Human Composting and Conservation Burial: Comparing Carbon Costs and Benefits

By Dr. Billy Campbell *with Lee Webster*

The New York Times recently published an article that discussed the carbon emissions for composting bodies.[i] The article reported the claim made by the natural organic reduction (NOR) company, Recompose, that they release only 20 Kg of CO_2 per body. The article said that each composting will save 1 metric ton of CO_2 emissions.

> *"Human composting, by Recompose's reckoning, … saves around a metric ton of CO_2 for every person composted, compared to conventional burial or cremation."*
> —Caitlyn Doughty, *If You Want to Give Something Back to the Earth, Give Your Body*, NYT Opinion, 12.5.22

Articles like this have put the spotlight on various methods of disposition that are being touted as green burial. Not only are they not green burial (full body earth disposition without impediment), there are some alarming carbon reduction claims—case in point—that require careful examination. Let's start with the basic question we should be asking: What is the real carbon footprint of central-facility body composting and how does it compare to conservation burial?

While there are lots of variables when looking at all disposition footprints, the bottom line must include the carbon footprint not just of the individual body's disposition, but of the supporting infrastructure and the materials that are required. In land protection terms, conservation burial grounds (CBGs) sustainably protect significant natural landscapes that is open for use by the public, not thousands of square feet of industrial space. They also use no energy for growing, harvesting, warehousing, or transporting materials, nor do they use fossil fuels or other energy resources to engineer the above-ground decomposition, or transport the residual material to a second location. Conservation burials are a one-time event that becomes part of the sustainability picture of the land where they occur. The evidence supports that conservation burials by far have the smallest carbon footprint and are actually significant carbon sinks, but let's take a measured look at what goes into natural organic reduction so as to evaluate its environmental ethic as compared with conservation burial.

One caveat: we are not privy to the specific proprietary formula of natural organic reduction, and there are variations in material ratios depending on type of facility, container, availability, and operator preference. The ensuing discussion is based on general scientific principles and calculations.

The Chemistry

Unlike conservation burial that sequesters carbon for years and perhaps decades, each industrially composted body produces one cubic yard of material (a minimum of 1250 lbs.) that has a high carbon content. It's not clear that one can really call the remains "soil" at that point, but claiming it is appeals to consumers eager for something more eco-friendly than vault burial or cremation. For our purposes, we will call it compost.

Composting itself releases a fair amount of greenhouse gasses, primarily carbon dioxide ($CO_{2)}$, along with other gases. Aerated composting releases relatively little methane (CH_4), and smaller amount of nitrous oxide (N_2O). Bodies composted in conservation burial graves almost certainly release more methane, which is produced in low oxygen environments, but less N_20. Both methane and N_2O are stronger greenhouse gasses than CO_2. Methane is around 23 times more powerful at greenhouse warming and N_2O is almost 300 times stronger than CO_2. A good estimate is that aerated composting will release around 1 ton of methane per 100 tons composted, and only 40 pounds of NO_2. That is equivalent to 23 tons of CO_2 and 6 tons of CO_2 respectively in terms of greenhouse gases. 100 composted bodies represent roughly 50 tons of material being composted, and the equivalent of nearly 15 tons of CO_2 in non-CO_2 greenhouse gasses.

However, CH_4 (methane) and NO_2 have much lower residence times in the atmosphere. The effective residence time of CO_2 is measured in centuries, while CH_4 has an atmospheric residence of only 9-12 years, and NO_2 of a century or so.

Most of the remaining material would presumably be placed on top of the ground and not buried, and most of the carbon in the woodchips, sawdust, and other organic materials would be released back into the atmosphere unless it is put out in very deep deposits, which would potentially harm recovering woodlands, not help them.

Composters in other fields point out that the carbon and nitrogen involved were fixed in recent times, so most of this might be considered greenhouse gas neutral. We certainly consider this to be true with in-ground composting. Most of us are dependent on high carbon-footprint industrial agriculture that includes industrial composting greenhouse gas costs of production and distribution. Conservation burial 'composting facilities'—meaning the soil—fixes many tons of CO_2. Keep in mind that the average human body contains about 14.5 kg of carbon, and oxidation of that much carbon emits over 55 kg of CO_2. It's a common mistake to say that the soil itself will fix; it's the natural flora based in the soil that fixes CO_2.

> *"86% of all water use in the West is attributable to irrigated agriculture."*
> — B. Richter, et al,
> Northern Arizona

We estimate that the Recompose company must truck in tons of mulching material to its roughly 18,000 square foot home. Additionally, there are likely significant costs to maintaining, heating, and cooling at least part of the large space. Unless they use exclusively electric vehicles that would also have a significant transportation carbon footprint.

The carbon cost of harvesting and preparing this material, as well as the fuel costs for transporting it, should be added to the carbon footprint of the burial. For instance, alfalfa, which is used to add nitrogen to speed the process, comes with significant energy costs in production, including the use of nitrogen and phosphorous fertilizers.[ii] It is also the most water irrigation-dependent livestock crop contributing to the draining of the Colorado River Basin, causing record years of drought in the American West.[iii] Of that, alfalfa consumes more than five times the water as corn silage and well over twice as much as grass hay, the three major cattle feedstocks. Together the three add up to 32% of all the water used or consumed annually in the West. Alfalfa production and transportation alone represent a major environmental risk, and that is just part of the compost makeup.[iv]

According to the article, approximately 1250 lbs. of composted material is being driven 175 miles from Seattle to Bell Mountain, Washington for disposal for each person. The carbon cost of transporting the load plus the return of an empty truck must be calculated and added to the carbon price tag. An average pickup truck can hold about 2.5 cubic yards of material, so each trip would probably transport the remains of 2 people, or 2500 lbs., perhaps more if hauled in a trailer. Each gallon of gas burned would create 20 lbs. of CO_2, and I calculate that the 350-mile trip would use at least 20 gallons of gas and release 400 lbs. of CO_2. This amounts to an estimated 200 kg. of CO_2 release.

The disposition of the compost will be a growing issue if this is to scale up. For instance, composting 100,000 people per year (a 4% market share of annual deaths in the USA) over a 10-year period would produce enough material to cover 7500 acres 1 inch deep. Let's take a closer look at the article's claim that the option reduces CO_2 emissions by one metric ton per disposition:

> *"We are the first to market with natural organic reduction, and we have been operating at capacity since opening our first location in late 2020. We have transformed over 100 bodies into soil and have over 1000 Precompose members. For each person who chooses Recompose, one metric ton of carbon is saved from entering the environment. That means we have already saved the emissions equivalent of 10 million miles driven, 480 homes powered for one year, or 450,000 gallons of gasoline. With your investment, that impact can increase exponentially."*[v]

The article claims that the company has saved the equivalent 450,000 gallons of gas and 10 million miles driven, but that would be by (so far) avoiding only 220,000 lbs. of emissions (1 metric ton= 1000kg=2200 lbs. x 100 actual composted dead= 220,000 lbs.). Each gallon of gasoline yields 20 lbs. of CO_2, so in reality, they have so far "saved" the equivalent of 11,000 gallons and (if average mileage is 36) just under 400,000 miles. Those people who have not died should not be counted in "carbon emission reduction so far".

Human Composting and Forest Restoration

Taking nutrient rich compost, whatever its source, and dumping it on conservation land does not make it beneficial. In fact, it may easily upset a fragile system or introduce an imbalance of nutrients, achieving precisely the opposition of the goal. It's important to have thought through the research concerning what we know about forest restoration.

"An approximate value for a 50-year-old oak forest would be 30,000 pounds of carbon dioxide sequestered per acre."
—Timothy J. Fahey, Professor of Ecology in the Department of Natural Resources at

Heavily degraded and even destroyed forests do recover naturally, particularly if near remnant forests, but maybe without previous diversity or vigor. Even intentional reforestation efforts can fall short. Elizabeth Pennisi noted that in one study of 176 reforested sites, the average seedling survival was only 44%, but stated that survival jumped to 64% if planted near mature trees.[vi]

Compost can accelerate recovery of areas such as decommissioned logging roads, camp sites, and logging decks, especially if mechanically worked into the compacted soil. However, an EPA paper, "Compost Use in

Forest Land Restoration", notes that nutrient loading is the worry.[vii] Application rates should be lower in areas dominated by nitrogen-fixing red alder. It also states that, "The recommendations of minimums of 33' from continuously flowing water were made to be consistent with EPA's 40 CFR 503 biosolids regulation".

Of particular interest in the article is the last photo published captioned, "Saplings planted with soil from human composting will grow to shade a stream on Bells Mountain, Wash., helping restore the salmon habitat on previously logged land." The compost has been applied to the very edge of the stream which seems to already have decent shade from what appears to be well developed alders. This is in apparent violation of EPA biosolid rules, as well as recommendations of being mindful of possible nitrogen overload when used in conjunction with existing nitrogen-fixing alders. A "before" picture taken in the summer would have been useful, as would a botanical survey.

What about the stimulation of vegetative growth on highly degraded forests damaged by fire, previous agricultural activities, or logging, or all of the above? Beyond improving compacted soils with adsorptive organic material, forest researchers also have entire conferences on the issue of fertilizing young forest stands. NOR additions might stimulate more and faster carbon sequestration in severely degraded/mineralized areas, particularly in compacted situations, coupled with tilling the compost into the dense soil, restoring water retention, and general soil health. This would be, at best, a marginal effect compared to whole cloth forest and prairie restoration and protection, as is the case with conservation burial.

I see no evidence that Recompose has or is developing science-based methodologies for where and how they distribute the compost, and I fear they could be inadvertently harming some areas without such an approach. Perhaps they have released the nutrient content of their composted material, and other "life cycle" energy costs, but I could not see it on their web site.

We Can Do Better: Why Conservation Burial Instead

A human composting costs around $7,000. Recompose has raised close to 10 million dollars, much of which has gone into hard infrastructure. That does not remove CO_2 from the atmosphere; in fact, construction and retrofitting inevitably put CO_2 into the atmosphere. These costs, both financial and environmental, must be assessed equally when making claims about the process as compared with others. The claim that NOR just doesn't add nearly as much as contemporary burial and cremation is disingenuous. This is similar to some cremation advocates claiming that cremation saves land by not "wasting" land for burial.

Conservation burial grounds focus on precisely that: saving land for the benefit of human and natural communities, now and well into the future. In rapidly growing areas, this is perhaps even more urgent. The scientific team at the USDA Natural Resources Conservation Service's Stewardship Program (CSP) found that human activities are causing the persistent and rapid loss of America's natural areas. The human footprint in the continental United States grew by more than 24 million acres from 2001 to 2017—equivalent to the loss of roughly a football field worth of natural area every 30 seconds. The South and Midwest experienced the steepest losses of natural area in this period; the footprints of cities, farms, roads, power plants, and other human development in these two regions grew to cover 47 percent and 59 percent of all land area, respectively. If national trends continue, a South Dakota-sized expanse of forests, wetlands, and wild places in the continental United States will disappear by 2050.[viii]

We need to protect much more land, and we need a better way of funding land acquisition and protection. Conservation burial is being used to enhance connectivity, restore habitat, and produce a sustainable revenue stream. We need to expand efforts to protect land, especially in rapidly growing areas. 10 million dollars could buy a lot of land. Burial on a fraction of each parcel is a tool in the toolkit to accomplish that and to develop greater community support. Case in point: Texas hill country only has 5% of its land protected.[ix] How might a conservation land buy that allows a portion to be used for renewable full body burial benefit the protection of more land and its inhabitants, both living and dead?

From 50,000 feet, conservation burial has a distinct advantage over NOR and other options, given the mission to save and ecologically restore land. Forests and prairies are carbon sinks. How much they absorb is dependent on species, climate, soils, age and other variables. Numbers range from 2.5-40 tons per acre. Timothy J. Fahey, Professor of Ecology in the Department of Natural Resources at Cornell University estimates a 50-year-old oak forest removes 13.7 metric tons per acre, or 30,000 pounds.[x]

By that estimate, an average, middle-aged 100-acre mixed deciduous forest absorbs more than 1,000 metric tons of CO_2 per year (this is site specific and might be more or less, see multiple sources below), or as much CO_2 as produced by driving 4 million miles in an average car getting 36 MPG (1000 mt = 2.2 million lbs.; each gallon of gas produces 20 lbs. of CO_2, so the equivalent of 110,000 gallons of gas x 36 = 3,960,000 miles). Prairies also store a tremendous amount of carbon because, unlike shallow-rooted lawns, prairie grass root systems can go down 10 feet. This can amount to 10 tons per acre with the resulting carbon sequestration instead of expenditure.

We estimate that Ramsey Creek Preserve here in South Carolina alone sequesters close to 600-700 tons of CO_2 per year, and releases very little.[xi] Our one 78-acre site annually offsets about six times more carbon than Recompose has “saved” in the past two years. And if you agree with their methodology, we also “saved” additional tons of CO_2 through burying people naturally vs. vault burial.

Members of the Conservation Burial Alliance are protecting and restoring nearly 2000 acres. If we put the sequestration at less than half of Fahey’s estimate (6 Mt per acre), we are removing 12,000 Mt of carbon each year, or 24 million pounds, and that is not counting the “savings” that Recompose uses to get its 1 Mt per disposition. That is enough to offset driving 43,200,000 miles. That would be more than enough to offset miles driven by staff and families for services, equipment, and visitor centers. And remember, it is the gift that keeps on giving, year in and year out.

Having said this, the main goal of conservation burial has been about preserving and restoring natural landscapes and connecting people to them. Carbon sequestration is a deliberate consideration, but not the only consideration. For example, we would never plant a eucalyptus grove in a piedmont prairie, even if it captured more carbon. We go out of our way to avoid forming adipocere—grave wax—that forms out of decomposed fatty tissue under certain conditions and that can stick around for many decades. (The main components are mostly carbon, with myristic, palmitic, and steric fatty acids.)

But we can do better as far as carbon goes. For natural burial, we need to look at the variables.

1. *Method of excavation.* Hand digging would obviously have a smaller footprint than excavation by a diesel-powered backhoe, and if the cemetery purchased the equipment, you need to include the carbon footprint of producing the machine itself.
2. *Method of grave preparation.* Removing all roots from the grave could contribute to the carbon footprint, especially if left on the ground, preserving as many live roots as possible is better. We generally line the bottom of the grave with boughs from cedar and mulch for aesthetics and to provide more oxygen to accelerate the decay of the body, and (especially with shroud burials) put vegetation on the top, called blanketing.
3. *The carbon associated with the casket/shroud*. Obviously, metal caskets have a much larger footprint than wooden caskets or shrouds. It would be interesting to look at how much energy it takes to harvest trees, mill the wood, and build and transport a wooden casket. Locally sourced wood and locally built caskets would have a lower carbon footprint than buying ones sourced from the other side of the country or from South America where wood for conventional hardwood caskets often comes from. The casket wood or shroud material would temporarily sequester carbon, how long depending on site specific condition. This should be slower than the increased carbon sequestered by plantings.
4. *Carbon sequestered by plantings on grave.* Peer reviewed literature demonstrates that grasses growing on hidden graves are often "supercharged" by the nutrients in the graves.[xii],[xiii] We have seen the same things at Ramsey Creek. We no longer plant big bluestem directly on graves because of this effect; it becomes huge and, presumably, related both to the nutrients and softness of grave soil, the root system is also huge.
5. *Transportation costs to bring the body to the facility.* Part of this can be mitigated as more facilities open. At first, at Ramsey Creek, we had clients from all over the country, because we were the only option. Electric vehicles can also help.

"Conservation burial is chiefly defined for what it does (save land) but even more notably for what it does NOT do. It does not use excess natural resources, it does not create greenhouse gas emissions, it does not require multiple phases and personnel and facilities in the supply chain."

6. *Maintenance.* We now use electric weed-eaters on the trails and try to avoid mowing by using fire. Mowing is still a major CO_2 issue for us. Burning the meadows does not actually result in net CO_2 emissions, and results in greater dominance of the deeply rooted native prairie plants we propagate.
7. *Going off grid* with visitor centers and other infrastructure should be a goal for conservation burial sites.

Conservation burial is chiefly defined for what it does (save land) but even more notably for what it does NOT do. It does not use excess natural resources, it does not create greenhouse gas emissions, it does not require multiple phases and personnel and facilities in the supply chain. Our bodies are brought to the burial ground where graves have been minimally dug, usually by hand, the body placed, and the grave closed in a way that allows soils and plants to regrown as efficiently as possible. Anything beyond that is a boutique service that is likely to separate those who have access to it and those who don't, and who can afford it and those who can't. By contrast, one of the goals of conservation burial is make these spaces accessible and affordable in an act of environmental justice for the benefit of all human, animal, and plant communities.

If we are to truly change disposition practices for the better environmentally, we need to begin paying closer attention to the work of scientists—forensic taphonomists and anthropologists, soil and agricultural forestry field scientists, hydrologists, carbon experts, and more. And we need to begin taking conservation burial more seriously as a means of sequestering carbon, eliminating wasteful, carbon-depleting steps and, above all, saving land.

Choosing to “give back your body” needn’t be this costly in financial or environmental terms. We already have a time-tested, nature-approved way of recycling our nutrients—conservation burial.

Authors

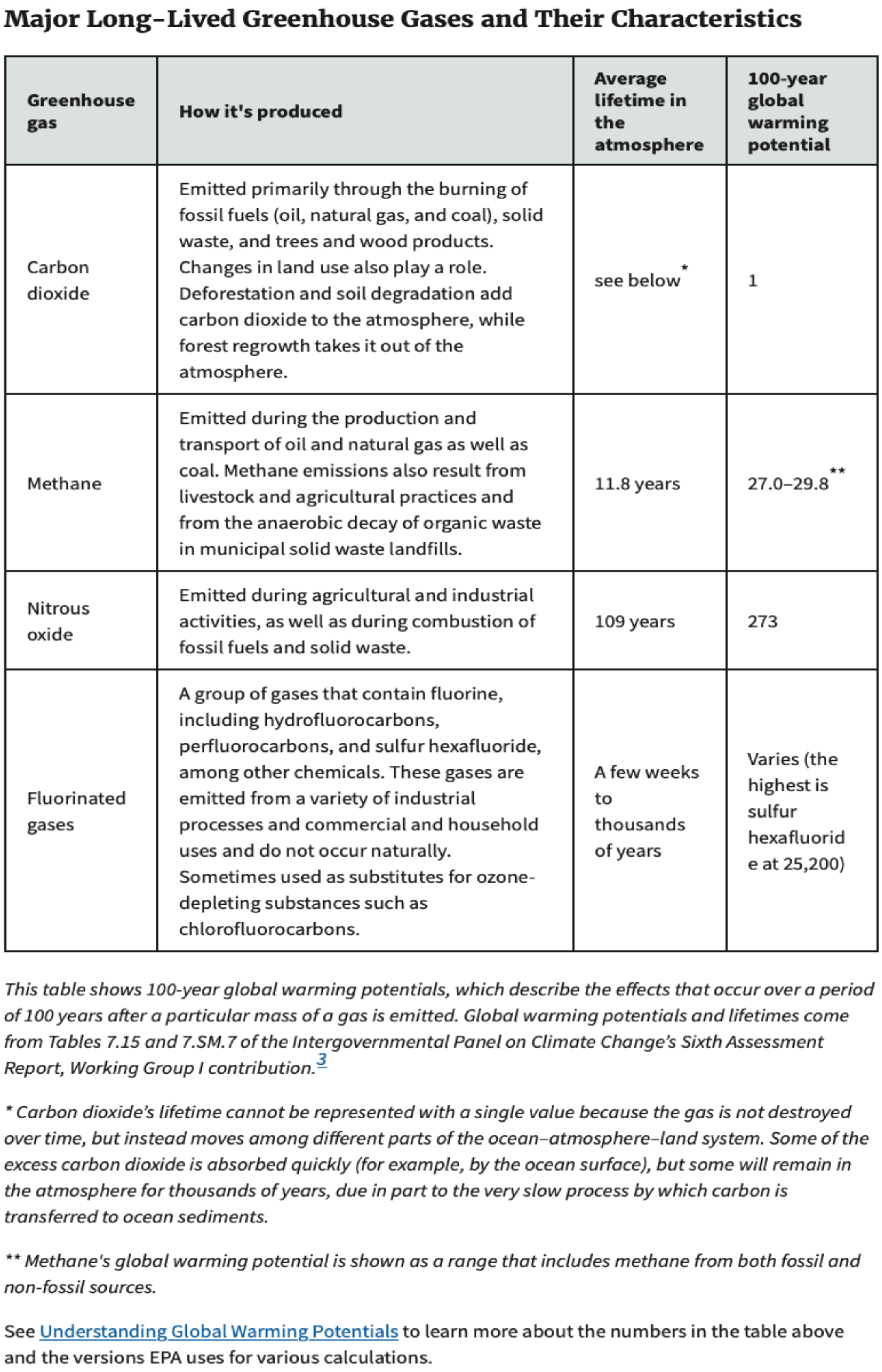
Dr. Billy Campbell co-founded Memorial Ecosystems with his wife, Kimberley, in 1996, prior to establishing Ramsey Creek Preserve, the first natural burial cemetery in the United States and first conservation burial ground in the world. A family physician by trade, he frequently turns his keen clinical curiosity to solving disposition-related scientific mysteries. Campbell was instrumental in founding the Green Burial Council and, together with Kimberley, is a co-founder of the Conservation Burial Alliance. A lifelong environmental watchdog and activist, he has led several conservation causes that prevented the exploitation and destruction of water catchment tributaries, including Coley Creek and the Chauga River, which resulted in the formation of South Carolina Forest Watch. Despite repeated local and corporate opposition, sometimes involving death threats, Campbell perseveres in his efforts to protect the land stewarded by generations of his family and to advocate for saving and restoring land through conservation burial.

Lee Webster is a writer, researcher, editor, and all-around funeral reform dogsbody. She has served in chief leadership positions with the Green Burial Council and National Home Funeral Alliance, and helped found the Conservation Burial Alliance and National End-of-Life Doula Alliance while directing New Hampshire Funeral Resources, Education & Advocacy and co-creating the Funeral.org Partnership. She regularly guest lectures at colleges and universities, mortuary schools, adult education programs, and co-teaches the Green Burial Masterclass, Doulas and After-Death Care, and other related courses at Redesigning the End. She is the author of several home funeral and green burial books, including The After-Death Care Educator Handbook, Changing Landscapes: Exploring the growth of ethical, compassionate and environmentally sustainable green funeral service, and contributions to The Future of the Corpse and other books on related topics.

Environmental Comparison of Body Disposition Methods Chart

METHOD	NET CARBON FOOTPRINT	FUEL EXPENDITURE	AMOUNT OF LEFT-OVER PRODUCT FOR DISPOSAL	LAND ACREAGE PROTECTED	ENVIRO COSTS OR BENEFITS	AVERAGE FINANCIAL COST
Conservation Burial	· Sequesters 10 tons of CO_2 per acre when built out, depending on site specifics	· Transportation of the body to the cemetery, usually within a 100-mile radius of the cemetery	-0-	· Minimum 20 acres per burial ground · Unlimited; often contiguous to protected land · Burial occurs on a fraction of the protected land	· One step · Land protection · Nutrient contributions to soil communities · Strategy component of a complete land conservation plan	$200 to 4,000
Human Composting	· Indeterminate positive greenhouse emissions (estimate pending, higher than reported)	· Sowing, watering, harvesting, processing, transporting of alfalfa, wood chips, other stock to facility; storage · Heating, cooling, maintenance of facility and its operating units · Transporting of finished material	· 1+ cubic yard of composted material including pulverized bone per person · 10 – 15 lbs. pulverized bone (*calcium phosphate and sodium, 11.8 pH, 200 – 2000 x what plants can tolerate*) added to composted material	-0-*	· Materials acquisition · Facility maintenance · Trucking of leftover materials · Smothered plant and soil communities if dumped · Restoration of depleted soil if intentionally tilled or incorporated	$7,000
Alkaline Hydrolysis	· Up to 200 lbs. CO_2 per person · Most AH waste will be turned into carbon and nitrogenous GHG by public wastewater treatment facilities	· Electricity or propane to heat 100 gallons of water under pressure 3-12 hours · Processing and transportation of potassium hydroxide (lye)	· 100 – 300 gallons of effluent · 10 – 15 lbs. pulverized bone (*calcium phosphate and sodium, 11.8 pH, 200 – 2000 x what plants can tolerate*)	-0-*	· Potential algae bloom from phosphorus run-off due to scatterings · Tree ringing from burial close to tree root and microbial system · Disposal of effluent (no state EPA has permitting)	$3,500
Flame Cremation	· Up to 250 lbs. CO_2 emissions per person · Mercury, particulate emissions into air and waterways	· Up to 500 gallons of fuel, usually natural gas, to burn @ 1700 to 2000° for 3-4 hours	· 7-10 lbs. pulverized bone (*calcium phosphate and sodium, 11.8 pH, 200 – 2000 x what plants can tolerate*)	-0-*	· Potential algae bloom from phosphorus run-off due to scatterings · Tree ringing from burial close to tree root and microbial system · Mercury, nitrous oxide, particulate matter release into air and water	$2,500

*Note that scattering or burying excess materials in "memorial forests" or on conserved land is not a guarantee that the land is being managed by an active land trust with a conservation plan



Major Long-Lived Greenhouse Gases and Their Characteristics

Greenhouse gas	How it's produced	Average lifetime in the atmosphere	100-year global warming potential
Carbon dioxide	Emitted primarily through the burning of fossil fuels (oil, natural gas, and coal), solid waste, and trees and wood products. Changes in land use also play a role. Deforestation and soil degradation add carbon dioxide to the atmosphere, while forest regrowth takes it out of the atmosphere.	see below*	1
Methane	Emitted during the production and transport of oil and natural gas as well as coal. Methane emissions also result from livestock and agricultural practices and from the anaerobic decay of organic waste in municipal solid waste landfills.	11.8 years	27.0–29.8**
Nitrous oxide	Emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.	109 years	273
Fluorinated gases	A group of gases that contain fluorine, including hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, among other chemicals. These gases are emitted from a variety of industrial processes and commercial and household uses and do not occur naturally. Sometimes used as substitutes for ozone-depleting substances such as chlorofluorocarbons.	A few weeks to thousands of years	Varies (the highest is sulfur hexafluoride at 25,200)

This table shows 100-year global warming potentials, which describe the effects that occur over a period of 100 years after a particular mass of a gas is emitted. Global warming potentials and lifetimes come from Tables 7.15 and 7.SM.7 of the Intergovernmental Panel on Climate Change's Sixth Assessment Report, Working Group I contribution.[3]

** Carbon dioxide's lifetime cannot be represented with a single value because the gas is not destroyed over time, but instead moves among different parts of the ocean–atmosphere–land system. Some of the excess carbon dioxide is absorbed quickly (for example, by the ocean surface), but some will remain in the atmosphere for thousands of years, due in part to the very slow process by which carbon is transferred to ocean sediments.*

*** Methane's global warming potential is shown as a range that includes methane from both fossil and non-fossil sources.*

See Understanding Global Warming Potentials to learn more about the numbers in the table above and the versions EPA uses for various calculations.

For more EPA information, go to: https://www.epa.gov/climate-indicators/greenhouse-gases

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End Notes

[i] Caitlyn Doughty, "If You Want to Give Back to Nature, Give your Body" *New York Times* (December 5, 22).

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[iv] B. Richter, D. Bartak, P. Caldwell, K. Frankel Davis, P. Debaere, A. Hoekstra, T. Li, L. Marston, R. McManamay, M. Mekonnen, B. Ruddell, R. Rushforth, T. Troy, *Nature Sustainability: Water scarcity and fish imperilment driven by beef production* (*Northern Arizona University Fewsion,* March 2, 2020). YouTube Video: https://www.youtube.com/watch?v=f0gN1x6sVTc

[v] Caitlin Doughty, "If You Want to Give Back to Nature, Give your Body"

[vi] Elizabeth Pennisi, "How to Regrow a Forest? Scientists Aren't Sure" *Science* (November 25, 2022) p. 816.

[vii] C. Henry and K. Bergeron, "Compost Use in Forest Land Restoration" University of Washington and King County (*Department of Natural Resources, EPA Publication*, July 2005).

[viii] Matt Lee-Ashley, "How Much Nature Should America Keep?" *American Progress*, (August 6, 2019).

[ix] "State of the Hill Country: 8 Key Conservation and Growth Metrics for a Region at a Crossroads" *Texas Hill Country Conservation Network*, (February 2022).

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[xi] "Calculation of CO2 Offsetting by Trees" (*Encon)*. https://www.encon.eu/en/calculation-co2-offsetting-trees.

[xii] "Native Grasses from Short to Tall" *The Native Plant Herald*, Prairienursery.com.

[xiii] Mark Tibbett and David O. Carter, "Forensic Taphonomy: Chemical and Biological Effects of Buried Human Remains" (*CRC Press*, 2008), p. 208.

Of particular note from "Compost Use in Forest Land Restoration":

"Although the common perception of biosolids is that it contains large amounts of contaminants, surprisingly it is the nutrients (primarily nitrogen) contained in biosolids and other organic residuals that restrict application rates ***. Many studies have documented this; seldom have heavy applications posed problems from contaminants, whereas over-application will invariably cause nitrate leaching.*** *Proper nutrient management – controlled application rates such as that used for any fertilization – will reduce risk of it occurring. Figure 3 shows actual data from a biosolids-applied site. For comparison purposes, both Douglas-fir stands and red alder stands are also show* ***. Red alder is a nitrogen fixer, and typically adds significant amounts of nitrate to ground and surface waters*** *. Current research is focused on nitrogen management, continually providing more accurate design of application rates. Secondly, site monitoring provides information to fine tune site specific application rates."*

"Roads and landings (compost incorporated ***). Where the compost is applied and incorporated into the soil,*** *a 2-3 inch application is recommended. This is equal to about 100 tons/ac dry matter."*

"Depending upon compost application method, material can be placed pretty close to where we want it, and waterways can be identified fairly easily in these disturbed areas."

Additional References

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