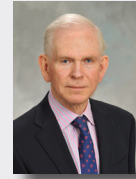


# GMO White Paper

Aug 2018

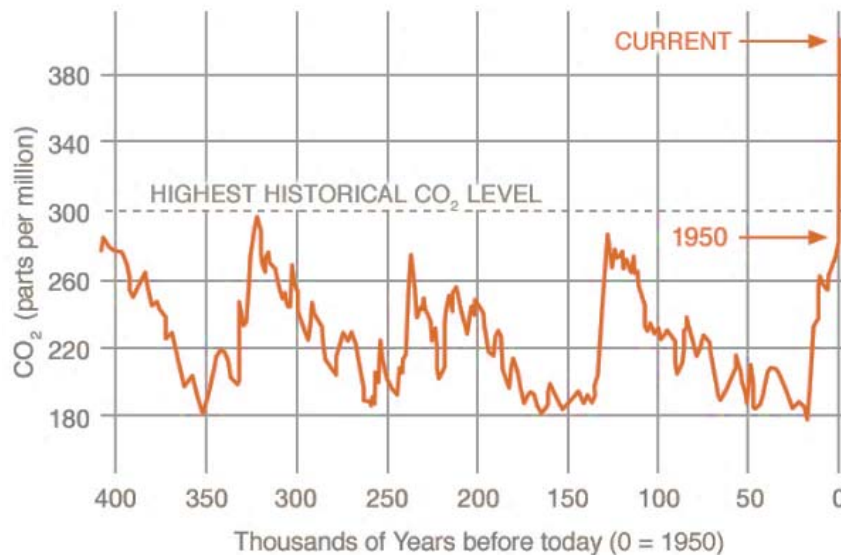
## The Race of Our Lives Revisited<sup>1</sup> (in a nutshell)

*Jeremy Grantham*



You could call this the story of carbon dioxide and Homo sapiens. You may not know, but if we had no carbon dioxide at all, the temperature of the Earth would be minus 25°C – a frozen ball with no life with the possible exception of bacteria. That crucial 200 to 300 parts per million of carbon dioxide has taken us from that frozen state to the pretty agreeable world we have today. CO<sub>2</sub> is therefore, thank heavens, a remarkably effective greenhouse gas.

Exhibit 1: Historical CO<sub>2</sub> Levels (Reconstruction from Ice Cores)

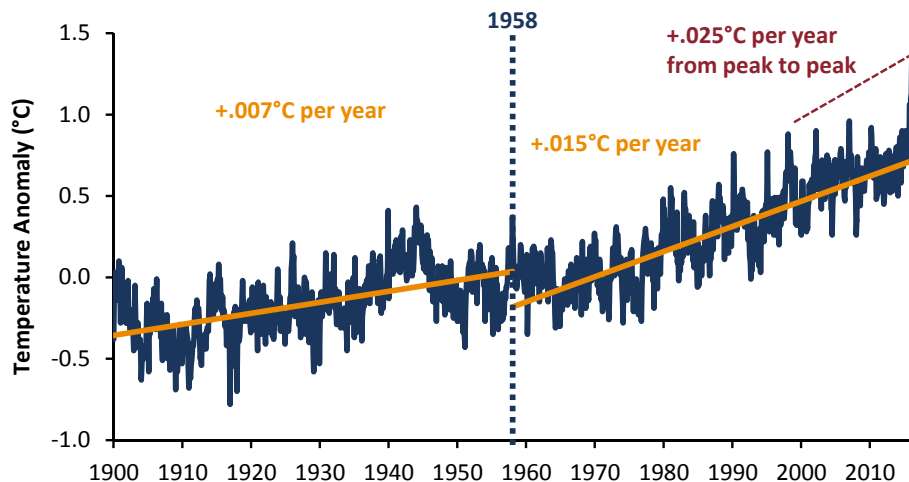


Source: NOAA

<sup>1</sup>This paper uses much of the same material presented at this year's Morningstar Investment Conference in Chicago in June and at London School of Economics in April 2018. Please make allowances for its conversational style. I have attempted to adapt and expand this version for the general public. And please remember you don't have to read this in one sitting. The original "Race of Our Lives" is part of the GMO Quarterly Letter from April 26, 2013 and can be read at [www.gmo.com](http://www.gmo.com).

Exhibit 1 is the famous chart you might have seen used by Al Gore. It shows that for hundreds of thousands of years, the Earth's atmosphere has had 180 to 300 parts per million of carbon dioxide. At 180 parts per million, we had ice ages. At the previous highs of 280 parts per million, we had the interglacials, where our species benefited from the temperate and relatively stable environment we have enjoyed for the last few thousand years: a remission from cold that allowed for and facilitated the growth of civilization in the last 12,000 years. In 1950, carbon dioxide levels were pretty much at the top of this historical range, and we were perhaps ready to slide into a new ice age in the next few thousand years. Then, bang, we added another 120 parts per million in the blink of an eye! We have added the same amount that separates the bottom of glacial phases from interglacials, and we've added it in just 70 years. It is a dramatic and reckless experiment. The best word to describe it is feckless. We are going to add another 120 parts per million, I give you my personal guarantee. By the time we finish, we will have tripled the difference between an ice age and an interglacial, and we must sincerely hope it is not worse than that.

**Exhibit 2: Global Surface Temperature Compared to 1951-1980 Average**

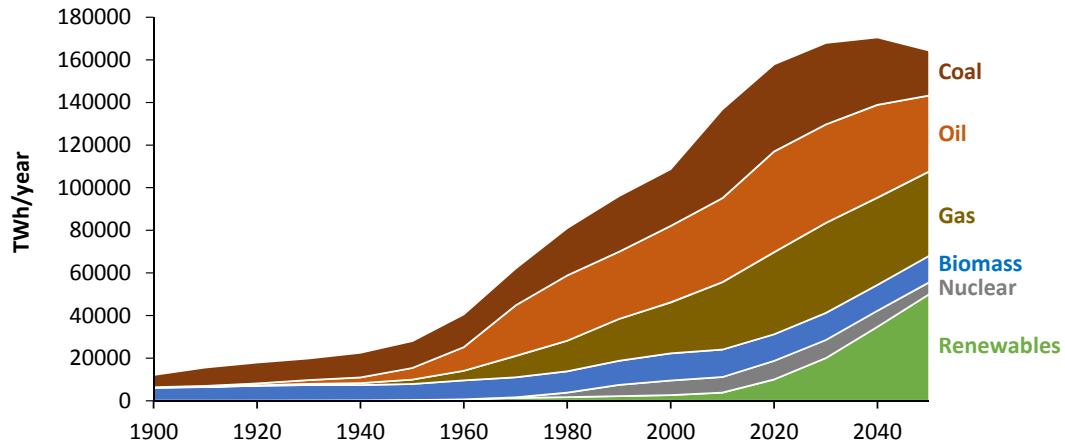


As of 8/31/16  
Source: NASA Goddard Institute for Space Studies, GMO

The data in Exhibit 2 is clear. The trendline through the first 50 years of the last century is an increase of 0.007°C per year. In the second half, the trend had doubled to 0.015°C per year. Then between the two El Niños – climate events that cause a temporary surge in global heat – of 1998 and 2016 (like lining up the top of bull markets), the temperature increased at an average of 0.025°C per year.

But technology, particularly the technology of decarbonization, has come surging in to help us in the great battle against global warming. If we were able to look ahead 40 years, I'm confident that there would be a decent sufficiency of cheap green energy on the planet. In 80 years perhaps it's likely we would have full decarbonization. Lack of green energy will not be the issue that brings us down. The truth is we've wasted 40 or 50 years since the basic fact about manmade serious climate damage became known. We're moving so slowly that by the time we've fully decarbonized our economy, the world will have heated up by 2.5°C to 3°C, and a great deal of damage will have been done.

Exhibit 3: World Annual Primary Energy Consumption by Source, 1900-2050



As of 9/30/17  
Source: OurWorldinData.org, Vaclav Smil, GMO  
Data from 2015-2050 is estimated or forecast.

The bad news is that although the renewables in green are surging, by 2050 over 50% of energy consumption is projected to still be driven by fossil fuels (Exhibit 3). What that means is even if fossil fuels were to peak in a couple of years, and I believe they certainly will peak by 2030 or 2035, the carbon dioxide in the atmosphere will continue to rise and rise. Climate change will not have been stopped. It will barely be slowing down.

Agriculture is, in fact, the real underlying problem produced by climate change. With climate change, there are two separate effects on agriculture. One is immediate: the increased droughts, the increased floods, and the increased temperature reduce quite measurably the productivity of a year's harvest. Then there's the long-term, permanent effect: the most dependable outcome of increased temperature is increased water vapor in the atmosphere, currently up over 4% from the old normal. This has led to a substantial increase in heavy downpours. It is precisely the heavy downpours that cause soil erosion. In regular rain, even heavy rain, farmers lose very little soil. It is the one or two great downpours every few years that cause the trouble. We're losing perhaps 1% of our collective global soil a year.<sup>2</sup> We are losing about a half a percent of our arable land a year.<sup>3</sup> Fortunately, it is the least productive half a percent. It is calculated that there are only 30 to 70 good harvest years left, depending on your location.<sup>4</sup> In 80 years, current agriculture will be simply infeasible for lack of good soil. We must change our system completely to make it sustainable, which, critically, involves reducing erosion to almost zero by using no-till or low-till farming combined with cover crops. Because these are significant changes for a conservative community, it will take decades and we've barely started.

Exhibit 4 shows the various projections including all these factors one-by-one. At the top is the simple extrapolation of the historic productivity gains. The next line down shows what happens when you build in the diminishing marginal returns that we have seen in Japan, Germany, France, and the UK. Next is the effect of erosion, and the effect of more erosion from increased downpours. Then there's the coup de grace from the climate change study.

<sup>2</sup> D.R. Montgomery, *Dirt: The Erosion of Civilizations*, University of California Press, 2007.

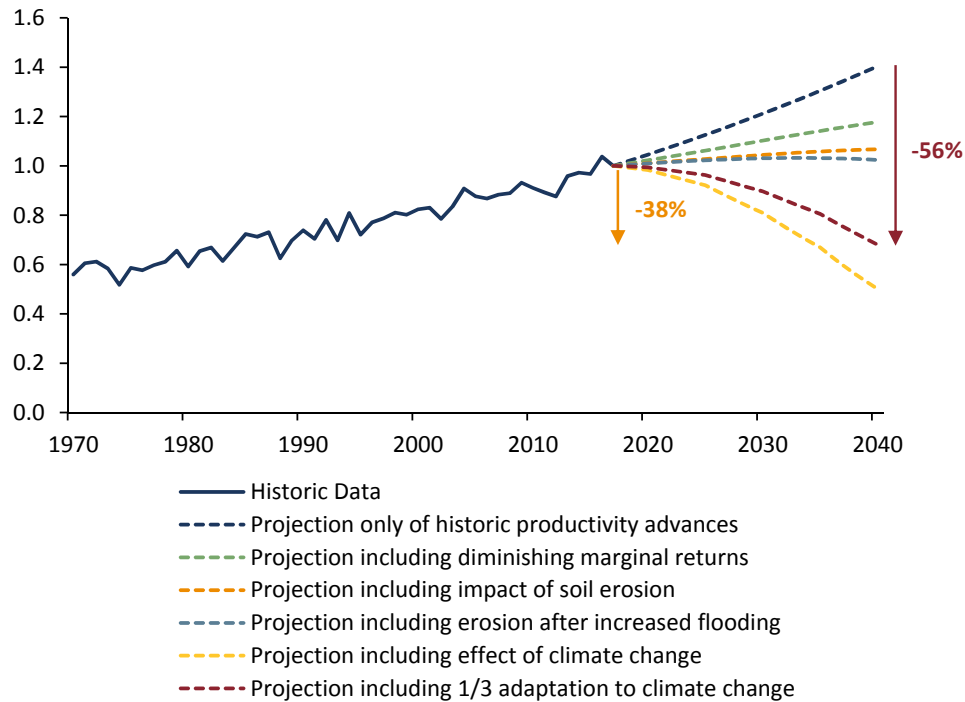
<sup>3</sup> Pimentel and Burgess, "Soil Erosion Threatens Food Production," *Agriculture*, August 2013.

<sup>4</sup> 2015 International Year of Soil Conference, UN Food and Agriculture Organization.

## Exhibit 4: Combined Effect of Climate Change and Soil Erosion

### US Grain Yields, Historical and Projected

Index averaging corn, wheat, soy, and rice yields, 2017 = 1



As of 4/30/18

Source: USDA NASS, Rhodes 2014, Liang et al 2017, GMO

We decided to give a one-third credit for adaptation to climate change: that farmers will be clever; they will change the crops they grow; they will work on building in more drought resistance or flood resistance. (By the way, you have to pick. You can't do both drought and flood resistance at the same time.) Even with adaptation, grain productivity will fall a lot. Maybe in real life farmers will excel and deliver a two-thirds credit for adaptation. What we really need here is improved policy, very productive research, and an unusual willingness to change. But unfortunately, even with substantial adaptation, productivity will still be way down from the historic trend and very likely even down from where we are today.

We have a growing population who want to eat meat, diminishing agricultural returns, and worldwide erosion taking 1% a year of the global soil and half a percent of our arable land. Then there is urban expansion, which is nearly always in fertile river plains, taking the best arable land and concreting it over – calculated to be about two and a half million acres a year.<sup>5</sup> Plus, there are water availability problems from hell that I could spend half an hour on, or an expert could spend a week on. Reservoirs in South Africa, in Morocco, in Spain, in Nevada, are all shrinking, all suffering from the increased heat. We're depleting our aquifers: in heavily irrigated areas such as Las Vegas or the Central Valley of California, well water levels have fallen by hundreds of feet. In China, parts of Beijing are sinking by four inches a year – that's how fast they're pumping out the water.<sup>6</sup> Over half a billion people globally totally depend on underground, very finite aquifers for their water and food.

<sup>5</sup> Bren d'Amour et al., "Future urban land expansion and implications for global croplands," *Proceedings of the National Academy of Sciences*, August 2017.

<sup>6</sup> M. Chen et al., "Imaging Land Subsidence Induced by Groundwater Extraction in Beijing (China) Using Satellite Radar Interferometry," *Remote Sensing*, 2016, 8(6) 468.

For all these many reasons, agriculture is the key to our future success or failure. It is also where climate change has its most consequential effects. But, sadly, it is not the only problem.

Capitalism also has a severe problem with the very long term because of the tyranny of the discount rate. Anything that happens to a corporation over 25 years out doesn't really matter to them.<sup>7</sup> Therefore, in that logic, grandchildren have no value. Corporations also handle externalities very badly. We deforest the land, we degrade our soils, we pollute and overuse our water, and we treat our air like an open sewer. All of this is off the balance sheet and off the income statement. Worse, any sensible response is deliberately slowed down by skillful programs of obfuscation, well-funded by fossil fuel interests and their allies. This does not happen in China, India, Germany, or Argentina. This is unique to the English-speaking, oily countries – the US, the UK, and Australia – where the power of the fossil fuel interests is used to influence both politics and public opinion.

Today climate change is the ultimate Tragedy of the Commons: it can only be dealt with by government leadership and regulation. All this is anathema to the new regime of maximizing an individual country's advantage and short-term corporate profits. Yet however much libertarians may hate regulation – and in general I am sympathetic – when it comes to climate change it is simple. There is simply no other way.

### **Investing and the Environment**

Climate change has moved faster than most thought possible and, as demonstrated above, is having a dramatic impact on the world. Temperatures and sea levels are rising, glaciers are melting, and extreme weather events are increasing in both severity and frequency. Massive amounts of investment are needed in order to head off climate change, and we believe there will be exciting investment opportunities in companies focused on climate change mitigation and adaptation. As costs continue to fall for wind, solar, and energy storage, we are reaching an inflection point where renewable energy is becoming increasingly competitive with conventional energy, even in the absence of subsidies and incentives. Even James Robo, CEO of NextEra Energy (which controls Florida Power & Light as well as the world's largest trading unit for wind and solar) has said "New wind and new solar, without incentives and combined with storage, are going to be cheaper than the operating cost of coal and nuclear in the next decade." Economics will drive the transition to a clean energy world, and the climate change sector is likely to experience strong secular growth.

Exhibit 5 is our portfolio at GMO of climate change opportunities, which has been around for a year. What we're trying to do is understand, a little ahead of the market, these powerful and complicated new crosswinds as we decarbonize. Unsurprisingly, the portfolio has lots of clean energy stocks, copper (which is 5 times more heavily used by electric cars than conventional cars), masses of energy efficiency opportunities, and around 20% in agriculture. I can say that I have a very high-confidence belief that these industries collectively will have higher top-line revenue growth than the balance of the economy.

---

<sup>7</sup>At a corporate discount rate of 15%, a common enough hurdle for new investments – today's value of \$1 earned 26 years from now is two and a half cents.

### Exhibit 5: Illustrative Climate Change Portfolio (Global Equities)

Segment	Exposure
<b>Clean Energy</b>	<b>39.4%</b>
Solar	9.7%
Wind	8.5%
Other Clean Energy	1.3%
Clean Power Generation	6.1%
Batteries & Storage	14.0%
<b>Smart Grid</b>	<b>6.2%</b>
<b>Copper</b>	<b>8.4%</b>
<b>Energy Efficiency</b>	<b>16.8%</b>
Transportation	6.6%
Buildings	0.4%
Diversified Efficiency	6.0%
Technology	1.9%
Lighting	1.4%
Recycling	0.5%
<b>Agriculture</b>	<b>19.1%</b>
Farming	3.8%
Farm Machinery	1.6%
Timber	0.7%
Eco-Chemicals/Seeds	1.5%
Fertilizer	5.5%
Fish Farming	5.9%
<b>Water</b>	<b>4.4%</b>
<b>Cash</b>	<b>5.6%</b>

Source: GMO

Though we believe there will be tremendous opportunities in the climate change sector, we also believe that a disciplined, value-oriented approach will be critical in navigating a sector likely to be rife with hype and stories. Furthermore, we believe that a public market approach can be a great complement to private equity in this space, not only for the liquidity and cost advantages, but also for the increased opportunities for diversification and the ability to allocate nimbly to new technologies as they emerge.

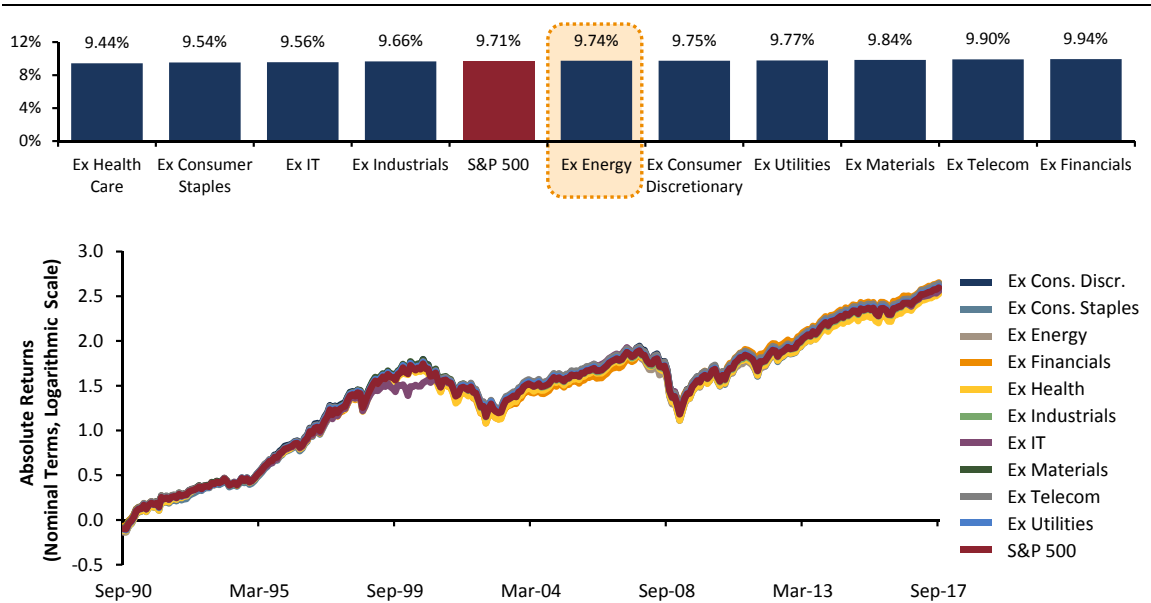
### The Alleged Perils of Divestment

It should be pretty clear from this discussion that if you're messing around with oil stocks, you're taking the serious risk of ending up with stranded assets. Oil companies are being sued everywhere because they've been caught red-handed. They were writing for peer-reviewed journals in the late 1970s, proving that carbon dioxide was dangerous and that the ocean levels would rise. They took advantage of their knowledge: they took it into account to drill in the Arctic and to site their refineries. And they have misrepresented the damage they knew their products would cause. They are vulnerable and face many legal battles as we speak. Yet investment committees, the most conservative groups on the planet as we know – I have spoken to perhaps 3,000 or so of them – maintain that if they divest from oil it will ruin their performance. If they accept any constraint at all, they feel, it will ruin their

performance. Exhibit 6 shows what we did to test this long-held divestment hypothesis. We took out each of the 10 major groups in the market for 30 years, leaving only 9 of the 10 groups in each portfolio, and what we found was that it didn't make any difference. The entire range from best to worst was only 50 basis points. The return you get without Energy is highlighted – you make 3 bps more without Energy. Look at the graph. Taken together, other than IT in the 2000 bubble, they look like a single series. Even the 2000 deviation settled back as if the bubble had never occurred.

**Exhibit 6: You Can Divest from Oil – or Anything Else – Without Consequence**

**Annualized Absolute Returns (Nominal Terms): 1989-2017 – Range: 50 bps**



As of 9/30/17  
Source: S&P, GMO

Now we can put a more accurate price on divestment and ethics. For example, if you were to consider it unethical to own these oil companies whose scientists wrote, as mentioned, about the serious dangers of climate change in the 1970s only to have management later ignore it all and fund deniers and obfuscators, you can believe the cost of your ethics is about +/- 20 basis points!

**What Should Investors Do About Climate Change?**

What I'm hoping you will do, first of all, is vote for green politicians. I don't care what party they belong to. It might surprise you to learn that all the great environmental law of the past 100 years came from Republicans. Second, lobby your investment firms to be a bit greener and encourage them to lean on their portfolio companies to do the same. Push them hard. Cash in some of your career risk units. You will at least be able to look your children in the eye. You may even feel better. And your firms may be able to attract more of the best kind of young recruits who are beginning to care very much more about these issues than we older folk collectively do.

We're racing to protect more than our portfolios from stranded assets and other climate change impact. That I believe is easy enough. But for those portfolio managers who happen to be human, we have a much more important job. We're racing to protect not just our portfolios, not just our grandchildren, but our species. So get to it.



## Conclusion

It was always going to be difficult for us – Homo sapiens – to deal with the long-term, slow-burning problems that threaten us today: climate change, population growth, increasing environmental toxicity, and the impact of all these three on the future ability to feed the 11 billion people projected for 2100.

Ten thousand years ago, or even a hundred years ago, these problems were either mild or non-existent. Today they are accelerating to a crisis.

Our one material advantage is in the accelerating burst of green technologies, which has been better than anyone expected 10 or even 5 years ago and that may in the future be able to offset much of the accelerating damage from climate change and other problems. Yet despite these surprising technological advances, we have been losing ground for the last few decades, particularly in the last few years. Somehow or other we must find a way to do better. We must expand on our strengths in technology while fighting our predisposition toward wishful thinking, procrastination, and denial of inconvenient long-term problems. We must also find inspirational leadership, for without it this race, possibly the most important struggle in the history of our species, may not be winnable. It is about our very existence as a viable civilization. We will need all the leadership, all the science and engineering, all the effort, and all the luck we can muster to win this race. It really is the race of our lives.

---

**Jeremy Grantham.** Mr. Grantham co-founded GMO in 1977 and is a member of GMO's Asset Allocation team, serving as the firm's chief investment strategist. He is a member of the GMO Board of Directors and has also served on the investment boards of several non-profit organizations. Prior to GMO's founding, Mr. Grantham was co-founder of Batterymarch Financial Management in 1969 where he recommended commercial indexing in 1971, one of several claims to being first. He began his investment career as an economist with Royal Dutch Shell. Mr. Grantham earned his undergraduate degree from the University of Sheffield (U.K.) and an M.B.A. from Harvard Business School. He is a member of the Academy of Arts and Sciences, holds a CBE from the UK and is a recipient of the Carnegie Medal for Philanthropy.

---

Disclaimer: The views expressed are the views of Jeremy Grantham through the period ending August 2018, and are subject to change at any time based on market and other conditions. This is not an offer or solicitation for the purchase or sale of any security and should not be construed as such. References to specific securities and issuers are for illustrative purposes only and are not intended to be, and should not be interpreted as, recommendations to purchase or sell such securities.

Copyright © 2018 by GMO LLC. All rights reserved.