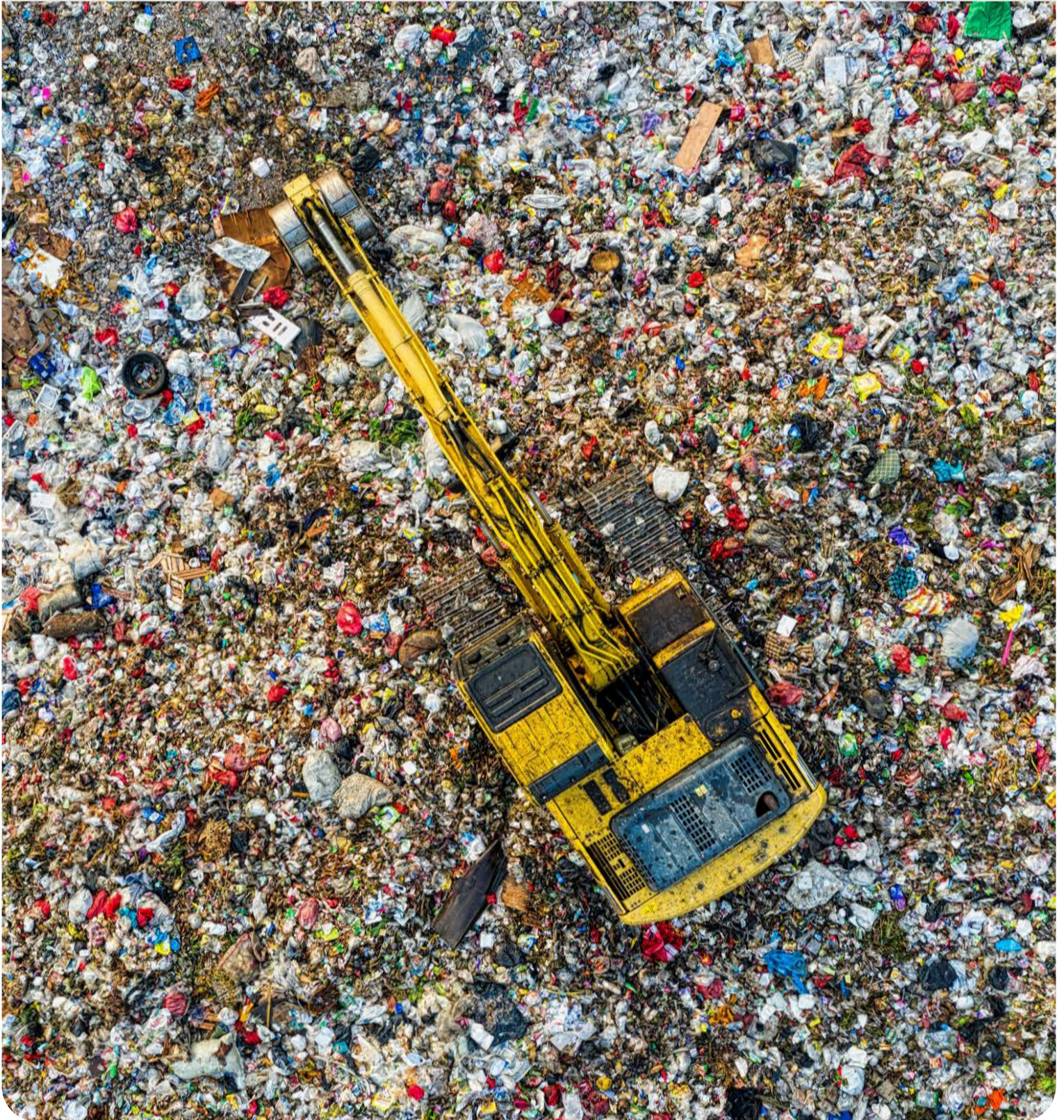


OurCarbon[®]

Life Cycle Assessment: Biosolids Landfill Avoidance

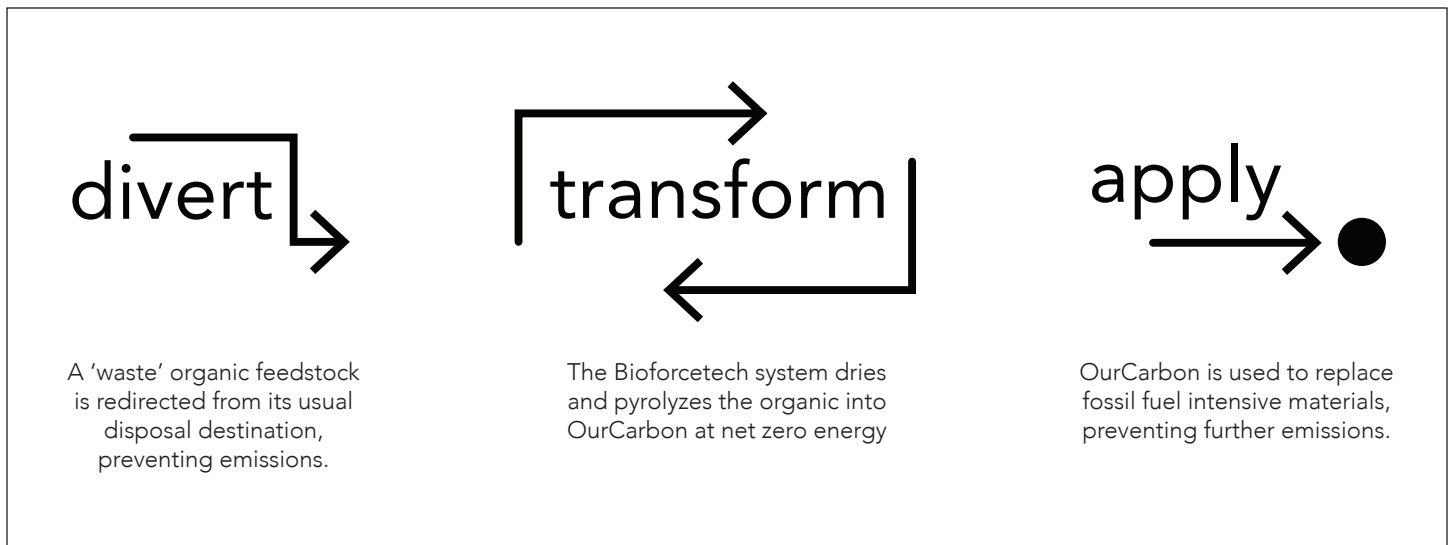
© Bioforcetech Corporation



Introduction

Biosolids, the solid residual from wastewater treatment, is an organic material created globally that currently sees few options for disposal. According to the US EPA roughly 27% of biosolids, around 1 million dry metric tons, were landfilled in 2022. Landfilling biosolids results in significant greenhouse gas emissions due largely to the methane that emits from the material being placed in these anaerobic conditions.

OurCarbon is produced from biosolids that have been diverted from landfill, avoiding the emissions that would have otherwise resulted. These avoided emissions are key in a municipalities decision to deploy technologies like Bioforcetech's and in understanding the overall impact that the creation and use of OurCarbon can have in helping to lower emissions overall.



Methodology and significant factors

The LCA work conducted for this study was executed by Northern Tilth, LLC. Northern Tilth is a trusted organics recycling technical consultancy and is extremely familiar with the Biosolids Emissions Assessment Model (BEAM), the industry standard model for assessing GHG emissions associated with biosolids management.

According to the BEAM Model, the amount of emissions a given amount of landfilled biosolids emits is dependent largely on three factors:

Climatic Region: The BEAM Model divides the US into four differing climatic regions based on their average temperatures, average precipitation, and average evapotranspiration rates. There are four regions: Cool/Dry, Warm/Dry, Cool/Wet, and Warm/Wet. Each region results in the same amount of biosolids emitting a differing amount of methane in landfill. Cool/Dry regions result in the least methane, while Warm/Wet regions result in the most.

Biosolids Digestion Level: In wastewater treatment, it is common to digest biosolids in order to create methane in a controlled space that can be utilized. Digested biosolids have already converted a portion of their volatile carbon to methane, so they will produce less methane in a landfill environment. The BEAM Model considers undigested solids, partially digested solids, and completely digested solids in its calculations.

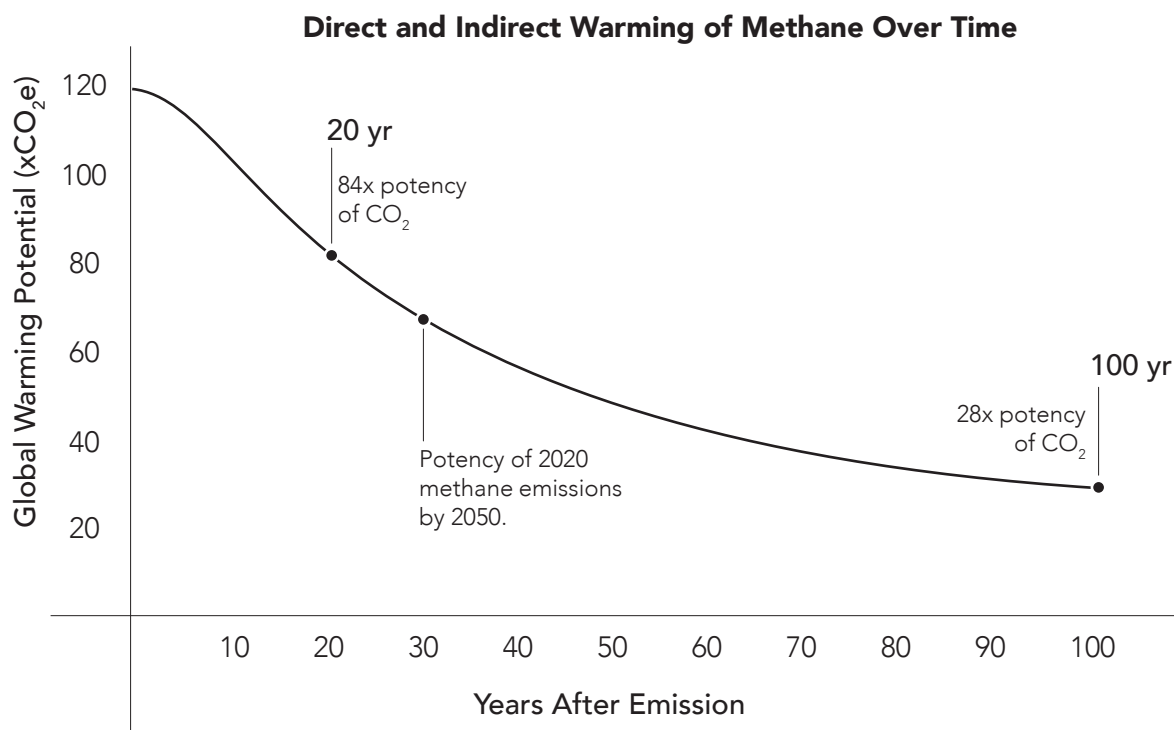
Landfill Management Practice: Landfills nationwide do or do not incorporate various strategies to reduce their greenhouse gas emissions. In this study, four differing landfill scenarios were modeled that cover the spectrum of landfill management. Three of the scenarios apply to the entire United States; a worst case scenario landfill, a typical landfill, and an aggressively managed landfill. A final scenario was created specifically for California due to the states stringent regulation on landfill management. The worst case scenario results in the largest methane emissions, while the aggressively managed landfill and California landfills result in the lowest methane emissions.

Methane on a 20 and 100 year scale

As a greenhouse gas, methane has a higher warming power than CO₂. This potency starts off high and reduces over time as the gas dissipates. Because of this change over time, Life Cycle Assessments look at the warming potential of emissions on a 20 year and a 100 year time horizon. 20 years after entering the atmosphere, methane is over 80 times as powerful as CO₂ in warming the planet. After 100 years, that same emission is reduced to over 20 times as powerful as CO₂.

Most government organizations operate on a 100 year time horizon, but given the urgency of the climate crisis and the significant avoided emissions that diverting biosolids to OurCarbon production offers, we have included both 20 and 100 year time horizon calculations.

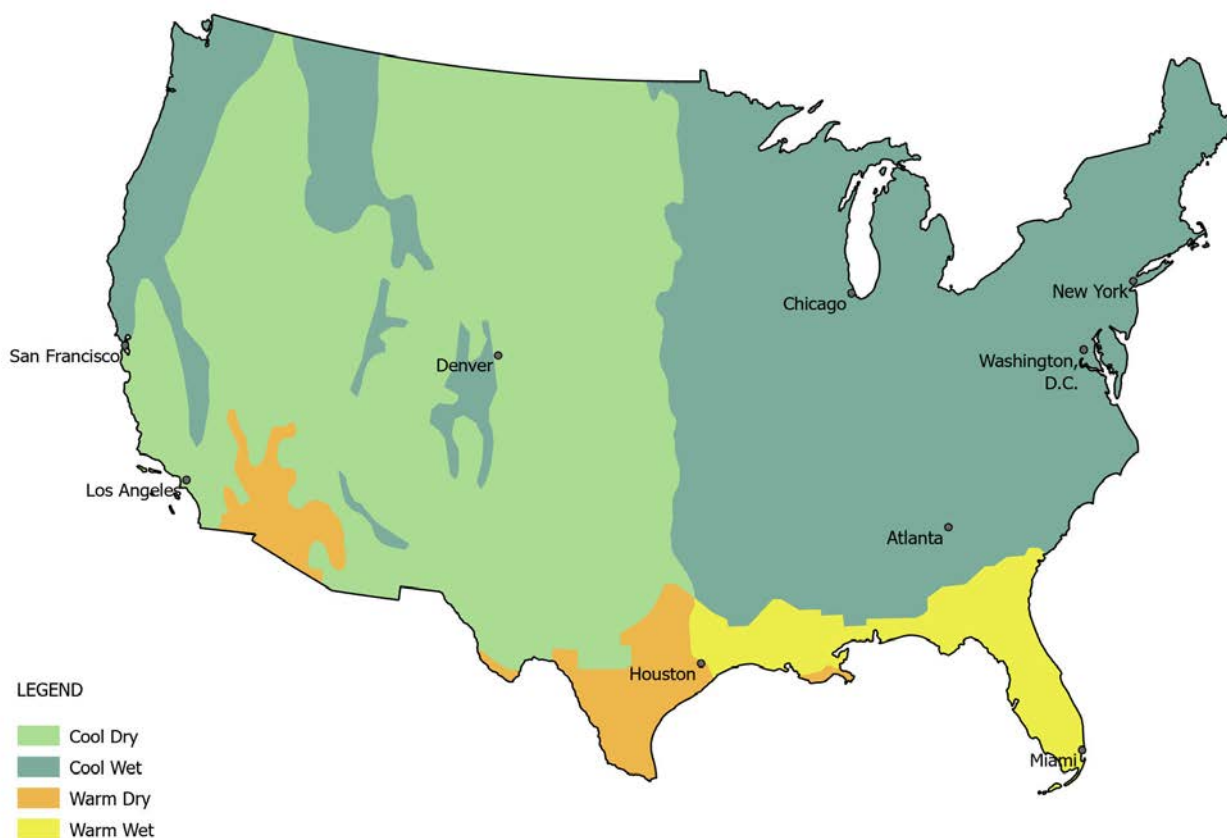
The below graph illustrates the degradation curve of methane in terms of CO₂ equivalent warming potential, as well as a point illustrating the power of a 2020 methane emission to in warming the planet by 2050.



The greenhouse gas methane has an increased global warming potential (GWP) compared to CO₂. This GWP is strongest at time of emission and then dissipates. Any methane emission released during 2020 will still be between 60 and 70 times more potent than CO₂ by 2050. After 100 years, the GWP levels out at around 28 times that of CO₂.

BEAM Climatic Regions

The below map illustrates the rough boundaries between the four climatic regions that the BEAM model divides the United States into. As discussed in the methodology, biosolids landfilled in cooler and dryer regions result in lower methane emissions as compared to the same strategy in warmer and wetter regions.

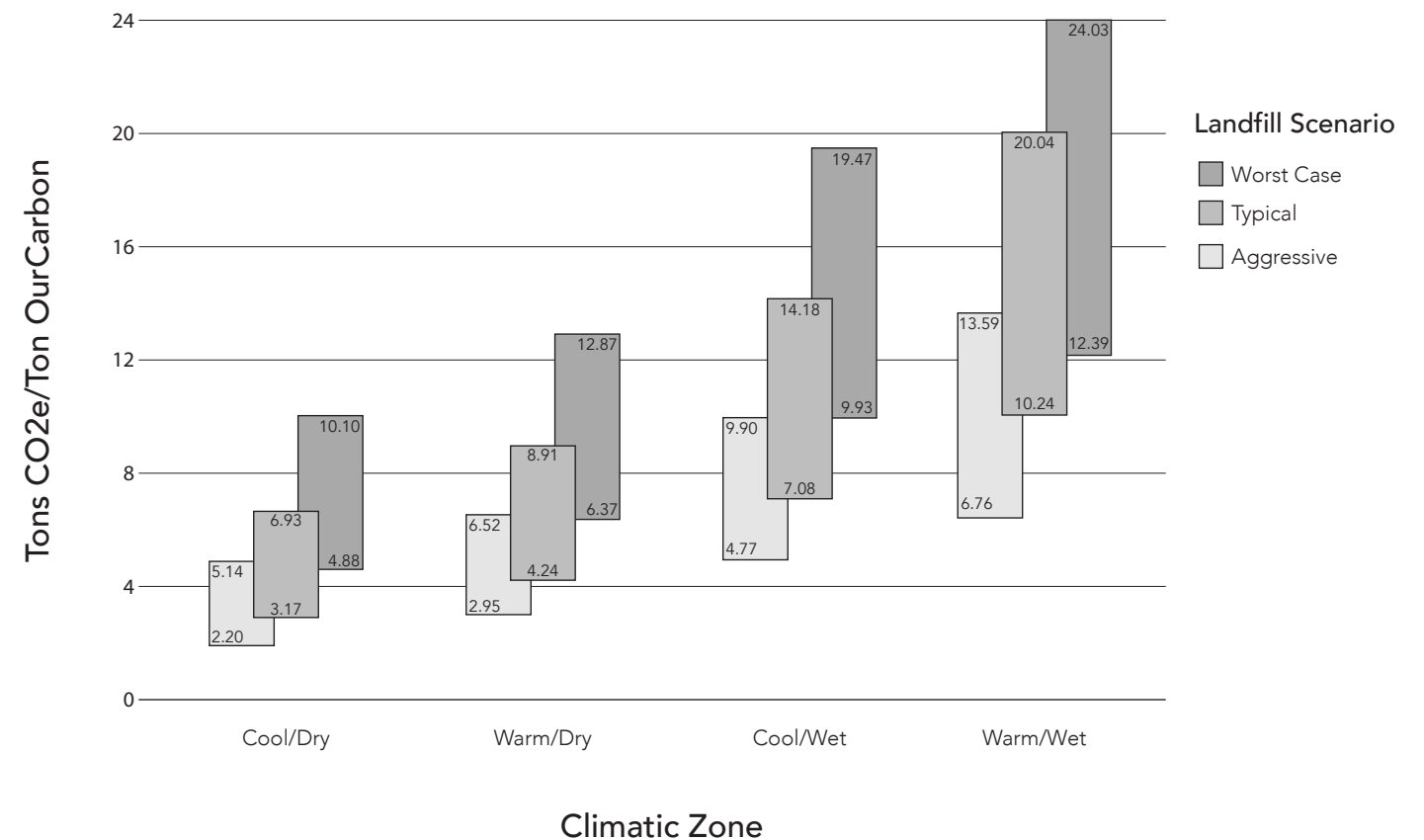


Results: USA Landfill Avoidance

The following graphs show the results of the BEAM study of biosolids landfill emissions on a 20 and 100 year time horizon in the United States outside of California. All figures are calculated based on the amount of biosolids required to produce one ton of OurCarbon. The maximum and minimum emissions for each climate are summarized in the table below

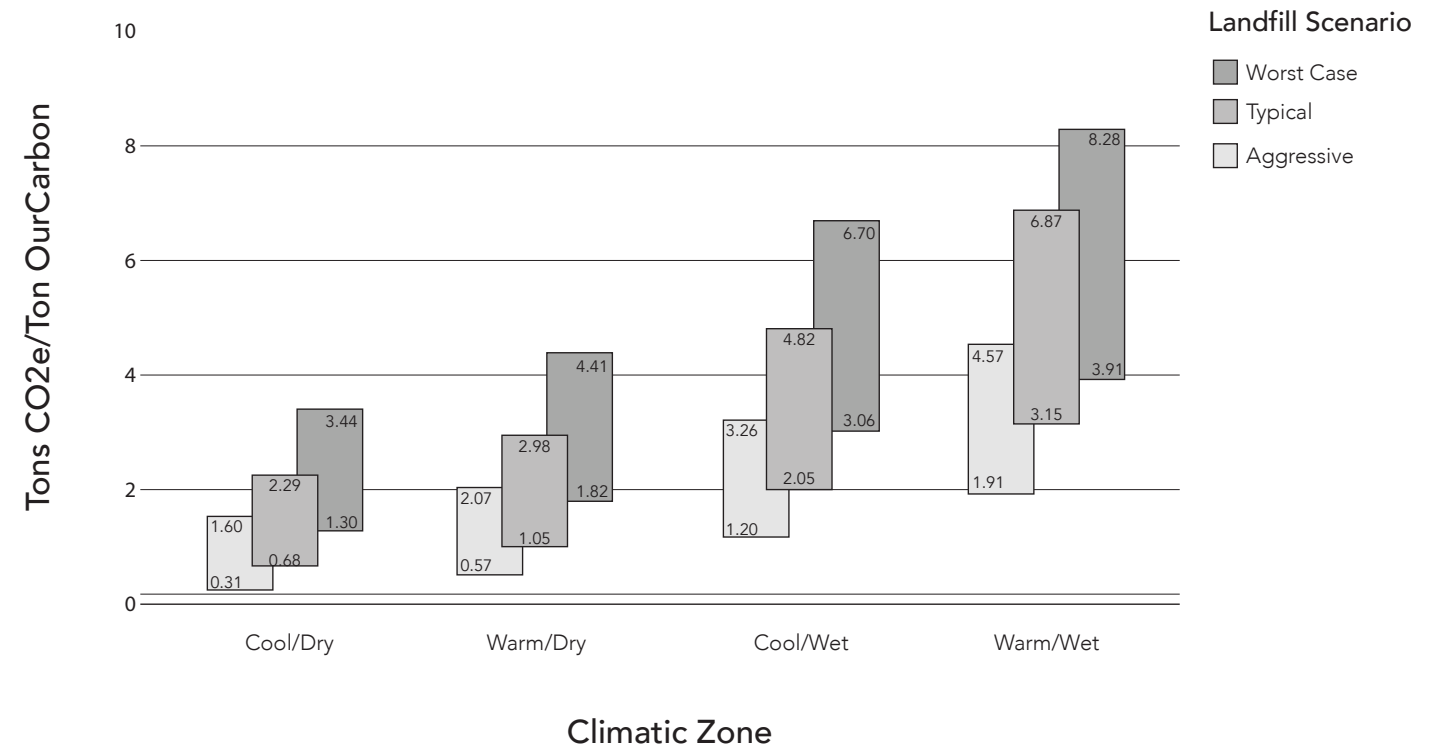
	Cool/Dry	Warm/Dry	Cool/Wet	Warm/Wet
Minimum Emissions 20 yr	2.20	2.95	4.77	6.76
Maximum Emissions 20 yr	10.10	12.87	19.47	24.03
Minimum Emissions 100 yr	0.31	0.57	1.20	1.91
Maximum Emissions 100 yr	3.44	4.41	6.70	8.28

Landfill Emissions in Various Regions of USA: 20 year projection



		Cool/Dry	Warm/Dry	Cool/Wet	Warm/Wet
Aggressive Landfill	Min	2.20	2.95	4.77	6.76
	Max	5.14	6.52	9.90	13.59
Typical Landfill	Min	3.17	4.24	7.08	10.24
	Max	6.93	8.91	14.18	20.04
Worst Case Landfill	Min	4.88	6.37	9.93	12.39
	Max	10.10	12.87	19.47	24.03

Landfill Emissions in Various Regions of USA:
100 year projection

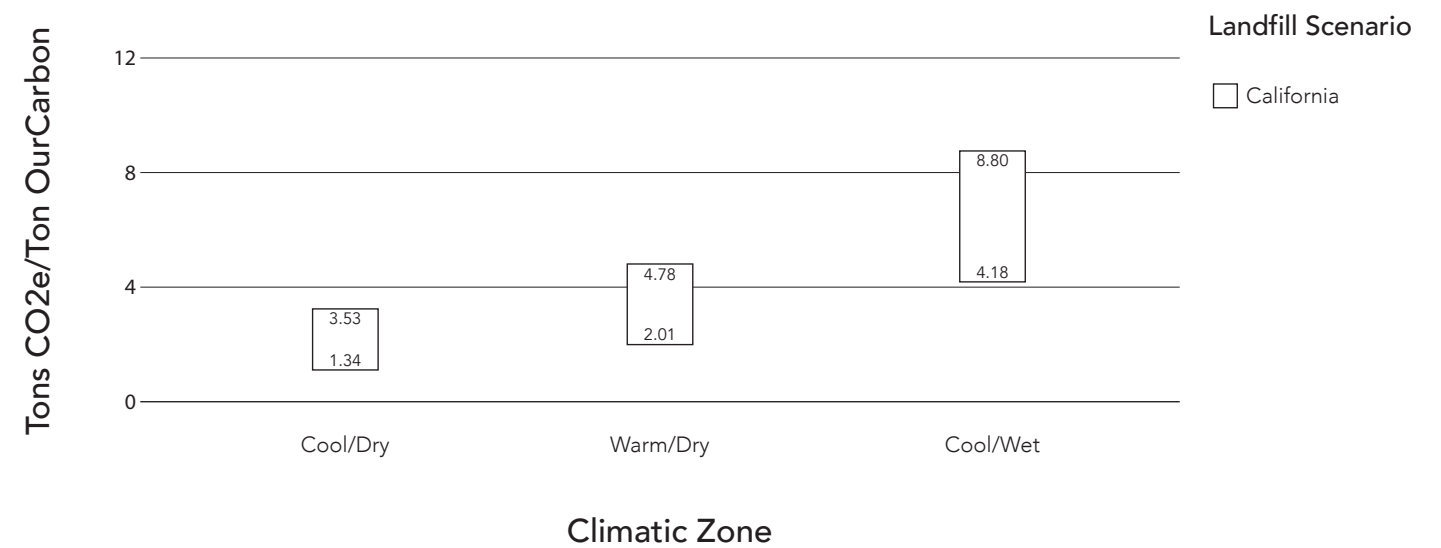


		Cool/Dry	Warm/Dry	Cool/Wet	Warm/Wet
Aggressive Landfill	Min	0.31	0.57	1.20	1.91
	Max	1.60	2.07	3.26	4.57
Typical Landfill	Min	0.68	1.05	2.05	3.15
	Max	2.29	2.98	4.82	6.87
Worst Case Landfill	Min	1.30	1.82	3.06	3.91
	Max	3.44	4.41	6.70	8.28

Results: California Landfill Avoidance

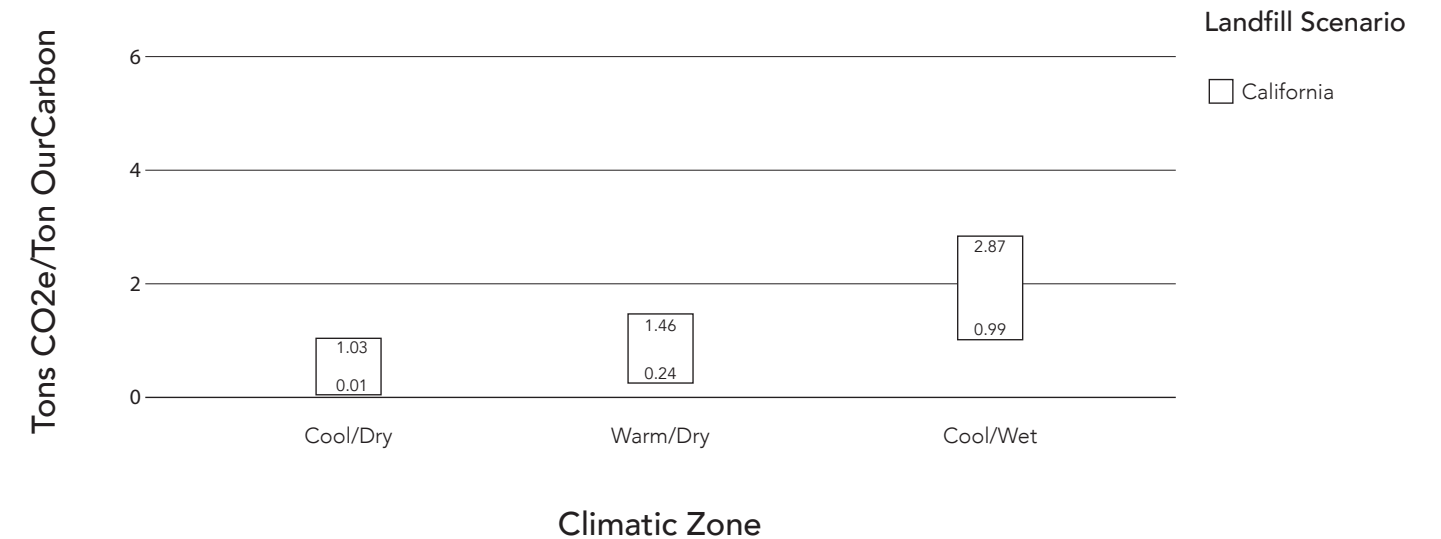
The following graphs show the results of the BEAM study of biosolids landfill emissions on a 20 and 100 year time horizon in California. Note that the Warm/Wet region is not included because this climate does not occur within California. All figures are calculated based on the amount of biosolids required to produce one ton of OurCarbon. The maximum and minimum emissions for each climate are summarized in the table below.

Landfill Emissions in Various Regions of California:
20 year projection



		Cool/Dry	Warm/Dry	Cool/Wet
California Landfill	Min	1.34	2.01	4.18
	Max	3.53	4.78	8.80

Landfill Emissions in Various Regions of California:
100 year projection



		Cool/Dry	Warm/Dry	Cool/Wet
California Landfill	Min	0.01	0.24	0.99
	Max	1.03	1.46	2.87