

---

## **Theories of “Reprecipitation” and Climate Change in the Settler Colonial World**

Meredith McKittrick  
[mckittrick@georgetown.edu](mailto:mckittrick@georgetown.edu)  
Georgetown University

### **Introduction**

In the late nineteenth and early twentieth centuries, men trained in science sought to change the climate of arid lands by impounding water in order to increase local atmospheric concentrations of water vapor. They argued that this would create the conditions for increased precipitation: the vapor would condense and fall as rain, which would evaporate and then reprecipitate as more rain, thereby creating a closed weather cycle. These arid lands, located on the margins of expanding empires, could be transformed from deserts into gardens suited to European settlement.

The idea that rainfall could be generated from land-based moisture originated in Europe but gained little traction there. Yet it circulated widely in the arid lands where people of European descent had settled. While controversial among scientific experts and government officials in the colonies, the dream of creating the conditions for local precipitation persisted, in some cases into the 1940s, appearing in North Africa, Brazil, the U.S. West, Australia, South West Africa, and South Africa.

This article traces the idea of reprecipitation as it flowed around the settler colonial world. It asks how the history of meteorology changes when we relocate it both physically and conceptually: from the self-proclaimed center of civilization to geographic margins that aspired to civilized status, and from a teleological story of scientific progress to a more meandering tale of contingency and uncertainty.

Historians freely acknowledge the limitations of climate knowledge prior to the mid-20<sup>th</sup> century. Thomas Dunlap captures some of this uncertainty when he writes of the late nineteenth century, “Expert opinion and the ideas of ‘practical men’ rested on the same foundations, and the experts usually knew no more than the farmers.”<sup>1</sup> And as Paul Edwards notes, the basic model of global circulation was understood by the middle of the 19<sup>th</sup> century, “yet the causal relationship between the circulation and the climate remained poorly understood” until the middle of the 20<sup>th</sup> century.<sup>2</sup> Many of the general factors that shaped climate had been identified, and there was a basic understanding that atmospheric conditions combined with local environmental conditions to shape weather patterns.<sup>3</sup> But the balance of these factors and the extent to which they could be modified was debated well into the 20<sup>th</sup> century.

The reality of what this uncertainty meant is often lost in historians’ quest for the origins of ideas we now take as foundational to our understanding of climate. In recent years, interest in the history of meteorology and climatology has exploded, as scholars seek to understand how these fields developed over the past two centuries.<sup>4</sup> The interest is motivated in large part by contemporary concerns over global climate change, and this has shaped the development of the field. Much of this literature seeks to identify pioneers who first understood what we know today--about past variations in the earth’s climate, the role of carbon dioxide in global warming, or the political implications of climate change, for example. But this is not a simple story of steadily accumulating scientific knowledge. The precursors to contemporary ideas about climate were embedded in an intellectual world from which they are not easily extracted, one that also incorporated ideas that have not withstood the test of time.<sup>5</sup> This fact is widely understood by climate historians, but little is said about those other, now-disproven, ideas.<sup>6</sup> They are regarded as historical dead ends of little consequence, aside perhaps from helping us understand the context of the times that produced the fields of meteorology and climatology.

Following those other, now-discredited ideas can yield its own historical insights, however. Sheila Jasanoff, describing the importance of “sociotechnical imaginaries,” argues that

<sup>1</sup> Thomas Dunlap, *Nature and the English Diaspora: Environment and History in the United States, Canada, and New Zealand* (New York: Cambridge University Press, 1999), 75.

<sup>2</sup> Paul Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA: MIT Press, 2010), 61.

<sup>3</sup> Sam White, “Unpuzzling American Climate: New World Experience and the Foundations of a New Science,” *Isis* 106, no. 3 (2015): 545.

<sup>4</sup> A sampling of recent work includes Vladimir Jankovic, *Reading the Skies: A Cultural History of English Weather, 1650-1820* (Chicago: University of Chicago Press, 2001; orig. Manchester University Press, 2000); James Beattie, Emily O’Gorman, and Matthew Henry, eds., *Climate, Science, and Colonization: Histories from Australia and New Zealand* (New York: Palgrave MacMillan 2014); Philipp Lehman, “Changing Climates: Deserts, Desiccation, and the Rise of Climate Engineering 1870-1950,” Ph.D. diss., Harvard University, 2014; Edwards, *Vast Machine*; Spencer Weart, *The Discovery of Global Warming* (Cambridge: Harvard University Press, 2003); James Rodger Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (New York: Columbia University Press, 2010); James Rodger Fleming, *Historical Perspectives on Climate Change* (New York: Oxford, 1998).

<sup>5</sup> Lehmann, “Changing Climates,” 45-46; Weart, *Discovery*, 5-7; Fleming, *Fixing the Sky*, 4; Fleming, *Historical Perspectives*.

<sup>6</sup> The supposed link between deforestation and reduced rainfall is an exception in this regard.

attending to competing visions of the future “restores some of the indeterminacy of history and avoids the determinism built into grand narratives of scientific progress.” Such imaginaries blend emerging technologies and scientific ideas with “material, moral and social landscapes” – landscapes that might otherwise escape our notice.<sup>7</sup> Following the theory of reprecipitation around the world reveals one set of responses to the winding down of what John Weaver has called “the Great Land Rush.” Settler societies built on decades of territorial acquisition in the temperate zones of North America, southern Africa, Australia, and South America found themselves against limits – often in the form of arid lands that were marginal for growing crops and, in some cases, for raising livestock as well. “[S]ocieties habituated to expansion scrambled for solutions,” Weaver writes.<sup>8</sup> One solution was to alter the climate of these marginal lands.

The scientific foundation for the dream of bringing rain to the world’s arid lands by flooding them was inadvertently laid by two men who are in other respects now considered pioneers: John Murray and Eduard Brückner. Murray is regarded as one of the founders of the field of oceanography (and indeed, is often credited with inventing the term).<sup>9</sup> Brückner, known for his work on glaciers and for using historical evidence to reconstruct past climates, is acclaimed today (including by the society that publishes this journal) as one of the first to think about the social and economic impacts of climate change.<sup>10</sup>

In the context of such achievements, Murray’s and Brückner’s work on reprecipitation is a historical footnote. Brückner’s articles on the land-based origins of rain and the circulation of water on the planet do not appear in a translated and edited volume of his work and are not cited by those who write about the importance of his ideas today.<sup>11</sup> Similarly, Murray’s article that inspired Brückner is not mentioned in any of the major websites dedicated to his achievements. As is often the case with climatology research in the 19<sup>th</sup> century, their work on the origins of rain was motivated by other concerns.<sup>12</sup> Murray’s interest was the ocean floor rather than rainfall: he sought to “estimate what portion of the rain that falls on the land finds its way back again to the ocean by means of rivers,” in part because he wanted to understand the terrestrial origins of marine sediments.<sup>13</sup> Brückner had proposed a 35-year weather cycle but realized that it

<sup>7</sup> “Introduction,” in Sheila Jasanoff and Sang-Hyun Kim, eds., *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (Chicago: University of Chicago Press, 2015), 2, 23.

<sup>8</sup> John C. Weaver, *The Great Land Rush and the Making of the Modern World, 1650-1900* (Montreal: McGill-Queens University Press, 2003), 311-12.

<sup>9</sup> John Rafferty, *Oceans and Oceanography* (New York: Rosen Educational Services, 2011), 242.

<sup>10</sup> Paul Edwards writes that Brückner was an “‘issue entrepreneur,’ promoting political action on the basis of scientific evidence ... a remarkable precursor to modern climate politics.” (Edwards, *Vast Machine*, 67.)

<sup>11</sup> Philipp Lehmann, “Whither Climatology? Brückner’s *Climate Oscillations*, Data Debates, and Dynamic Climatology,” *History of Meteorology* 7 (2015), 49-69; Nico Stehr and Hans von Storch, eds., *Eduard Brückner: The Sources and Consequences of Climate Change and Climate Variability in Historical Times* (Dordrecht: Kluwer Academic Publishers, 2000).

<sup>12</sup> Fleming, *Historical Perspectives*, 65, makes the same observation of Tyndall and Arrhenius.

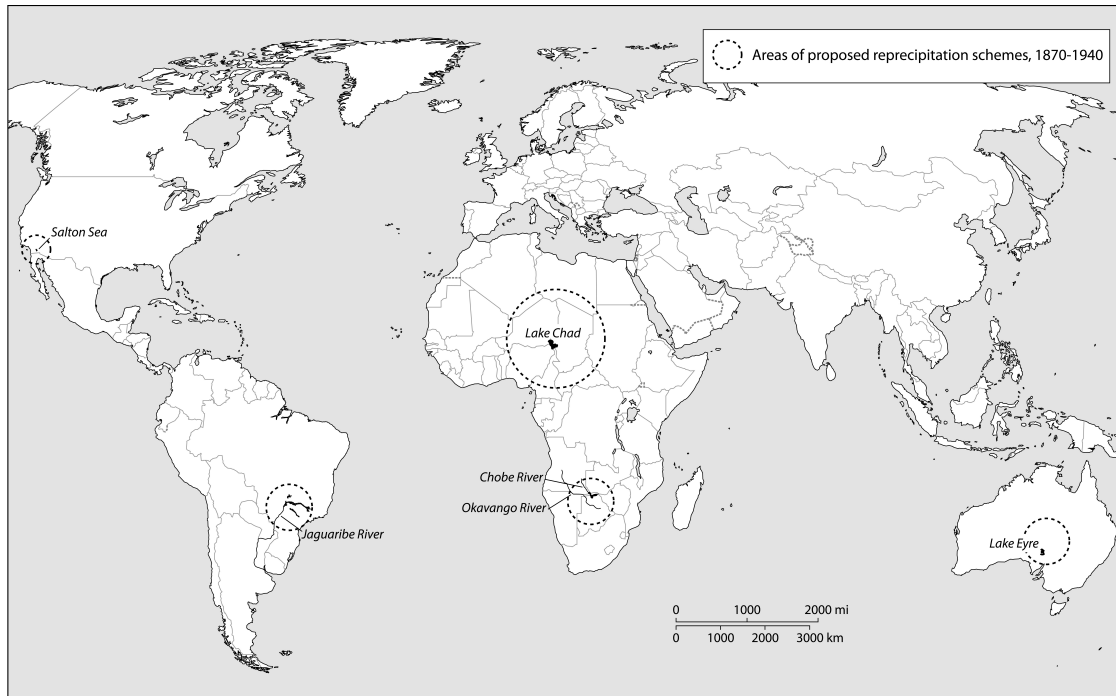
<sup>13</sup> John Murray, “On the Total Annual Rainfall on the Land of the Globe, and the Relation of Rainfall to the Annual Discharge of Rivers,” *Scottish Geographical Magazine* 3 (1887), 65.

seemed to operate differently in western and eastern Europe. His investigation into the origins of rainfall was an attempt to explain the discrepancy and thus to salvage his theory.<sup>14</sup>

But Murray's and Brückner's ideas about the land-based origins of rain rippled far beyond the concerns that gave rise to them. They offered a scientific basis for popular ideas and had a substantial impact on European settler societies emerging on the margins of empire. Explorers and settlers trained in science found in the idea of reprecipitation a way to make sense of why the interior lands they encountered were so arid – and a possible explanation for why evidence of former lakes and running water appeared in places that now appeared waterless. Many argued that a prior, self-perpetuating cycle of rainfall created through the evaporation of water from inland lakes had been disrupted in some way. Surface water had drained away to the sea and initiated a cycle of progressive desiccation – a cycle some said could be reversed. In northeastern Brazil and in southern Namibia, a Brazilian military engineer and a German farmer-scientist cited Brückner when they argued that diverting rivers and creating “inland seas” could increase precipitation and change local climates. Similar schemes using the same logic were proposed for North Africa, Australia, and South Africa. Even when Murray and Brückner were not cited directly, their calculations of the supposed proportion of precipitation originating on land were invoked to prove that such inland seas would indeed increase rainfall. It was the shared – and troubling - experience of aridity in these far-flung lands that gave Murray and Brückner's calculations similar significance in otherwise quite different contexts.

---

<sup>14</sup> Eduard Brückner, “Über die Herkunft des Regens,” *Verhandlungen des VII Internationalen Geographenkongresses* 2 (1899), 412-20; reprinted in *Geographische Zeitschrift* 6 (1900), 89-96. Brückner was part of a larger conversation that sought to calculate the Earth's water balance. See M. I. Lvovitch, “World Water Balance (General Report),” in IASH/UNESCO/WMO, *World Water Balance: Proceedings of the Reading Symposium July 1970* (Gentbrugge: IASH, 1972), 401-415.



**Fig. 1.** Locations of proposed reprecipitation schemes, 1860s-1940s.

Late nineteenth and early twentieth century meteorology thus looks very different when viewed from the edges of empire, in part because the animating concerns were so different. Past evidence of ice ages held little significance in places like Australia's interior, the Sahara, southwestern Africa, the Brazilian *sertão*, and the U.S. West. Here, the driving fear was not a return of glaciers but the specter of drought. When people spoke of climate change they referred not to the cooling or warming of the planet, but to an increase or decrease in rainfall. And here, apparent evidence of past well-watered landscapes – in the form of dry riverbeds and lakeshores, eroded rock, marine fossils and, sometimes, the oral accounts of indigenous people – could not be easily explained by the ending of an ice age and the melting of glaciers. Many who observed these places where geomorphology and current climate seemed to tell conflicting stories speculated that there had been a radical change, one that needed explaining. The work of Murray and Brückner formed the foundation of an explanation.

### Desert mysteries

Historians have paid far more attention to the idea that forests affect rainfall than to the idea that bodies of water could create local precipitation. In part this is because the former was more

widely stated and investigated than the latter.<sup>15</sup> Before geo-engineering became conceivable in the late nineteenth century, planting trees was a more practical intervention than creating bodies of water for those who wished to shape the climate. But the two ideas share a fundamental assumption about the importance of “vapors” on climate – one that was modified in the nineteenth century to accommodate understandings of evaporation and condensation in the water cycle. The idea that land-based water, like forests, played a role in local rainfall seems to have been common sense long before it was scientifically investigated.

In the temperate climates of Europe and eastern North America, people talked about the effect of surface water or forests primarily in terms of air temperature – the feature of the climate that most concerned people. Swamps and forests released more water vapor into the air than open, drained land. Water vapor cooled the air, resulting in a colder climate. It was this concept that served as the basis for the claims of North American settlers that their arrival had moderated the continent’s climate. The removal of trees and cultivation had opened up the land to the heat of the sun and reduced the amount of cooling vapor released into the atmosphere; the result was warmer winters with less snow – but also drier air that was healthier for human bodies.<sup>16</sup> There were those who challenged the idea that changes associated with settlement necessarily improved climate. But the notion of what constituted a climate improvement was quite consistent, and it focused primarily on warmer winter temperatures and less humid air. When European settlers ventured into more arid environments, however, the notion of what an improved climate looked like was turned on its head. Men encountering the dry lands of Southern Africa, the American West, North Africa, and the Australian interior were hardly concerned about too much moisture and cold. The mechanisms that drove climate change were understood in similar ways, but the direction of desirable change was reversed.

In 1843, the missionary, explorer and doctor David Livingstone, traveling in the Kalahari, followed a dry watercourse that “must have been as broad as the Thames at Westminster.” Coming to “what must have been a large lake,” he found collections of fossil bones.<sup>17</sup> A few years later, Livingstone arrived at Lake Ngami in the Okavango Delta, on the northern edge of the Kalahari, and observed that it had been much larger in the past. Describing the outlet of the lake, he wrote, “The water supply of this part of the river system ... takes place in channels prepared for a much more copious flow. It resembles a deserted Eastern garden, where all the

---

<sup>15</sup> See e.g. Richard Grove, *Green Imperialism*. In the 19<sup>th</sup> century, a diverse range of scientists sought to demonstrate the impact of forests on rainfall. See A. Woeikof, “Der Einfluss der Wälder auf das Klima,” *Petermanns Mitteilungen* 31 (1885), 81-87. He notes that the difference in evaporation between forest and nonforest areas is too great to be explained by the greater moisture, and lower temperature of forests and argues that it is the capacity of forests to reduce wind that matters. His arguments influenced Ferdinand Gessert, the reprecipitation enthusiast in South West Africa.

<sup>16</sup> Fleming, *Historical Perspectives*, Chapter 2. Also Clarence Gacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the 18<sup>th</sup> Century* (Berkeley: University of California Press, 1973), 687-9.

<sup>17</sup> Quoted in Georgina Endfield and David Nash, “Drought, Desiccation, and Discourse: Missionary Correspondence and Nineteenth-Century Climate Change in Central Southern Africa,” *The Geographical Journal* 168, no. 1 (2002), 39.

embankments and canals for irrigation can be traced, but where the main dam and sluices having been allowed to get out of repair, only a small portion can be laid under water.”<sup>18</sup> Livingstone repeatedly referenced the “proofs of desiccation met with so abundantly throughout the country” – local people who insisted dry streambeds had once watered rich herds of cattle; shorelines and mollusk shells found far from existing surface water; pools that had vanished and springs that had weakened over the course of a few years.<sup>19</sup>

Livingstone’s experiences were shared by many newcomers to the Kalahari and its margins, but their explanations for such apparently recent and radical changes varied. Many blamed the loss of forests at the hands of African and European settlers, resting their arguments on the popular belief that forests attract rain. Livingstone speculated that geomorphological changes were the cause. The African continent is an inverted bowl, with high ridges along its edges and lower elevations in the interior. This bowl had trapped large quantities of water, Livingstone reasoned, until breaches in the ramparts along the margins, made via erosion or earthquakes, allowed the water to escape. Livingstone surmised that the Zambezi River was once “collected in a vast lake” that had drained when the earth fissured to create Victoria Falls, thereby diverting the mighty river to the Indian Ocean.<sup>20</sup>

The geographer Siegfried Passarge, surveying the Kalahari in the late 1890s, reviewed the accounts of 19<sup>th</sup>-century travelers and concluded, “a wealth of observations not only indicates a decline in water in historical times, but deposits, river beds, old lakebeds, imply a very different climate and a much greater water supply.”<sup>21</sup> While noting that many writers in South Africa and beyond attributed a drying climate to deforestation, Passarge insisted that there was no evidence of deforestation in the Kalahari and its margins.<sup>22</sup>

In the 1860s, Americans also wondered at the evidence of once-abundant water in dry lands. A doctor named Joseph Widney, traveling across the Colorado Desert, wrote that the desert was “a serious disturbing element in the climate of southern California,” a “huge furnace from which withering blasts make forays upon more favored territories around.” But it had not always been thus: Widney also observed “the parched and death-stricken remains of some ancient world.” Aquatic fossils, stands of dead trees, a well-defined shoreline, and local tales of vanished human populations in this waterless land prompted him to conclude that the area’s climate had changed dramatically only a few centuries before.<sup>23</sup> The basin had once been a gulf, he wrote, “its waters shallow and easily heated ... a steaming cauldron, keeping the air-currents

<sup>18</sup> David Livingstone, *Missionary Travels and Researches in South Africa* (New York: Harper and Brothers, 1858), 79-80.

<sup>19</sup> Livingstone, *Missionary Travels*, 76; also 16, 62, 125. Livingstone’s father-in-law, the missionary Robert Moffat, traveled through a valley in what is now eastern Botswana and also marveled at evidence of water erosion in the form of smoothed stones and boulders (Endfield and Nash, “Drought,” 40).

<sup>20</sup> Livingstone, *Missionary Travels*, 363.

<sup>21</sup> Siegfried Passarge, *Die Kalahari: Versuch einer physisch-geographischen Darstellung der Sandfelder des südafrikanischen Beckens* (Berlin: Dietrich Reimer, 1904), 103.

<sup>22</sup> Passarge, *Die Kalahari*, 662.

<sup>23</sup> Joseph Widney, “The Colorado Desert,” *Overland Monthly*, 10 (Jan. 1873), 44-50.

above constantly saturated with moisture.” He argued that the evaporation from the gulf, “if all recondensed and precipitated” would have added 12 inches of rain over an area twice the size of Ohio and lowered the temperature significantly. The lower evaporation rates of a cooler climate had once allowed water to percolate into the ground and feed springs and streams, he argued.<sup>24</sup>

Widney concluded that diverting the Colorado River toward the now-dry basin in order to form a freshwater lake would reestablish these conditions. The proposal was popular, but an 1874 report concluded that his claims for climate amelioration required further investigation.<sup>25</sup> That investigation never seems to have happened. Charles John Frémont, governor of Arizona territory in the late 1870s, temporarily resurrected Widney’s idea to dam the Colorado in order to fill the Salton Sea. Frémont argued that resulting vapors “would cool off the entire American Southwest, changing its arid climate,” and he proposed to Mexican president Porfirio Díaz that they work together to create “an agricultural paradise.”<sup>26</sup>

The existence of shallow pans, seasonal swamps, lakes that were occasionally filled with water, fossil riverbeds and water channels, and evidence of aquatic life and water erosion puzzled these visitors from temperate zones. The concept of an Earth that was more than a few thousand years old was still relatively new. By the late 19<sup>th</sup> century the planet was regarded by most men of science as somewhere between 50 million and 150 million years old.<sup>27</sup> But accounts of local people and the presence of dead trees, mollusk shells, and other apparently recent traces of wetter times led even visitors who were not attached to biblical time scales to assume that changes had taken place over the course of centuries – or at most millennia – not over millions of years. These changes thus appeared relatively recent.

There also is little indication that new arrivals understood that these features might be a normal part of deserts; arid and semi-arid environments were largely conceived as waterless. Instead, the geomorphology of many desert landscapes led travelers to conclude that aridity was a new condition, evidence that nature had taken a wrong turn – one that perhaps could be reversed. It was an idea echoed as late as the 1940s by the popular Australian writer Ion Idriess, who described the dry riverbeds that crossed the interior, evoking a climate “which once spilled great quantities of water into what is now desert.”<sup>28</sup> “Watercourses from opposite points of the compass, coming from the far east and far west, have been designed by nature to meet,” he wrote. “It would be one of the greatest meetings of the waters in the world if these waters did

<sup>24</sup> Widney, “Colorado Desert,” 47.

<sup>25</sup> P. Laflin, *The Salton Sea: California’s Overlooked Treasure* (Indio: Coachella Valley Historical Society 1995), Ch. 1.

<sup>26</sup> Andrew Rolle, *John Charles Frémont: Character as Destiny* (Norman: University of Oklahoma Press 1991), 251. President Díaz’s response is not recorded. Eventually, Widney’s proposed scheme was carried out – although by accident rather than design. The Salton Basin partially refilled in 1905-07, when the Colorado River overwhelmed diversion canals meant to bring irrigation water into the basin. A 1915 study by a team of engineers concluded that the creation of the sea had not changed the area’s rainfall. H.T. Cory and William Blake, *The Imperial Valley and the Salton Sink* (San Francisco: J. J. Newbegin, 1915), 14-16.

<sup>27</sup> G. Brent Dalrymple, *The Age of the Earth* (Stanford: Stanford University Press, 1991).

<sup>28</sup> Ion Idriess, *The Great Boomerang* (London: Angus and Robertson 1948), 18.



meet, as in ages past. ... Those thousands of square miles of barren hollow should and were meant to be filled by a chain of freshwater lakes.”<sup>29</sup>

The impression of a lost pluvial golden age was particularly powerful in North Africa, which – unlike other arid environments Europeans encountered in the 19<sup>th</sup> century – had long been part of Europe’s known world. Many French writers argued that North Africa had once been among the most fertile places on earth, and physical features in the landscape suggested a wetter past. As Diana Davis has shown for French Algeria, the idea that the land had become sterile through mismanagement by the local people drove key aspects of French policy, including projects to plant trees and laws restricting indigenous Algerians’ access to forest resources.<sup>30</sup>

Here as elsewhere, ideas about increasing rainfall through afforestation coexisted with plans to increase rainfall through creating large bodies of water. In 1874, the military officer and engineer François Roudaire noted the vast, dry “chotts” or pans in the Saharan lands France was claiming. Roudaire suggested that sand blown from the south had filled channels that delivered water to the chotts. “The retreat of the waters to the sea appears ... to have profoundly modified the climate of these flourishing regions.”<sup>31</sup> Roudaire claimed the newly constructed Suez Canal was influencing precipitation on the surrounding land. The implications for the Sahara were dramatic: if a simple canal could increase rainfall, a “vast gulf” recreated in the chotts could have a much greater impact, he argued.<sup>32</sup> Roudaire proposed diverting Mediterranean water inland to create a “Saharan Sea” and secured the support of Ferdinand de Lesseps, the French diplomat who had recently overseen the successful completion of the Suez Canal.<sup>33</sup> The British engineer Donald Mackenzie, who simultaneously proposed a similar scheme, also argued that diverting water into the chotts would create a self-reinforcing cycle: “the rivers which find their way into this depression would be considerably larger, because the evaporation would cause the rainfall to be much heavier in the surrounding countries.”<sup>34</sup>

Such ideas were not limited to the realm of folk culture and educated lay people. In 1885, the geologist and botanist Ralph Tate argued that Australia’s geomorphology told a similar tale. “A vastly increased rainfall over what is now the arid region of Australia in former times is demanded by the extinct rivers and lakes and the former existence of large herbivores,” he wrote. Tate did not dwell on the causes of this change, but he saw such shifts as self-reinforcing cycles: “The replacement of the arid plains by freshwater seas, though a consequence of an amelioration

<sup>29</sup> Idriess, *Boomerang*, 31.

<sup>30</sup> Diana K. Davis, “Restoring Roman Nature: French Identity and North African Environmental History,” in Diana K. Davis and Edmund Burke III, *Environmental Imaginaries of the Middle East and North Africa* (Athens: Ohio University Press 2011), 70-74; see also Diana Davis, *Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa* (Athens: Ohio University Press 2007).

<sup>31</sup> François Elie Roudaire, *Rapport à M. le Ministre de l’Instruction Publique sur la Mission des Chotts: Études relatives au projet de mer intérieure* (Paris: Imprimerie Nationale, 10<sup>th</sup> ed., 1877), 79.

<sup>32</sup> Roudaire, *Rapport*, 66.

<sup>33</sup> Lehmann, “Changing Climates” Chapter 2, details the Sahara Sea scheme.

<sup>34</sup> Donald Mackenzie, *The Flooding of the Sahara: An Account of the Proposed Plan for Opening Central Africa to Commerce and Civilization from the North West Coast* (London: Sampson Low, Marston, Searle, and Rivington, 1877), 222-223.

of climate, must have had a reciprocal effect, conversely as the existence of a dry zone produces aridity and thereby intensifies the effect.”<sup>35</sup> Irrigation, too, could theoretically increase precipitation: John Wesley Powell, lauded now for his realistic assessment of the U.S. semi-arid lands, predicted in 1888 that bringing irrigation to “lands that now present the desolation of deserts” would allow the local evaporation of water that would otherwise run to the sea, “and the humidity of the climate will be increased thereby ... As the general humidity is increased, the moister air, as it drifts eastward in great atmospheric currents, will discharge more copious rain ... as the lands gain more and more water from the heavens by rains, they will need less and less water from canals and reservoirs.”<sup>36</sup>

### On the origins of rain

If the belief that the local production of water vapor had a direct relationship to rainfall was an old one, it was given scientific respectability at about the same time that Powell was speculating about the impact of irrigation channels on the climate. In 1887, John Murray published an article that attempted to quantify what proportion of rain falling on land ran to the oceans and what portion evaporated into the atmosphere. In the 1870s the Canadian-Scottish Murray had been part of the *Challenger* expedition, a four-year endeavor to explore the world’s oceans. In subsequent decades, he continued his marine research from Scotland and oversaw the publication of a 50-volume report on the *Challenger* expedition. Murray’s interest in the question of rainfall derived from his interest in the oceans: he sought to “estimate what portion of the rain that falls on the land finds its way back again to the ocean by means of rivers,” in part because he wanted to understand the origins of the solids that had been deposited on the ocean floor.<sup>37</sup> Murray admitted that his data were imperfect: He used a world rainfall map created by Elias Loomis, a Yale professor of natural philosophy with an interest in meteorology, in order to calculate mean rainfall in various river drainage basins, on continents, and over 10-degree bands of latitude. Murray also relied on existing measurements of river flow – data whose inaccuracies mirrored the unevenness of European knowledge of the world. He thus overstated the importance of the rivers Europeans knew best, and underestimated the flow of many that were less well known.<sup>38</sup> His deceptively precise conclusion -- that 1/4.499 of the rain that fell on land ran to the oceans-- was thus built on a numerical house of cards. But it carried with it a powerful implication: that

<sup>35</sup> Ralph Tate, “Post-Miocene Climate in South Australia,” *Transactions and Proceedings and Report of the Royal Society of South Australia* 8 (1884-5), 53, 55.

<sup>36</sup> John Wesley Powell, “Trees on Arid Lands,” *Science* 12, no. 297 (Oct. 1888), 170-1. Grove Karl Gilbert of the US Geological Survey wrote the chapter on water supply in Powell’s 1879 report, speculating that the impact of the Great Salt Lake on the climate of the land just east of it was to vastly increase humidity and precipitation. *Report on the Arid Lands*, 79-80.

<sup>37</sup> John Murray, “On the Total Annual Rainfall on the Land of the Globe, and the Relation of Rainfall to the Annual Discharge of Rivers,” *Scottish Geographical Magazine* vol. 3 (1887), 65.

<sup>38</sup> As just one example, Murray used figures for Asian rivers, such as the Indus and Ganges, that were around half and one-fifth their actual flows.

virtually all the rest was evaporated into the air and reprecipitated as rain. Thus, most of the rain that fell on the earth's land surfaces did not come from the oceans, as many held, but rather came from water vapor derived from land surfaces.

In an article titled "On the Origins of Rain," the German scientist Eduard Brückner seized on Murray's argument. Brückner noted that most scientists had assumed that rainfall derived almost entirely from the oceans. A few geographers, including the Austrian Alexander Supan and the Russian Alexander Woiekof, had speculated that land-based evaporation contributed to rainfall, mainly in the form of transpiration from trees. But scientists had been unable to calculate how much water vapor the earth's land surfaces contributed to the atmosphere because there had not been a reliable way to measure global evaporation. Murray's calculations, combining river flow and rainfall data, offered a way out of this predicament. Brückner - simplifying Murray's figure - argued that if only 22%, or 2/9, of the water that falls on land returns to the sea, it followed that the rest was eventually evaporating from the land itself. Brückner concluded: "The role of the land's surface is not passive in the water cycle; to an enormous extent it contributes to the moisture content of the air: nearly two-thirds of falling rain comes from the water vapor delivered by the land surface, and so are of continental origin. ... A water particle, which came to the country from the ocean through the atmosphere, falls an average of three times as precipitation, before it returns to the bosom of the ocean."<sup>39</sup>

Brückner and Murray were part of a growing interest among scientists in working out the "water balance" of a given region by measuring precipitation, streamflow, and evaporation -- an interest which eventually extended to the water cycle of the entire planet.<sup>40</sup> But Brückner, like Murray, was motivated by other concerns. He had recently proposed a 35-year cycle of rainfall, and he had realized that it worked differently in western and eastern Europe. Ideas of land-based rainfall offered a way out of this conundrum: Brückner suggested that evaporation in western Europe ultimately contributed to precipitation in eastern Europe - but did so on a delay as the recycling process played itself out, thereby explaining why the continent's weather cycles were not synchronized.

Land-based water vapor could only come from surface evaporation or transpiration from plants. Murray and Brückner's work therefore breathed new life into debates about the impact of forests on rainfall, as transpiration from trees was considered a major source of water vapor. The theory that forests attract rain remained controversial into the early 20<sup>th</sup> century but it was by no means entirely discarded. Instead, some scientists suggested that new understandings of atmospheric processes offered a mechanism that could explain the role of forests in precipitation. In 1912, Raphael Zon of the U.S. Forest Service cited Brückner's work in arguing that forests were a key source of the water vapor generated on land. Winds that blew onto the U.S. mainland from the Atlantic and Gulf dropped their load of moisture fairly close to the coasts. Without the

---

<sup>39</sup> Brückner, "Über die Herkunft," 96.

<sup>40</sup> Jamie Linton, *What is Water? The History of a Modern Abstraction* (Vancouver: University of British Columbia Press, 2010), 114-15.

“vast forest areas” of the coastal plains and the Appalachians, there would be no new source of moisture. The southerly winds that blew into the prairies would be dry and the American breadbasket would produce a vastly smaller harvest. The forests of the eastern United States explained why the Midwest did not look like the U.S. West, Zon argued: they helped recycle oceanic rainfall on land, ensuring that interior areas received precipitation.<sup>41</sup>

American agronomy also adopted these ideas. In an essay on plant succession and crop production, a professor of botany at Ohio State University restated Brückner’s ideas to explain precipitation patterns in the United States and is worth quoting at length:

It is not difficult to see that if an air current loaded with moisture from an ocean reservoir reached a land area and deposited some of this water, the air current would become rapidly dry as it passed over the land. Very little moisture would, under these conditions, be transported inland for any great distance. An examination of the earth shows that a good deal of water falls on the land at some distance from the oceans, leading up to the obvious conclusion that a current of air is picking up water vapor and precipitation water all the time as it passes over a continent. ... A current of air moving over the land and precipitating moisture would be continually having more moisture added to it, a reinforcement of the supply so to speak, from the evaporation of water from the land surface.<sup>42</sup>

As Jamie Linton has argued, “a kind of hydrological Orientalism” was at work in many of these scientific attempts to represent the water cycle and imagine the origins of rainfall. They were rooted in “a discourse that normalizes copious volumes of liquid surface water” and demonstrated “faith in the universality of humidity.”<sup>43</sup> It was in semi-arid and arid environments where such faith was most dramatically tested. In the absence of vast tracts of forests – or the possibility of establishing them – the idea of reprecipitation came to rely almost entirely on the existence of bodies of water. The xerophytic plants of these areas released very little water vapor into the air, as Edwin Quayle, an Australian meteorologist, noted. Quayle investigated the impact of both surface water and the irrigated cultivation of non-native plants such as wheat on Australia’s rainfall. He argued, on the basis of rainfall records, that widespread irrigation in parts of the country had caused an increase in rainfall – but also that rainfall was higher near bodies of water such as Spencer’s Gulf.<sup>44</sup>

<sup>41</sup> Raphael Zon, “Forests and Water in Light of Scientific Investigation,” Appendix V of *Final Report of the National Waterways Commission* (Washington: Government Printing Office 1912).

<sup>42</sup> Adolph E. Waller, “The Relation of Plant Succession to Crop Production: A Contribution to Crop Ecology,” *The Ohio State University Bulletin* 25, no. 9 (Jan. 20, 1921), 19-22.

<sup>43</sup> Linton, *What is Water?*, 123-24. Linton notes that modern diagrams of the water cycle do the same thing.

<sup>44</sup> E.T. Quayle, “Possibilities of Modifying Climate by Human Agency, with Special Application to South-eastern Australia,” *Proceedings of the Royal Society of Victoria* 33 (1921), 115-132.

In 1921, a German hydrologist named Karl Fischer critiqued Brückner's 1899 article, arguing that Brückner seemed to posit an inner water cycle, independent of the general circulation of the atmosphere – an assumption that did not stand up to scrutiny. Fischer noted that some of the water evaporated from land drifted to oceans and precipitated as rainfall there, and vice versa. The hard and fast figure of 7/9 was thus based on a simplistic understanding of the water cycle.<sup>45</sup> Yet debates continued. Sixteen years later, a popular climatology textbook by W.J. Humphreys, a former president of the American Meteorological Society, stated, "All rain on land does trace back, of course, to evaporation over the great bodies of water, but in part through one or more reevaporations and reprecipitations." Humphreys repeated a simplified version of Murray's figure, stating that "the total annual run-off from all lands" is about one-fourth the total precipitation that falls on them. And he reiterated the concept of the self-reinforcing cycle: "[A] wet region furnishes abundant evaporation for the production of more rain, while a dry one, of course, furnishes relatively little evaporation and therefore tends to remain dry. In short, droughts tend to hang on and rainy spells to persist – little rain less rain, much rain more rain."<sup>46</sup>

The importance of local conditions in the weather cycle made sense to many people seeking to understand the logic of the climate. But it appeared particularly logical to men grappling with those parts of the world that little interested Murray and Brückner: the arid lands Europeans were encountering in the 19<sup>th</sup> century, many of them part of closed drainage basins. These closed basins were commonly regarded as being in some sort of balance: Zon stated of them that "the precipitation and evaporation are, as a rule, equal."<sup>47</sup> But if conditions on the ground shaped the amount of water vapor that could precipitate as rain, what would happen if conditions inside one of these basins changed? At this point, men who marveled at evidence of once-abundant water in lands that were now dry picked up the emerging scientific understanding of the water cycle and decided that humans could shape the climate by engineering the surface of the land.

### Redemption through reprecipitation

When Widney and Roudaire thought about bringing water into deserts to make it rain, they were working from an understanding of the origins of rain derived from folk knowledge and what was accepted as common sense. Their successors were often trained in science, and they cited the research of respected scientists such as Brückner and Supan when they argued for the feasibility of their climate-engineering schemes. And although no one seems to have cited Murray's 1887

<sup>45</sup> Karl Fischer, "Die Grundgleichungen des Wasserhaushaltes der Flussgebiete," *Meteorologische Zeitschrift* 38 (1921), especially 333-35.

<sup>46</sup> W.J. Humphreys, *Weather Rambles* (Baltimore: Williams and Wilkins Company, 1937), 251-2.

<sup>47</sup> Zon, "Forests and Water," 224.

article, his calculation of the amount of rain that derived from land-based evaporation was treated as fact by those who hoped to create cycles of reprecipitation in arid environments.

One of the first of this new generation of aspiring climate engineers was Ferdinand Gessert, trained in physics in Germany. In the 1890s, Gessert used the prize money he'd won for a physics paper to travel to the southern part of Germany's new colony of South West Africa, an area whose average rainfall was less than 150 mm a year. There he acquired a 50,000-hectare farm from a local chief. Gessert began to teach himself farming, experimenting with water storage, irrigation, and a variety of crops. But within two years of his arrival, he was also considering the possibility of changing the climate of his adopted home.

German officials had already suggested diverting the Kunene, a perennial river on the colony's northern border, in order to relieve intense water shortages in a nearby region where most of the colony's African population lived.<sup>48</sup> Gessert argued that such a diversion would do more than increase the water supply; it would quite likely improve the climate by filling Etosha Pan, a seasonal drainage basin whose ancient shorelines indicated it had been much larger in the past, thereby increasing atmospheric humidity and precipitation.<sup>49</sup>

The evidence Gessert marshaled to support his claim illustrates the range of literature he managed to acquire from his outpost on the margins of the Namib Desert. South West Africa was twice the size of California and had fewer than 1000 Germans living in it, most of them clustered in a few towns. Yet Gessert was aware that others were venturing into arid zones around the globe. He cited the accounts of visitors to the Gobi Desert -- a place where, he argued, the disappearance of a large lake had reduced rainfall and caused advanced civilizations to collapse. Gessert used German colonial publications to contrast the fate of the Gobi to that of East Africa, where the Great Lakes sustained a rain-rich climate and a promising German colony.<sup>50</sup> The farmer-physicist also must have read Powell's report on the arid lands of the United States, because he summarized Grove Karl Gilbert's chapter in the report, which argued that water evaporating from the Great Salt Lake in North America condensed on the surrounding mountains, resulting in markedly higher rainfall around the lake's eastern shores.<sup>51</sup> And he discussed -- approvingly -- Roudaire's plan for an inland sea in the Sahara.<sup>52</sup>

Gessert also referenced nearly every published account by 19<sup>th</sup>-century explorers in southwestern Africa to support his contention that the climate of southern Africa was becoming increasingly dry -- "on the path to the desert," as he put it. Echoing Livingstone, Gessert wrote that southern Africa was suffering the fate of the Gobi, its surface water vanishing due to

<sup>48</sup> It's unclear who first suggested diverting the Kunene River into north-central Namibia, but it is referenced in P.H. Brincker, "Bemerkungen zu Bernsmanns Karte des Ovambolandes," *Globus* 70, no.5 (1896), 80.

<sup>49</sup> Ferdinand Gessert, "Der Seewind Deutsch-Südwestafrikas und seine Folgen," *Globus* 72, no. 19 (1897), 297-99.

<sup>50</sup> Ferdinand Gessert, "Klimatische Folgen einer Kunene-Ableitung," *Globus* 71, no. 24 (1897), 391-2.

<sup>51</sup> Gessert, "Klimatische Folgen," 391-2.

<sup>52</sup> Ferdinand Gessert, "Die mutmasslichen klimatischen Folgen einer Kunene-Ableitung," *Zeitschrift für Kolonialpolitik, Kolonialrecht und Kolonialwirtschaft herausgegeben von der Deutschen Kolonialgesellschaft* 6 (1904), 161.

geomorphological changes. Livingstone had suggested that the Zambezi was to blame for the draining of southern Africa; Gessert added the Kunene, which emptied into the Atlantic. Both rivers, he said, had once drained inland but were now “gnawing” into the terrain, seizing inland-draining rivers and sending their water to the oceans.<sup>53</sup>

Brückner’s article was crucial to Gessert’s theory that river diversion could repair this damage – and that in the absence of such diversion, rainfall would continue to decline. Gessert cited Brückner when he argued that 7/9 of the rain that fell on land was reprecipitated – derived from water evaporated from the continents rather than from the oceans. He echoed Woiekof without attribution when he wrote that reprecipitation accounted for the heavy rainfall along the Amazon River. For Gessert, this meant that providing more land-based water vapor was an urgent necessity. The vast lake that would result from diverting the Kunene inland would save southwestern Africa from becoming a vast desert.<sup>54</sup>

These ideas were adopted by other Germans in southern Africa. The farmer Heinrich Paulsmeier wrote to the *South African Agricultural Journal* in 1914, “It is quite certain that such a large sheet of water in the center of southern Africa must have had a decided influence for the good on the rainfall of South Africa.”<sup>55</sup> The geographer Passarge agreed but placed the Kalahari in the context of the entire continent’s climate history. Aware that the Sahara had once been wetter, Passarge speculated that Africa had experienced cycles of moister and drier conditions that mirrored the ice ages of Europe. But then, Passarge wondered, why had the Congo basin retained its water even in a cycle of declining rainfall while the Sahara and the Kalahari had lost so much of theirs? Passarge’s answer was drawn from Brückner, as well as Supan and Woiekof: The Congo basin’s moisture was reprecipitated, derived “from the Congo Basin itself.” By contrast, the geomorphology and wind systems of the Sahara and the Kalahari combined to ensure that evaporated water was swept away, to fall as rain elsewhere. As a result, central Africa remained dominated by rivers and moist forest, while desert conditions prevailed at the northern and southern ends of the continent.<sup>56</sup>

Gessert’s proposal to reverse this pattern of water loss was given a much wider audience by another scientist of German ancestry: a British-born geology professor named Ernest Schwarz. Schwarz had arrived in South Africa a year after Gessert, working for the Cape Geological Survey before becoming a professor at Rhodes University. Like others, he was impressed by the marine fossils and water-sculpted landforms he found while surveying the Cape’s arid lands. In 1918, Schwarz assured readers of South Africa’s largest newspaper that the subcontinent was drying up and that without measures to increase its rainfall, white South Africans would soon find themselves enveloped by an expanding Kalahari.<sup>57</sup> Most progressive farmers and

<sup>53</sup> Ferdinand Gessert, “Über Rentabilität und Baukosten einer Kunene-Ableitung,” *Globus* 85, no. 21 (1904), 339, 348.

<sup>54</sup> Gessert, “Über Rentabilität und Baukosten,” 348-52.

<sup>55</sup> H. Paulsmeier, letter to the editor, *South African Agricultural Journal* 7 (Jan.-July 1914), 737-8.

<sup>56</sup> Passarge, *Die Kalahari*, 664.

<sup>57</sup> Schwarz, “Remedy for Droughts,” *Johannesburg Star*, Jan. 30 1918.

government scientists denied that rainfall was declining in South Africa, but much of the white population believed that it was.<sup>58</sup> Schwarz therefore found fertile ground for his ideas. A few months after his newspaper article appeared, he developed his argument in an academic paper he read before the South African Association for the Advancement of Science – and then, in 1920, published a popular book on the subject.<sup>59</sup>

Taking his readers on a tour of the African continent, Schwarz sketched a picture of a large inland plateau that had once been abundantly watered by slow-moving rivers that fed extensive networks of lakes and pans. All this surface water had created higher precipitation levels and kept the land lush and green. In Schwarz's historical reconstruction of African hydrology, fast-moving coastal rivers that plunged from the plateau to the sea had, over time, lengthened themselves through erosion at their headwaters, "capturing" these slower rivers and draining away their water. The loss of massive quantities of interior surface water caused rainfall to decline. The outcome of these processes was the Sahara and the Kalahari – deserts that continued to expand.

Schwarz not only diagnosed the problem; he offered a solution: building weirs across the Kunene and Chobe rivers (the latter a major tributary of the Zambezi), two of the "captured" rivers whose redirection had deprived inland lakes of their water source. Diverting them into the Kalahari would recreate those lakes and thus increase atmospheric humidity and precipitation. Schwarz never acknowledged Gessert or Paulsmeier – something that greatly irritated the latter – but both supported Schwarz, as did many other whites in southern Africa over the course of three decades.<sup>60</sup> The Schwarz Kalahari Thirstland Redemption Society was founded in 1933, five years after Schwarz's sudden death in Senegal, and operated until the late 1940s; in response to public pressure, the South African government investigated the scheme three times in as many decades.

Schwarz had a Brazilian counterpart. In the same month that Schwarz published his newspaper article, Luis Mariano de Barros Fournier, a military engineer, presented a paper advocating for a river engineering scheme to change the climate of the *sertão*. Fournier told Brazil's National Society for Agriculture that damming rivers and creating a massive inland lake in the impoverished and drought-prone region would vastly increase atmospheric humidity. This water vapor would condense over the surrounding mountains, he said, resulting in predictable rainfall in an area notorious for climatic fluctuation. Like Schwarz, Fournier attempted to

---

<sup>58</sup> William Beinart, *The Rise of Conservation in South Africa: Settlers, Livestock, and the Environment* (Oxford: Oxford University Press, 2004), discusses the creation of a class of "progressive" farmers who largely agreed with the views of government scientists and other emerging "experts," but overstates the extent to which an educated white population embraced expert opinion. For more on popular views of climate and environment among white settlers see Meredith McKittrick, "Talking about the Weather: The Language of Environmental Crisis in South Africa, 1915-1945," forthcoming in *Environmental History*, Jan. 2018.

<sup>59</sup> Ernest Schwarz, *Kalahari: Or, Thirstland Redemption* (Cape Town: T.M. Miller, 1920).

<sup>60</sup> H.J.C. Paulsmeier, "Trocknet Südafrika heute noch weiter auf?" in *Der Kalaharisee* (Windhoek: John Meinert, 1941). Gessert wrote several letters to the South African magazine *Farmer's Weekly* in support of Schwarz.



popularize his scheme in a 1920 book, although it never achieved the popularity of Schwarz's Kalahari scheme.<sup>61</sup>

If Fournier was aware of his counterparts in southern Africa and elsewhere, he did not acknowledge them. But like them, he drew on a mixture of folk wisdom and scientific writing to justify his plans. People living in the *sertão* believed that their climate had become drier since settlement of the region had commenced in earnest in the early 19<sup>th</sup> century. This was commonly blamed on deforestation. But ideas about the influence of bodies of water had also entered popular consciousness. A spate of reservoir building in the 1860s, motivated by a need to create a more secure water supply, was followed in the early 1870s by historically heavy rains. In spite of the severe drought that followed several years later, many in the *sertão* linked those heavy rains to the construction of the reservoirs.<sup>62</sup> Fournier's proposal that a large lake would increase the rainfall thus tapped into already existing ideas of reprecipitation.

Fournier gave popular ideas about the *sertão's* climate a scientific foundation. Like Schwarz in Africa, he described Brazil's geological history as one that had once been dominated by bodies of water. Taking readers on a tour through the last 500 million years, Fournier argued that what was now the *sertão* had been covered by what he called the "Great Lake" – one of several massive lakes in what is now South America. Fournier described the gradual diminishment of these lakes as the Andes formed and water drained away, referring to the process as an epic struggle between the continent and the sea – a struggle won by the continent. Alluvial deposits from the newly formed mountains filled the lakebeds, leaving only the river courses.<sup>63</sup> Fournier cited "Brückner's law" on the continental origins of rain to explain the drivers of climate in the *sertão*, and he implicitly linked the drainage of these lakes to the *sertão's* current aridity: "The rain depends mainly on the evaporation of the waters from the surface of the earth," he wrote.<sup>64</sup>

Both Schwarz's and Fournier's schemes were direct descendants of Brückner's and Murray's ideas. But they were also shaped by their knowledge of the Sahara and its history. Indeed, the Sahara loomed in the background for virtually all settlers worried about the future of their arid environments. White settlers around the world seemed aware that the Sahara was a relatively recent creation and had once been a well-watered grassland. In an era where long-term climate cycles were only beginning to be understood – and for the most part, only with reference to Ice Ages – the formation of the Sahara had no obvious explanation. But whether its current condition was due to geological factors, as Schwarz and Passarge argued, or to mismanagement of its resources, as many French colonials believed, the Sahara was a symbol of how semi-arid environments could become arid ones. Schwarz told his readers that without human intervention

<sup>61</sup> Luiz Mariano de Barros Fournier, *O Problema das Seccas do Nordeste* (Rio de Janeiro: Villa Boas and C., 1920), 18.

<sup>62</sup> Roger Cuniff, "The Great Drought: Northeast Brazil, 1877-1880," (PhD diss., University of Texas, Austin, 1970), especially 106-7.

<sup>63</sup> Fournier, *O Problema*, 27-8.

<sup>64</sup> Fournier, *O Problema*, 14-5, 54.

into southern Africa's climate, "the central supply for our rain will dry up entirely; desert conditions will spread until South Africa will become a waste land like North Africa."<sup>65</sup> Fournier indirectly referenced the Sahara, proposing that "To conquer the desert it takes not just a drop of water; to conquer the desert it takes a cascade" and concluding "Delenda deserto!" – destroy the desert, a direct invocation of the Roman phrase "Delenda est Carthago", urging the destruction of Carthage.<sup>66</sup>

And the Sahara itself remained the focus of climate engineering schemes to create reprecipitation, well into the 20<sup>th</sup> century. In October 1928, the *Queenslander* newspaper of Brisbane, Australia, informed readers of a plan by American Dwight Braman to raise \$50 million as part of a project to flood the Sahara with Mediterranean water. The resulting inundation would cover 10,000 square miles and create a shipping route deep into southern Algeria, but "(t)he main purpose... is to affect climatic conditions and increase rainfall." The article noted that Braman was seeking a concession and had met with French officials.<sup>67</sup>

Australian newspaper readers were interested in such distant reprecipitation schemes because they themselves had been toying with the idea for decades. A scheme to flood Lake Eyre in Australia by diverting water from Spencer Gulf was suggested in the 1870s – and rejected by the Parliament of South Australia in 1883 as too expensive. Nevertheless, the idea was repeatedly revived in the 1890s and early 1900s. A newspaper article in 1892 suggested: "the whole climate and character of Australia from north to south may someday be destined to be thoroughly changed, turning what are arid deserts into a huge inland sea, surrounded by cultivated shores, and extending over hundreds of miles of now useless inhabited country."<sup>68</sup>

The most well-known version of this scheme emerged forty years after Brückner wrote his article on the origins of rain. J. J. C. Bradfield, the engineer who built the Sydney Harbor Bridge and other bridges and dams around the country, adopted the idea of refilling inland lakebeds to increase the precipitation in Australia's interior. Bradfield invoked Quayle's work on the influence of irrigation and bodies of water on Australia's rainfall, although Quayle himself had expressed doubts that reprecipitation would work in the arid interior.<sup>69</sup> But Bradfield wrote, "We can redeem the arid inland when we have acquired the common sense to store above ground the floodwaters which now sink into the sand and lose themselves, so that the sun can get to

<sup>65</sup> Schwarz, *Kalahari*, 178.

<sup>66</sup> Fournier, *O Problema*, 76.

<sup>67</sup> "Flooding the Sahara," *The Queenslander*, 11 Oct. 1928, 4. The New York Times also wrote about the scheme, the following year (27 April 1929, 5), noting that 100,000 square miles of land would be "reclaimed" and that the German Herman Sörgel had proposed a similar scheme after Braman – this the well-known Atlantropa scheme. (See Lehmann, "Changing Climates," Ch. 3.)

<sup>68</sup> Charles Stewart, "A Possible Australian Inland Sea," *Brisbane Courier* 19 July 1892.

<sup>69</sup> E.T. Quayle, "Possibilities of Modifying Climate by Human Agency, with Special Application to South-eastern Australia," *Proceedings of the Royal Society of Victoria* 33 (1921), 115-132.

work, and evaporate the conserved water. The rainfall after refreshing the country will evaporate and fall again as rain.”<sup>70</sup>

Bradfield’s ideas were publicized in a dramatic fashion by Idriess, the popular Australian writer. Like his counterparts in arid environments around the world, Idriess argued that changes in Australia’s geomorphology had interrupted a virtuous cycle of continental reprecipitation and replaced it with a deadly one of desiccation. Once-great mountain ranges that had attracted rainclouds from the north coast had eroded: “the diminished height of the ranges has produced a corresponding loss in rainfall.”<sup>71</sup> Idriess also embraced the idea of a self-perpetuating cycle. The Dead Heart was expanding, he argued: “(T)he curse of aridity is slowly but surely creeping out to good lands far away from it.” His solution was remarkably similar to those proposed for southern Africa, North Africa, and Brazil: Idriess imagined a boomerang-shaped chain of freshwater lakes across 600 miles of the Australian interior, achieved by diverting rivers from the eastern Queensland coast – “water running to waste” – and bringing them over the coastal ranges to the headwaters of the dry, inland-draining channels. “Probably, regular rains would then fall over thousands of square miles of very dry country ... I may be wrong, of course, but these results seem to be to be in accordance with natural laws.”<sup>72</sup> The scheme continues to have its supporters, as Tom Griffiths and Tim Sherratt have demonstrated. In 2005, a professor asked whether a large lake in the center of the ground might “act like a giant humidifier, evaporating water that moist winds would then sweep across vast areas of the continent?”<sup>73</sup>

## Conclusion

In 1937 a USDA employee named Benjamin Holzman challenged the concept of a closed, local weather cycle. Holzman, who worked in soil conservation and later as a climatologist, accepted a version of Murray and Brückner’s calculation - that about 25% of precipitated moisture ran to the seas through direct runoff and underground channels while the rest was evaporated from land surfaces and bodies of water on the land. But he was more critical of assumption that the water evaporated from land reprecipitated as *local* rainfall. “The idea that the principal source of moisture of precipitation over land areas is derived from continental evaporation is held by a number of hydrologists, foresters, and others,” he wrote. Yet “there have not been offered any substantial arguments that help to prove the contention that continental evaporation is genetically

<sup>70</sup> J. J. C. Bradfield, “Rejuvenating Inland Australia,” *The Walkabout* July 1941, 12; see also J. J. C. Bradfield, “Restoring Australia’s Parched Lands,” *The Australian Quarterly* 14, no. 1 (March 1942), 27-39.

<sup>71</sup> Idriess, *Great Boomerang*, 39.

<sup>72</sup> Idriess, *Great Boomerang*, 83, 212, 217-18.

<sup>73</sup> Quoted in Tom Griffiths and Tim Sherratt, “What If the Northern Rivers Had Been Turned Inland?”, in Stuart Macintyre and Sean Scalmer, eds., *What if? Australian History as It Might Have Been* (Melbourne: Melbourne University Press, 2006), 253.

associated with continental precipitation.” Such a contention rested on a model of stagnant air currents; these, Holzman pointed out, were quite rare.<sup>74</sup>

Holzman then proceeded to lay out what was known about atmospheric circulation. Most of the water vapor that came from land surfaces and their associated bodies of water was carried by air currents to the sea; if it reprecipitated anywhere, Holzman argued, it was likely over the oceans. Closed weather cycles simply did not exist.<sup>75</sup> It was not atmospheric moisture, but the presence or absence of conditions for condensing it that affected rainfall.

Holzman was critical of schemes that sought to produce rainfall by increasing atmospheric moisture through various means, including impounding water. Many of these had been based on assumptions that bodies of water would change air temperature and wind circulation, thereby ensuring that conditions for release of moisture also changed – but Holzman argued that in the early 20<sup>th</sup> century, these assumptions had been largely based on conjecture about circulation patterns, which were poorly understood.

Beyond the temperate zone, however, the notion of the virtuous cycle – and its life-extinguishing opposite – persisted. In southern Africa, Schwarz’s scheme was still debated in the press every time there was a drought.<sup>76</sup> The government insisted it would not work, yet yielded to popular pressure and investigated it again in 1945. Bradfield’s scheme continues to be revived periodically into the present day. The later iteration of these proposals claimed to account for the factors Holzman had highlighted, such as wind and temperature shifts that might accompany the creation of new bodies of water.

Enthusiasm for evaporation-based climate engineering schemes had largely waned by the 1950s. But the sixty-year life of Murray and Brückner’s ideas about reprecipitation, largely forgotten in their place of origin but ricocheting around the colonial world, demonstrates the global circulation of meteorological ideas and the way that encounters with local environments informed those ideas and determined their longevity. It suggests new avenues of thinking about settler intellectual histories. Most notably, historians have focused on the tendencies of settlers and colonial officials to blame indigenous inhabitants for environmental degradation and even climate change (as in the case of deforestation and its supposed impact on rainfall). But highlighting the supposed role of bodies of water in shaping climate demanded a different set of explanations for changes in precipitation – explanations that most often focused on changes in geomorphology that had no apparent human cause. The role of indigenous inhabitants, so often blamed for environmental degradation in colonial Africa, looks very different in this context.

---

<sup>74</sup> Benjamin Holzman, “Sources of Moisture for Precipitation in the United States,” USDA Technical Bulletin No. 589 (Oct. 1937), 11, 14.

<sup>75</sup> Holzman, “Sources of Moisture,” 13.

<sup>76</sup> In 1948 Daniel Francis Kokot, an engineer in the Irrigation Department, published a 160-page book in which he sought to refute Schwarz’s scheme and the climatic assumptions underlying it. (*An Investigation into the Evidence Bearing on Recent Climatic Changes over Southern Africa* (Pretoria: Government Printer, 1948).

---

The long debate over reprecipitation and the climate of arid lands being settled by Europeans also demonstrates some of the limitations of reading the history of meteorology and climatology “backwards,” by looking for the precursors of ideas that are now widely accepted. Such methods remove scientists who appear to be visionaries from the context in which the totality of their knowledge was generated, and obscure significant realms of scientific and popular debate from historians’ view. This article traces an alternative genealogy of climate ideas. They are less easily integrated into a story of ever-more-accurate and verifiable knowledge, but they shaped events and popular opinion in their time, and echoes of them are with us today.

### **Acknowledgements**

I’m grateful to Dagomar Degroot and Kathy Olesko for initial suggestions as I began to research this piece, and to many other colleagues in the Georgetown History Department Faculty Seminar for comments on parts of this article.