakes, wetlands and aquifers. Such efforts should be coupled with comprehensive land-use planning within the ecological, social, and economic context, to maximize the benefits of the biotic pump effect and ensure sustainability. Also important is the application of micro-water management. This entails localized, small-scale strategies aimed at enhancing water retention in the soil and considerably slowing the run off after big rains. It can include swales, bunds, hedge rows, the use of mulches to retain soil moisture, construction of small check dams and ponds for water storage and groundwater recharge, cover crops and agroforestry to improve water retention and reduce erosion and more technical application like drip irrigation in drier areas or seasons. These practices are often

[5] - Sheil D. [Forests, atmospheric water and an uncertain future: the new biology of the global water cycle | Forest Ecosystems]

low-cost and easy to apply. Sometimes nature helps, like in the case of beaver ponds, gofers and mice digging tunnels or elephants digging water holes in dry river beds, alligators and crocodiles that create "gator holes" by digging depressions at the edges of wetlands that hold water during dry periods.

The relationship between Total Precipitable Water (TPW), bioprecipitation, and bioaerosols

CALCULATIONS

Comparing SCP Climate Solution vs Regenerative & Mechanical 3 28 24.xlsx by Ed Huling

Restoring the earth's damaged temperature regulation is the fastest way out of the climate crisis

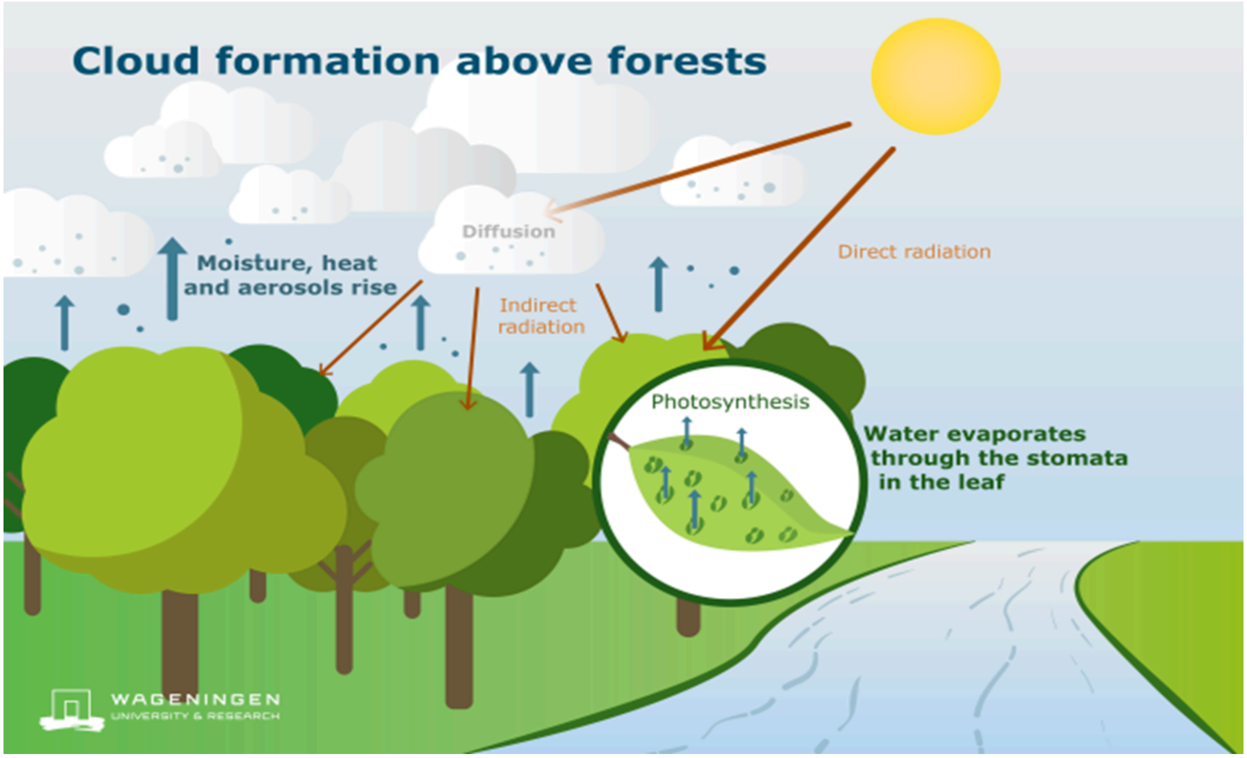
RESOURCES:

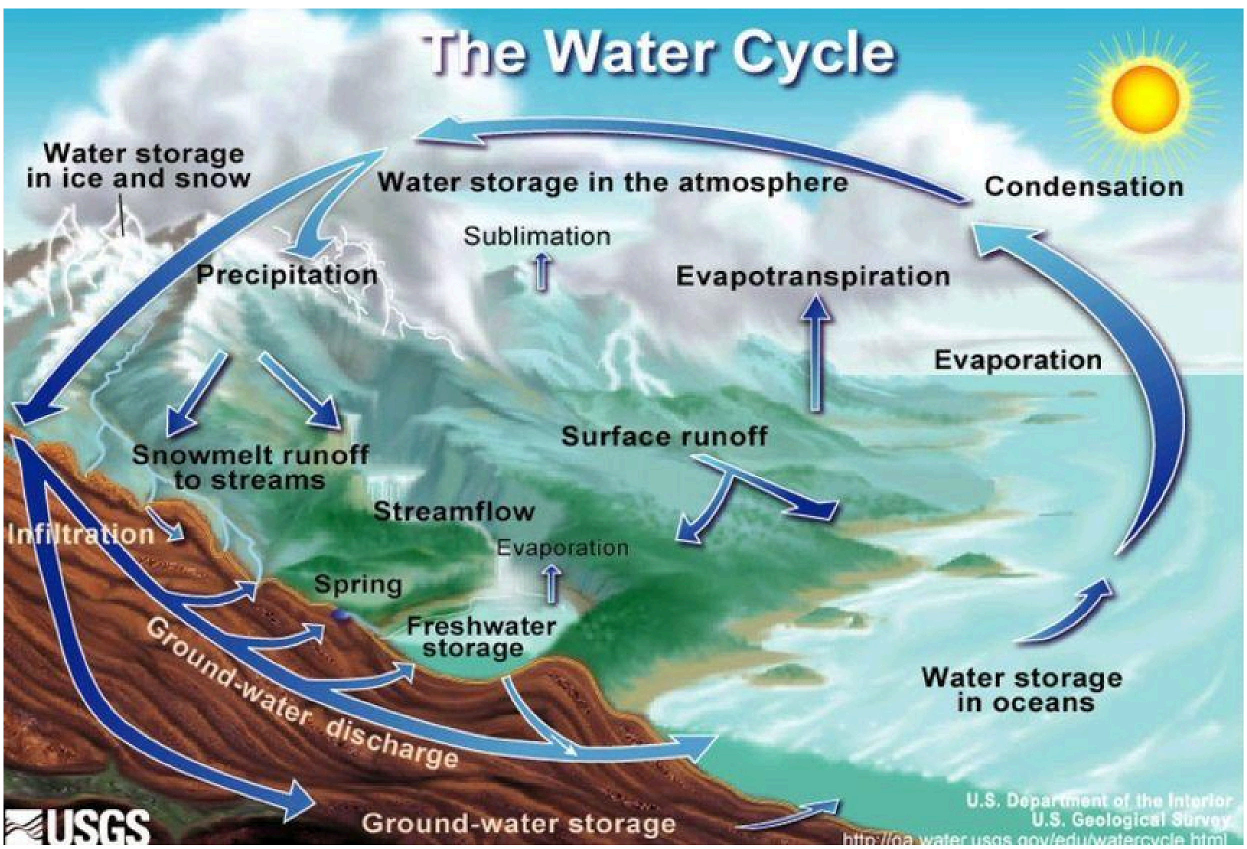
Forests buffer against variations in precipitation
Wetlands and Forests Regulate Climate via Evapotranspiration | SpringerLink
https://en.wikipedia.org/wiki/Forest_Landscape_Integrity_Index
Restoring the earth's damaged temperature regulation is the fastest way out of the climate crisis
(lots of sources in the bibliography)
Soil and Forests

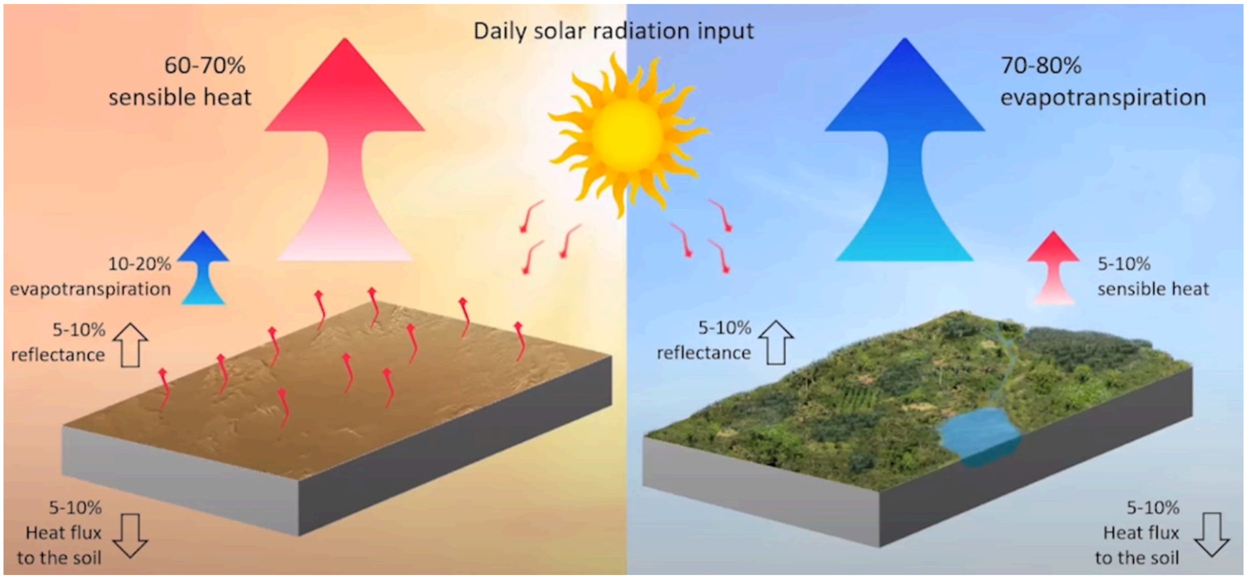
https://substack.com/home/post/p-145825117

Summary: Strategic Afforestation and Its Impact on Bioprecipitation

PICTURES AND VISUAL MATERIAL


Cloud formation above forests
Diffusion
Moisture, heat
and aerosols rise
Direct radiation
Indirect
radiation
Photosynthesis
Water evaporates
through the stomata
in the leaf
WAGENINGEN
UNIVERSITY & RESEARCH


The Water Cycle
Water storage
in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Precipitation
Evapotranspiration
Evaporation
Surface runoff
Snowmelt runoff
to streams
Streamflow
Infiltration
Evaporation
Spring
Freshwater
storage
Ground-water discharge
Water storage
in oceans
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey



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The_Effects_of_Tropical_Vegetation_On_Rainfall

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https://www.youtube.com/watch?v=rO3UAbDLILg (from minute 37 min)