

## African Dust Plumes and Their Effects on Caribbean Coral Reefs

As humans we tend to think that our environmental footprint only affects the part of the world that we place it in. We see our presence on the Earth as a nest of closed circuits, each one independent from the rest, and that our actions only affect the things directly in our little bubbles. It's easy to get caught up in this mentality and not think too hard about the ecological problems occurring on the other side of the world. After all, problems located so far away from us couldn't possibly affect our quality of life, so we needn't bother. Or so we would like to think.

Africa and Central America are divided by the vast Atlantic Ocean. They are practically a world apart. Yet recent scientific evidence suggests that coral reef decline in the Caribbean can be partly attributed to dust particles blown over from the Sahara desert. This paper will explore these two seemingly unrelated ecological issues and uncover how they are actually closer than they appear.

The Sahara desert spans across the north of Africa, taking up almost of third of the continent. It is the third largest desert in the world and the hottest. The desert is known for its harsh conditions, hot days, cold nights, and seemingly endless stretches of sand. It is also known for its iconic dust storms that occur when eastern winds sweep tons of fine sand particles into the air. The Bodélé Depression in Chad is especially noted for its frequent dust storms and is considered one of the largest contributors to African Transatlantic dust migration called “the dustiest place on Earth” [4]. However, dust storms themselves are not the problem. In fact, dust storms are a natural phenomenon that have been prevalent for hundreds of millions of years. What has ecologists worried, though, is that the size and number of dust storms as well as the amount of sediment being carried over the Atlantic has been steadily increasing. This has been attributed to the fact that desertification of the Sahel region is causing the Sahara desert to expand.

The Sahel is the bio-geographic region lying just below the Sahara desert. Like the desert, the Sahel region spans from west to east across Africa. It is often thought of as a transition area between the Sahara desert and the Sudanian Savanna. The Sahel has a semi-arid climate made up mainly of grasslands. The area is an ideal location for farming when it is not stricken by drought. Unfortunately desertification has decreased the arable land in the region causing potential farmers, as well as the desert in the north, to move south. The exact cause of the Sahel's degradation is not certain and could be any number of reasons.

Climate change caused by global warming is thought to be a major cause. The Sahel frequently experiences drought, but as the temperature has increased so has the severity of these droughts. Intense droughts have greatly reduced the amount of vegetation in the region. The soil, without vegetation to keep it in place, loosens and adds to the growing desert. [1].

But global warming isn't the only factor in the loss of the Sahel. The Property and Environment Research Center (PERC) published an interesting article [2] that details human abuse of the land, starting with the French colonization of West Africa. Before the arrival of the French in the late 1800's, the Sahel had two distinct groups of people: the nomads and the farmers. The nomads raised cattle and traded with farmers between the Sahara and the Sahel. It was a careful balance. Farmers let the nomads use their wells to support their cattle and so the nomads could continuously move their herds from place to place. While there was some overgrazing, cattle numbers were carefully controlled so there was never any lasting damage.

When the French took over, however, this balance was disrupted. Farmers and nomads abandoned their routine trading for French policies that pushed export crops and overseas trade. This sudden increase in farming caused the area to stagnate over the next couple decades. The French dug more wells and deployed veterinary and medical campaigns, thinking this would cease this stagnation [2]. But well ownership was not clear, which led to overgrazing, and while the medical programs did increase the population of both animals and humans, this only put further stress on the land as there were more mouths to feed. As their lands continued to degrade, the locals were forced to move further

and further south to where the land was better. But their over-farming and overgrazing only served to turn this new land to dust as well. The drought of the early 70's only helped to exacerbate this problem further. Seeking to help the impoverished, Western countries raised large amounts of money to fund more medical aid and dig more wells. This only served to further overextend the land with cattle and people. While their intentions were good, they simply did not understand that their “help” was the source of the problem.

To this day the Sahel is still in decline. Farmers have shifted away from large cattle such as cows and camels towards browsing animals such as a goat and sheep [1]. Goats and sheep prefer to consume woody plants, however, which has only helped to loosen the soil. With this decline, the Sahara expands and with this expansion comes an increase in dust and therefore, dust storms. Appendix A shows a picture of a particularly large dust plume blowing off the coast of Africa.

As stated before, dust storms by themselves aren't bad. In fact, it is thought that the iron rich African dust blowing in from over the Atlantic has played a big role in fertilizing the Amazon rainforest, allowing it to grow as big and lush as it is today [4]. It's what the storms carry with them mingled among the dust that becomes hazardous to an ecosystem. The smaller the particle, the more volatile it is, and the more likely that it will be carried into the atmosphere [8]. It's no wonder then that the most harmful pollutants are found in the air. Only 20 percent of dust in a dust storm is taken into the atmosphere and even then only 20 percent of that falls into Central America. That's only about four percent of the original storm. It doesn't seem like much, but in July 2000, the Puerto Rico Dust Experiment (PRIDE) recorded almost 8 million tons of African dust reaching Puerto Rico within a one month period [1]. That's a lot of pollutants being carried across the ocean – pollutants that come from developing areas, wood burning, and other environmentally unfriendly practices. And when this pollution settles in the ocean it wrecks havoc on the organisms in it, most notably coral.

The coral structure we typically see is actually limestone that has been secreted by a coral polyp over a long amount of time. These polyps form colonies and generate these almost-exoskeletons. Corals are delicate and if something happens to the polyps that create the coral structure, then there is no hope for the coral to revive itself. Coral provides a home for a wide range of organisms and the collapse of one reef can prove to be disastrous for the rest of the ecosystem.

In the last couple decades, there has been a significant decline in coral populations all over the world. Appendix B shows a picture of the Carysfort reef off the coast of Florida [5]. In the 1975 picture, the reef looks healthy. But moving to the 1995 picture, 20 years later, the reef is now noticeably barren. There are many reasons as to why coral dies out. Climate change has caused waters in tropical regions to get warmer than coral can adapt to. This causes bleaching which essentially kills the coral and robs it of its vibrant colors. Over fishing has decimated coral in areas by cutting out a rung of the food web which can cause an ecosystem to collapse. Iron rich dust from Africa is essential in keeping the ocean fertile, but too much iron can have negative effects. Iron in the water promotes the growth of algae, but too much algae can essentially block sunlight from reaching the coral which will cause them to wither and die.

Disease is another frequent coral killer. The documentary, “African Dust, Coral Reefs, and Human Health” says that not only do dust storms from Africa carry pollutants with them, they may also carry disease-causing bacteria as well [7]. Their hypothesis was that because African locusts are frequently carried across the Atlantic and reach the Caribbean unharmed, there was reason to believe that much smaller organisms could survive the trip as well. To test this hypothesis, the scientists mentioned in the video took air samples from various locations in the Sahara and in the Caribbean. They found that while there was a lesser concentration of bacteria in the Caribbean air than the African air, there was indeed significant presence of viable bacteria. There was some confusion as to whether the bacteria in the Caribbean originated from Africa or the Caribbean itself. Further research was done at the Lawrence Berkeley National Lab. They have developed technology, called the folic chip, to detect thousands of different kinds of bacteria in an environmental sample [7]. So far scientists have

found carcinogens, neurotoxins, endocrine disruptors, and suppressors of immune systems [7]. Testing has been done to determine whether African dust directly harms coral. So far, preliminary lab research has found that several pesticides found in both Africa and the Caribbean interfere with the settlement of coral larvae which is instrumental in the growth of coral [7].

Coral reefs, in the areas that have them, are a huge proponent of tourism. As someone who's experienced them first hand, I can say that the coral reefs of the Caribbean are astounding. It's clear that a whole industry has been built around tourists wanting to snorkel and scuba dive amongst the colorful fauna. Because reefs are so prized for their beauty, I can safely say that they are an ecosystem service. To lose a coral reef is to lose the beauty it brings use as well as the income it brings the people of the Caribbean who rely on our tourism. A destroyed coral reef also affects the organisms that depend on it. To wipe out a reef is to wipe out a food web. And without the clams, mussels, and fish that once thrived in the area, fishermen whose livelihoods depend on the reefs will begin to feel the loss as well.

Several solutions have been proposed to combat the threat of coral decline. The NASA Earth Observatory site has an interesting article that talks about better monitoring coral areas in need of help [5]. While we are very aware of the populations of coral that are in danger of being wiped out, there are many reefs out there that we do not know the immediate state of. These coral reefs are usually in areas that are difficult to get to. Not only that but monitoring reefs requires physically going into the ocean and looking at the reefs, which can take long amounts of time. The article talks about how monitoring reefs from above lessens the time spent observing them and makes it easier to truly spot the areas in need of assistance. The technology isn't perfect yet and it is sometimes difficult to distinguish coral from rock, but it is definitely a good step in the right direction.

Another solution that many countries have imposed is to ban fishing in threatened areas. Over fishing can put further stress on declining coral populations and make it harder for reefs to recover. Banning fishing in these areas gives the coral a chance to heal.

Both of these solutions seem practical and have potential to greatly improve these declining ecosystems. I worry, though, that simply monitoring coral and banning fishing in high risk areas will not be enough. Climate change is still causing the water to warm and coral to bleach as a result. The best answer would be to reduce our carbon emissions, but that is definitely easier said than done. The state of our environment and what is to be done about it is so tightly wrapped up in political debate that I fear it will be a long time before any significant action is taken. Therefore I propose a solution that will tackle the next best thing.

My solution would be to alleviate some of the stress put on coral by stopping or slowing the excess amount of African dust coming over the Atlantic. Increased dust has been flowing over from Africa because the Sahara has been expanding. The Sahara has been expanding because the Sahel has been shrinking due to a mix of climate change and poor soil management. So we start by fixing the poor soil management. The way to do this is to go back to the old ways of managing farmland in Africa. The best part of this solution is that it has already been proven to work.

Appendix C shows the outline of the Sahel region and it is immediately apparent that vegetation in the area has become scarce. But Scientific American published an article [9] about African farmers who have managed to revitalize their once decimated lands in the Sahel. The article focuses on one particular farmer, Yacouba Sawadogo, who unlike the majority of people in the area, did not abandon his farm during the terrible droughts of the 1980's in favor of better lands [9]. Instead, Sawadogo stayed and found innovative ways to rehabilitate his lands. Local farmers have a practice of digging zai, which are shallow pits that concentrate scarce rainfall onto the roots of crops. Sawadogo took this practice further by digging larger zai and adding manure. What was interesting was that not only did his crop yield increase, but trees began to sprout up near the crops from the seeds deposited in the manure. After several growing seasons Sawadogo saw a significant increase in yield thanks to his new trees.

The article then goes on to describe the success achieved by African farmers that grew trees alongside their millet and sorghum. They make a distinction between 'planting' and 'growing'. Planting

implies that the farmer would deposit seeds in the soil and then leave the tree to its own devices. While this certainly works in temperate climates, the high winds and heat of the Sahara-Sahel region would sweep the freshly planted seeds away. Not to mention that the soil contains very little nutrients.

Conversely, by actively letting trees grow amongst their crops and taking care of both tree and crop, farmers saw vast improvements. Trees buffer the wind and protect crops from the sweltering heat. Roots dig into the soil and keep it from eroding and blowing away. The leaves of the trees are also useful as they fall to the ground and decay which then boosts soil fertility.

Another similar solution is to change the way cattle are raised. Cattle are notorious for overgrazing and trampling land. In fact, overgrazing has played its part in the desertification of the Sahel. Allan Savory, president of the Savory Institute, has proposed a project that will hopefully reverse desertification by changing, or rather creating, the migration patterns of cattle [10]. Savory proposes, rather than letting cattle graze farmland indefinitely, cattle should be moving constantly in order to avoid eating up too much of one area. This harkens back to before the French colonized West Africa and put an end to nomadic herding. This technique requires precise timing on a military level [10] but it would give overgrazed lands time to heal.

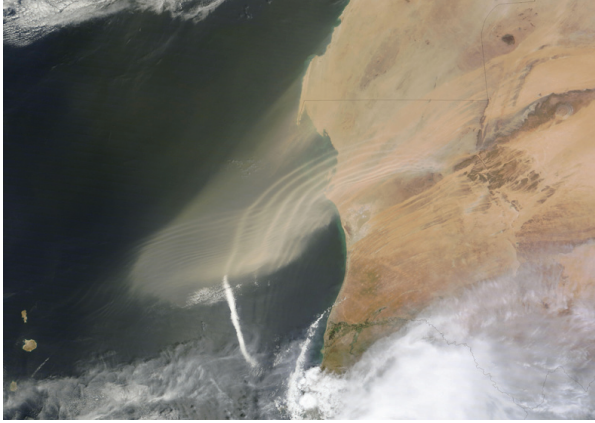
This two in one solution relies solely on a better understanding of how farming and cattle raising affects soil. My solution has already seen positive results, in the case of Sawadogo, and it would be far less expensive to hire people or volunteers to teach soil sustainability than it would be to dig more wells, as was done in the past. By combating the encroaching desert by restoring the Sahel, the amount of dust being blown over Atlantic would decrease as well as the number of pollutants being carried with them that are negatively affecting coral reefs. This coupled with better monitoring reefs and lessening the impact of over fishing them should alleviate stress put on the reefs and give them more of a chance to recover.

When it comes to the environment, we tend to think that the damage we cause exists in a closed circuit – that polluting one area will only affect that particular ecosystem. But by looking at the effects dust storms in Africa have on coral reefs in the Caribbean, we can see that this isn't the case at all. The world's ecosystems are all interconnected in complicated and unseen ways. This makes it difficult to fully gauge our effect on the environment as many of the changes we make won't become apparent until decades and sometimes even centuries later. I've heard skeptics say that global warming is simply our planet going through a period of warming and nothing more. But even if that is the case, why should that be an excuse to further decimate our planet? It is our responsibility as humans to take responsibility and stop avoiding problems that we can't immediately see. We are in a dire situation right now, but there is definitely hope. We are an innovative species, after all, we just need some motivation.

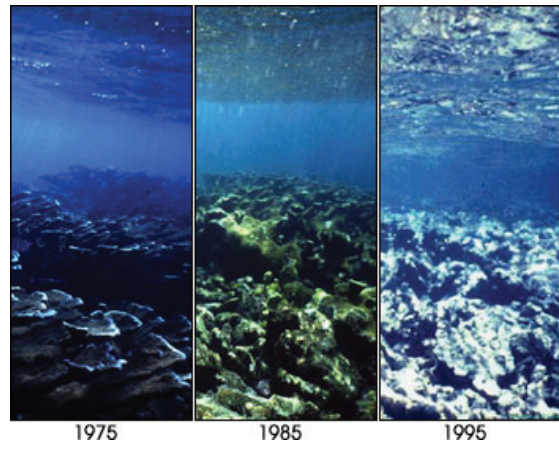
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# Appendix



Appendix A [11]



Appendix B [5]



Appendix C [9]