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REVERSING GLOBAL WARMING WITH HERDS OF COWS IN THE SAHARA, SAHEL, AND SAVANNA

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Without a doubt, global warming is a complex subject. Early debates during the formation of the UDHR, through to contemporary adoption of conventions recognizing the environment, indicate that complexities continue to surface and challenge how we think about, perceive, and attempt to confront global warming. Primary challenges encompass conceptual questions of anthropology, design science, ecology, and governance. Such primary challenges become particularly highlighted with respect to systemic inequality between the Global North and the Global South. This design proposal traces how vulnerabilities to increased risk of soil carbon loss causes desertification, and presents an approach to their reversal, via flora restoration in the Sahara Desert, the Sahel, and the Sudanian Savanna, using infrequent megaherbivore grazing regimes. The proposal concludes by identifying how nation-states can effectively implement the proposed project, having the power both to restore native species and also to reverse global warming.

SUMMARY

THE GLOBAL ENGINEERING DESIGN TEAM is an initiative, sponsored by the Tokyo Global Engineering Corporation ("TGEC"), in which students of engineering and other disciplines design a system or device that will solve a problem faced by several governments. The goal of this particular project is to restore flora of the Sahara, Sahel, and Sudanian Savanna using domestic cattle via a system that will maximize plant species by increasing disturbance frequency and mineral-soil disturbance, while subsequently enhancing fauna habitat, with more precision, accuracy, and efficiency than any current system. The governments for which this project is presented are the People's Democratic Republic of Algeria, Burkina Faso, the Republic of Cameroon, the Republic of Chad, the Arab Republic of Egypt, the State of Eritrea, Libya, the Republic of Mali, the Islamic Republic of Mauritania, the Kingdom of Morocco, the Republic of the Niger, the Federal Republic of Nigeria, the Republic of Senegal, the Republic of the Sudan, and the Republic of Tunisia, as well as the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD), the only international, legally binding framework created to combat desertification.

Since its formation in 1994, the UNCCD has attempted to combat desertification via long-term integrated strategies that focus simultaneously, in affected areas, on improved productivity of land, and the rehabilitation, conservation, and sustainable management of land and water resources, leading to improved living conditions, in particular at the community level. With this system, affected land areas have not been fully rehabilitated.

The system proposed here has the following advantages over UNCCD methodology. No efforts to improve human living conditions, manage land or water resources, or improve land productivity are made. The sole purpose is to restore flora, which effectively transfer carbon from the atmosphere to the lithosphere, thus reversing global warming. The advantage of not taking a development approach reduces the risk of human rights violations, such as those detailed in post-development literature. This increases the comfort of participating governments and allows them to combat desertification solely by maintaining herds of roaming cattle.

This proposal consists of a project description, subsystems (location selection, infrequent megaherbivore grazing regime, species advantage and selection, maintenance and support, cost analysis), implementation schedule, and conclusions and recommendations.

The annual cost of implementing and maintaining this project should not exceed a small fraction of any national ministry of agriculture’s budget. Implementation cost will vary depending on individual nation-states’ costs of producing cattle, generally.

PROJECT DESCRIPTION

Introduction

The single greatest threat to all Earthian species is global warming. Despite rigorous, innovative research to decrease, halt, and even reverse global warming, many proposed projects are never implemented.

Infrequent megaherbivore grazing regimes use large, plant-eating animals to rehabilitate environments by allowing large herds of heavy fauna to ravage land with their hooves and nourish it with their urine and feces, the latter of which contains intestine-processed seeds of the very plants they are to restore. This method can reverse desertification and, more specifically, were it performed in an area as large as the Sahara Desert, would reverse global warming by removing vast quantities of carbon from the atmosphere over time, via years of dead, decomposed plants, literally, the creation of topsoil.

The UNCCD is the only extant legal framework to combat desertification on an international scale. The UNCCD implements integrated strategies that focus on improved productivity of land, and the rehabilitation, conservation, and sustainable management of land and water resources. Under this system, deserts have not been fully rehabilitated. Our proposed process allows for direct removal of carbon from the atmosphere and its storage in the lithosphere.

By focusing solely on carbon transfer, this system will more efficiently reverse global warming. This allows for sooner cessation of climate changes, which reduces existential threat to extant species.

There is no cost to design the method; it is already implemented in small areas of conserved land elsewhere. The cost of implementing the method in the proposed area is greatly affected by individual nation-state cost of animal husbandry, essentially, the cost of a few new herds of cattle each year, and their annual maintenance, for sixty-two years.

Background

Exactly when humans began causing global warming is a matter of continuing research. Evidence points to early agriculture and large hominin populations (Li et al. 2009; Ruddiman 2003; Delcourt 1987), with anthropogenic changes in biota beginning thousands of years ago (Ruddiman 2003: 261). The earliest known hominins existed 4.4 million years ago in what is now Ethiopia (White et al. 2009: 64), on the opposite side of what is now the Sahara Desert, from where *Homo sapiens* originated 315 ± 34 thousand years ago, in what is now Morocco (Hublin et al. 2017: 289). During this time span, the area that is now the Sahara Desert was considerably populated with fauna, including amphibians (Borkin 1999; Le Berre and Chevallier 1989a), birds (Borrow et al. 2001), crocodiles (Trape et al. 2012; de Smet 1998), fish (Lévêque 1990; Le Berre and Chevallier 1989a), freshwater mollusks (Van Damme 1984), lizards and tortoises (Trape et al. 2012), mammals (Kingdon 2015; Le Berre and Chevallier 1989b), and reptiles (Sindaco et al. 2008; Le Berre and Chevallier 1989a). Toward the end of this time span, hominins hunted some megafauna (big cats, elephants, Cape buffalo), while also using some for agriculture (Sanga cattle) (Barich 2013; Vernet 2002; Gautier et al. 1994; Grigson 1991). Such civilizations had devastating effects on the environment (Foley and Lahr 2015) and megafauna (Sandom et al. 2014).

Overview

The project concept involves implementing a process that will cause plants to grow in desertified areas, via bovine activity. Herds of four-hundred cows will be placed in areas twenty kilometers wide and one- to two-hundred kilometers long, depending on extant biomass. The subsystems that comprise the overall design are location selection, infrequent megaherbivore grazing regime, species advantage and selection, maintenance and support, and cost analysis. Figure 1 shows the relationship among these subsystems.

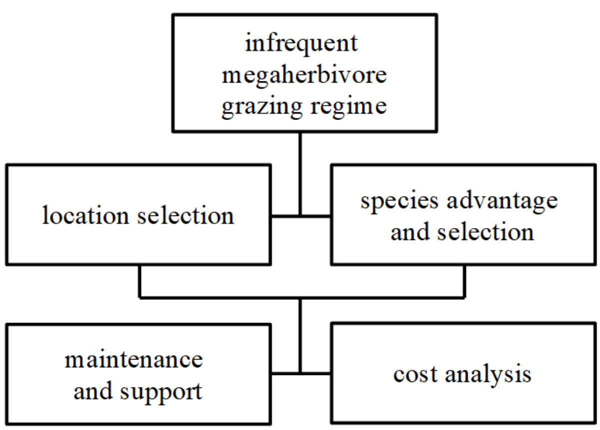

Fig. 1. *Project flow chart*.

The infrequent megaherbivore grazing regime (IMGR) is the root of the project. Branching from that are location selection, and species advantage and selection. The subsections combine for maintenance and support, and cost analysis.

The IMGR subsection encompasses meeting with all stakeholders to determine their expectations, evaluating their requirements, and ensuring a sixty-two year commitment to the project. The location selection encompasses determining area biomass and appropriate area length. Location selection considers not only available plants, but also available water, other sources of food, and terrain. The species advantage and selection subsection determines which cattle are best suited for each location. Upon determination of area and species, maintenance and support needs can be identified and implemented, with a concurrent cost analysis, which can determine how the project affects stakeholders and help them to evaluate their ability to continue. Each subsystem, when combined and continuously implemented, will produce a fully functional system that allows for direct removal of carbon from the atmosphere and its storage in the lithosphere more efficiently than any other proposed system.

Cost

The overall cost of this project is unknown; however, because the cost should not differ from the cost of general cattle maintenance, the annual cost of implementing and maintaining this project should not exceed a small fraction of any national ministry of agriculture's budget. Implementation cost will vary depending on individual nation-states' costs of cattle, generally; that is, the cost is greatly affected by local costs of animal husbandry, essentially, the cost of a few new herds of cattle each year, and their annual maintenance, for sixty-two years. For example, the cost of producing cattle in the eastern Sahara, near the Nile river, may be lower than the central Sahara. Similarly, producing cattle near a river but transporting them far from such river would bring cost. Alternatively, it may be that another organization, such as UNCCD, already has approved funds and resources available for such purposes.

Table 1. *Prospective costs*.

accounting
administration
aerial observation
animal husbandry
artificial intelligence
collars and virtual fences
cowherd training
cowherd salaries

cowherd shelters
cowherd sustenance
communications equipment
emergency transportation
feed, seed, and water
herding dogs
procurement
public affairs and notice
training of riding cattle
veterinary services
weapons

Another prospective cost could be dependents' education; however, the propriety and safety of dependents being housed at proposed areas is a recruitment incentive that must be considered carefully. Herds will attract predators, such as lions and crocodiles.

Schedule

Below is a table listing the steps required to produce steady-state operations. Please note that the estimated times are for the first year's implementation and may either increase or decrease with the addition of successive areas each year, and that many items can run concurrently. Also note that husbandry needs may vary depending on cattle species.

Table 2. *Schedule to implement*.

administrator recruitment: 30 days
administrator onboarding: 1 day
procurement clerk recruitment: 10 days
procurement clerk onboarding: 1 day
procurement, including delivery:
- animal husbandry: 279-287 days
- herding dogs: 30 days
- riding cattle: 30 days
- artificial intelligence: 30 days

collars and virtual fences: 30 days
cowherd shelters: 90 days
cowherd sustenance (blanket purchase agreement): 10 days
communications equipment and warranties: 30 days
emergency transportation (dune buggies): 90 days
fuel services (blanket purchase agreement): 10 days
dune buggy maintenance (blanket purchase agreement): 10 days
feed services (blanket purchase agreement): 10 days
water services (blanket purchase agreement): 10 days
seed (blanket purchase agreement): 10 days
veterinary services (blanket purchase agreement): 10 days
weapons: 30 days
ammunition, weapons maintenance (blanket purchase agreement): 10 days

cowherd recruitment: 90 days
cowherd training: 1 day

(This will vary considerably for cowherds with no herding or riding experience, but otherwise consists of instruction on how to use virtual fences, how to use new communications equipment, how to request emergency services, how to interact with the employing organization, generally, and introduction to herd of assignment.)

cowherd sustenance, calls against BPA: ongoing, delivery direct to shelters
seed, calls against BPA: ongoing, delivery direct to feed service provider
feed services, calls against BPA: ongoing, delivery direct to herds
water services, calls against BPA: ongoing, delivery direct to herds
veterinary services, calls against BPA: ongoing, at least annual, delivery direct to herds, dogs
fuel services, calls against BPA: ongoing, delivery direct to dune buggies
dune buggy maintenance, calls against BPA: as needed, at least annual
ammunition, weapons maintenance, calls against BPA: as needed, at least annual
communications equipment repair under warranty: as needed
aerial observation: one day per year
accounting services: one audit per year
public affairs: ongoing interaction with public by cowherds
public notice: annual notification in new areas

SYSTEM DESCRIPTION: INFREQUENT MEGAHERBIVORE GRAZING REGIME (IMGR)

Overview

The positive effects of megafauna, particularly grazing by herding mammals, is well established (Galetti et al. 2018; Poulsen et al. 2018; Vitt et al. 2017; Winter et al. 2015; Virk and Mitchell 2014; Campos-Arceiz and Blake 2011; Petty et al. 2007; Chen et al. 2005; Hickman et al. 2004). The negative consequences of loss of such animals in savanna is also established (Keesing and Young 2014). When grazing is severely restricted, large populations of megafauna cause environmental loss, such as giant pens at beef production centers (Subak 1999). However, large megafauna herds provide for soil recovery and enhanced productivity when grazing patterns are appropriate (Blignaut et al. 2017). Although wild browsing herbivores can suppress pollinator species, well-managed cattle may benefit important pollinators and the plants that depend on them (Wilkerson et al. 2013). Indeed, native and domestic ungulates differ significantly in their effects on plant growth and reproduction (Damhoureyeh and Hartnett 1997: 1719). However, presence of wild grazers improves alpha- and beta-diversity of all focal insect taxa when compared to grazing of domestic livestock, which indicates that introduction of large native mammals in conservation areas populated by domestic livestock is optimal (Pryke et al. 2016). An infrequent megaherbivore grazing regime maximizes plant species by increasing disturbance frequency and mineral-soil disturbance, while subsequently enhancing fauna habitat (Hess et al. 2014; Dorrough et al. 2004).

Infrequent megaherbivore grazing regimes[1]

"[T]he land needs the presence of feeding animals and their droppings for the cycle to be complete […] [I]f you take grazers off the land and lock them away in vast feedlots, the land dies."

- HRH The Prince of Wales, 2012
viewable at https://www.youtube.com/watch?v=EsmhTACrfOk

IMGRs typically involve a wagon-wheel rotation of cattle in an area being rehabilitated, with feed and water located centrally among the no fewer than eight pastures within the wagon wheel. However, IMGR can be applied without the wagon-wheel design (Holechek et al. 2000:18).

Herds of four-hundred cows will be placed in areas twenty kilometers wide and one- to two-hundred kilometers long, depending on extant biomass. To estimate areas of low biomass, we used Brown et al. (1996), Figure 2, the black line of which we superimposed to indicate the southernmost starting line for the proposed project, which corresponds with exactly 50 megagrams of biomass per hectare.

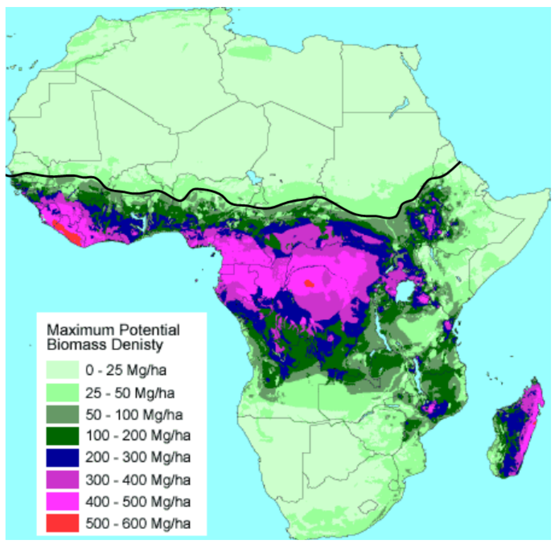

Fig. 2. *Maximum potential biomass density*.
Source: Brown, Sandra, Greg Gaston, and Richard C. Daniels, "Tropical Africa: Land use, biomass, and carbon estimates for 1980," United States of America Department of Energy Technical Report No. ORNL/CDIAC-92, NDP-055. Oak Ridge National Laboratory, 1996.

[1] also known as adaptive grazing, adaptive multi-paddock grazing, cell grazing, controlled grazing, deferred rotation grazing, grazing management, high frequency-short duration grazing, high-intensity short duration grazing, holistic grazing, holistic management, intensive short-duration grazing, managed grazing, management-intensive grazing, planned grazing, prescribed grazing, rapid rotation grazing, rest-rotation grazing, Savory grazing, season-long grazing, swath grazing, and time-controlled grazing (Mann and Sherren 2018: 1848)

Figure 3 follows, and shows area progression at a rate of five years per image in the areas of ≤50 Mg/ha, as identified by Brown et al. (1996).

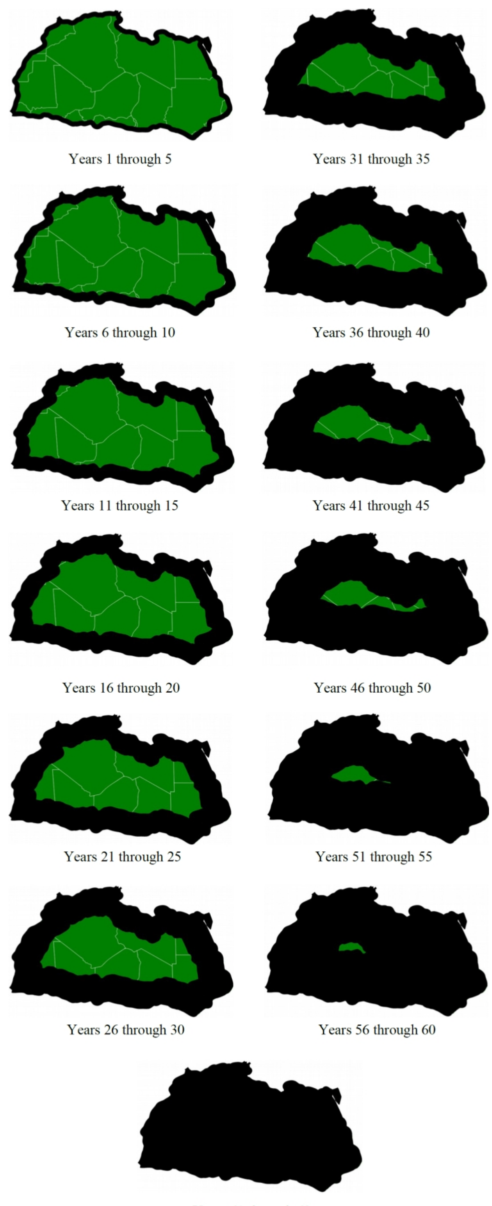

Fig. 3. *Area progression, by half decade.*

Design considerations

This project will be implemented in one of the most desolate and dangerous places on the planet. Therefore, specialized design considerations must be considered. Cowherds, as well as their family members (if accompanying) will have unique needs when located far from established communities. For this reason, special considerations must be made to allow them to reside in remote, desertified areas. For this same reason, not all prospective needs can be identified.

SYSTEM DESCRIPTION: LOCATION SELECTION

Beginning at the outermost ring identified in Figure 3, areas twenty kilometers wide and one- to two-hundred kilometers long will be partitioned using virtual fences, depending on extant biomass (plants that the cattle are to eat). Areas with less biomass per square kilometer for cows to eat would be among the longer areas, so as to provide equal total biomass. A new inner ring (twenty kilometers) will be added each year, for a total of sixty two years.

Coastlines, beaches in particular, would be excluded because cattle would have little incentive to travel nineteen kilometers inland. However, although area groundwater is suitable for cattle (El-Shahat et al. 2017: 644), cattle could be led to beaches and allowed to drink seawater on an emergency basis, if they evolved in desert (Macfarlane 1971: 161).

Cowherds' permanent shelters can be established in central areas, or in areas providing greater physical safety. For example, all of an entire area could be a floodplain, except for a hill in a corner of a partitioned area, which is where such a shelter should be placed. Similarly, an area known to have lions may also have an empty cave, which should be considered as a shelter's location. Temporary, overnight shelters may be used in areas where cattle require constant protection, when resting far from permanent shelters.

SYSTEM DESCRIPTION: SPECIES ADVANTAGE AND SELECTION

Absent plants and water, cattle can feed each other via their lactate, including adults. Whereas the breed with the greatest lactate output is Holstein Friesian (Ojango and Pollott 2001: 1742), in emergency situations, cattle are more likely to survive if they evolved in desert (Macfarlane 1971: 161). Therefore, breeds will need to be selected based on features unique to individual tracts, such as distance to groundwater and ease of feed delivery.

Domesticated cattle rarely cause deliberate injury to humans, unlike the proposed area's historically native megafauna, some of which are notoriously fatal to humans, such as giraffes and elephants. Given widespread reliance on cows as sources of human nutrition, most economies already have infrastructure for bovine generation and maintenance via national ministries of food and agriculture. Ergo, no new infrastructure should be necessary to implement this project. Rather, not eating or milking cows, and instead setting entire herds aside for roaming, would result in economic benefit (Neilly et al. 2018: 205). The authors hold that such herds could do to the Sahara, Sahel, and Sudanese Savanna what environmental engineering did during the "Dust Bowl Dirty Thirties" in its most effective project to date, the United States of America's Great Plains Shelterbelt, naturally, more effectively, and cheaply, while reversing global warming.

SYSTEM DESCRIPTION: MAINTENANCE AND SUPPORT

Maintaining large herds of animals is something humans have cheaply done since antiquity. However, the proposed, remote desert areas will bring unique expenses.

Feeding large herds of cattle will become progressively easier with continued land rehabilitation and growing seasons. However, when cows have consumed all available biomass prior to growth and cannot be led outside assigned areas to consume other biomass, calls against blanket purchase agreements for feed will be necessary. The same applies for water, when seawater consumption is not feasible, and also for seed, when recent biomass consumption has not occurred.

Whether when led to nearby farms or remain on site, veterinary services will need to be provided regularly to cattle and herding dogs.

Cowherds will result in the greatest maintenance expense, stocking and maintaining their shelters, especially with regular delivery of fresh food and drinking water, and access to emergency medical care via strategically located dune buggies, which could serve as delivery vehicles, and will also require regular maintenance. Cowherds will require weapons to protect themselves and herds from predators; weapons will require maintenance.

The ability to call for help is paramount, and cowherds must be equipped with the latest communication equipment, including handheld Internet-accessible equipment, as well as solar battery-charging equipment, all of which should be purchased with warranty that provides for extreme weather exposure.

Aerial surveys should be conducted annually, with key stakeholders given opportunities to examine rehabilitated areas directly, from above. Such surveys would provide immediate identification of areas' success or lack thereof, and would not need to consist of more than one flight back and forth across a single nation-state's rehabilitated areas.

SYSTEM DESCRIPTION:
COST ANALYSIS

Historically, the most effective long-term projects provide for ongoing accounting. Cost analyses must be performed at least annually to determine overall benefit of project implementation. The purpose of the project is to reverse global warming. After the first year of the project, there should be noticeable environmental benefit. Whether that benefit is worth financial costs warrants regular review.

CONCLUSION

The authors posit that which no research has yet supported: that the Sahara Desert is an anthropogenic artifact.[2] Put differently, the area was once filled with flora and fauna, and hominins exterminated them all, via environmental impact. Whether this striking hypothesis is correct is not the purpose of the instant writing. Rather, the authors posit that, because the area that is now the Sahara Desert was once filled with plants and animals, it can again be. Temporary herds of proxy megafauna would prompt return of native species, resulting in subsequent subterranean placement of atmospheric carbon via deceased flora, a complete reversal of global warming, at the lowest economic cost, mere domesticated dairy cows.

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[2] Although the Sahara may be the greatest example of anthropogenic desertification, it is a poor example of extinction. Sandom et al. (2014) found that high extinction, despite a relatively stable climate, is most striking in South America, in contrast to Africa (sub-Saharan Africa, in particular), where extinction was minimal, despite similar glacial-Holocene climate changes. Ergo, it may be that the megafauna of the area that is now the Sahara Desert merely migrated south, where, though threatened, they remain today.

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