CO_2 and Climate Change

The **Friends of McIntosh Reserve Walk and Talk** on July 18, 2015 was presented by Dr. Jerry Stober on the subject of atmospheric CO_2 concentrations as related to climate. While the boomer and older generations may not be severely impacted by the changing climate their children and grand children are likely to face numerous increased risks and sharply rising costs in coming decades. Our earth systems are on a destructive path which needs immediate correction.

Physics-Light energy from the sun is transmitted in very short wave lengths mostly as visible light, which passes through the atmosphere to the surface of the earth. The Earth warms and sends its own energy back out into the universe, and since it is cooler the wave lengths are longer than the sun's. This infrared light is absorbed by greenhouse gases (carbon dioxide and methane) in the atmosphere thus slowing its escape back into space. By slowing the escape of energy from the Earth, the greenhouse gases raise the temperature at the Earth's surface, much as a blanket keeps us warmer in the winter. The Earth would be a frozen ball of ice without this natural "blanket". Our natural greenhouse effect keeps the average temperature of the earth about 57^{o} F warmer than it would be without greenhouse gases. However, by adding excessive greenhouse gases to the atmosphere we effectively are putting on a thicker blanket. Long-term independent records from weather stations, satellites, ocean buoys, tide gauges, and other indicators confirm that the world is rapidly warming and will continue to do so until a new energy balance is reached.

CO_2 has been monitored consistently since 1957 in the pristine air atop Hawaii's Mauna Loa. A steady increase from 315 ppm in 1957 to 400 ppm in 2014 was observed. An analysis of gas bubbles in ancient glacial ice showed CO_2 concentrations prior to 1850 were 280 ppm. The overall trend is upward, increasing 2 ppm each year.

CO_2 moves from the atmosphere to the oceans, seawater can hold 50 times more carbon than the atmosphere but this process takes hundreds of years. When CO_2 absorbs into seawater it forms carbonic acid increasing the acidity and decreasing the survival of marine organisms like pteropods, oyster spat and other shelled species. As more CO_2 is dissolved into the oceans the equilibrium between air and water shifts and seawater absorbs less atmospheric CO_2. As atmospheric CO_2 increases, both air and sea surface temperatures rise, but CO_2 is less soluble in warm water. The equations say the atmospheric carbon dioxide concentrations will continue to spiral upward. Since the 1750's, we have dug up and burned massive amounts of coal, oil and gas (fossil fuels) and the levels of CO_2 in the atmosphere have increased by more than 40%. Beginning the second decade of the 21^{st} century we were dumping 8 billion tons of carbon into the atmosphere annually. This is up from 7 billion metric tons at the turn of the century. The oceans cannot save us from fouling our nest.

Temperature-Global surface temperatures show that since 1980 the decadal average temperature has increased by about 0.36^{o} F each decade. The global average temperature increase has been 1.4^{o} F since 1750 with 2014 being the warmest year on record. Warming near the poles has reached at least 4.5^{o} F higher contributing to an increasing loss of ice with multiple ramifications affecting the weather. A rising sea level will displace millions of humans around the planet since about 80% of the population live within 50 miles of the coast. As ocean temperatures increase, evaporation also increases and more rainfall occurs. Both climate models and satellite observations indicate that there will be 3.8% more water in the atmosphere, and almost that much more precipitation, with each 1^{o} F increase in atmospheric temperature. The precipitation will not be evenly distributed because storm tracks and jet streams will be warped by a warmer atmosphere.

Agriculture-Risks to food, health and ecosystem services are increasing as the planet heats up and this is occurring at a time when the global human population will exceed 9 billion by 2050. The present production of food will have to double in order to feed that many people. Displacement of people due to sea level rise will increase the loss of open farmland. Farmland preservation will become a much higher priority to protect the future production of food. Climate change is pushing agricultural productivity in a negative direction. With each one degree rise in global temperature from 10 to 16 % of agricultural productivity is lost due to extreme weather events like droughts, floods, high temperatures, insect infestations, invasive species and new diseases. .

What to do-We should take a proactive approach to solving this problem and look at it as an opportunity. We need to change our energy economy from fossil fuels and nuclear to solar and wind and back these changes with progressive policies and incentives to speed the change. Cap and Trade has been used to mitigate the impact of acid rain successfully over the last 20 years. A free market approach with carbon fee and dividend is currently being proposed by Citizens Climate Lobby to move the market to clean energy options. The UN Conference on Climate Change will be held in Paris this fall to establish global political will and carbon reduction contributions to be achieved by each country.

Planet earth is a "sweet spot", on which we live being the right distance from the sun, 70% covered by ocean and with an atmosphere allowing the planet to operate at optimum life supporting temperatures. Climate reacts to whatever is forcing it to change: earth's orbit, the amount of heat from the sun, greenhouse gases and aerosol particles released by volcanic eruptions, and notably in the past 300 years, greenhouse gases released by human activities. The Earth has warmed and cooled. In the past temperatures have risen and fallen with changes in atmospheric CO_2. These episodes have occurred over 100,000 to 1,000,000 year time spans before returning to normal.

Political will-With the added CO_2 levels presently being released, it remains to be seen if humans can pull together and agree on an effective course of action. Many previous

civilizations could not avoid extinction due to ignorance. We have the technology to understand this problem, monitor its progression and how to mitigate it and we are left with no excuse. Nonetheless, people throughout the world continue to burn coal, oil and natural gas at breakneck speed, gambling that our warming atmosphere won't spin out of control. There is only one Earth and we are engaged in an experiment that we can do only once.