Steps to Sustainability
Part 35 of a Series:
Systems Thinking Basics – Feedback

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This is the latest installment in our Signs of Sustainability series, organized by Sustainable Tompkins. Visit them online at www.sustainabletompkins.org

To access all of Franke's Steps to Sustainability essays, go to
https://msuweb.montclair.edu/~franker/FrankeTompkinsWeekly.htm

This essay appeared in *Tompkins County Weekly* Vol. 12, No. 40, November 27 to December 3, 2017, pages 7 and 8.

Remember the last time an unexperienced public speaker pointed the microphone inadvertently towards one of the speaker boxes? The screeching howl led to audience shivers until someone told the person holding the mic to point it away and keep it away from the output speakers. What happened? The person speaking had his/her voice come out through the boxed speakers where it got fed back into the mic and went through the sound system then again. It's called "feedback."

Feedback is an important feature of all systems. Understanding it is part of our mini-series on systems thinking. Feedback occurs whenever an output from a part of a system circles back through that part of the system again.(For a clickable list of links to earlier short pieces on other aspects of systems thinking, go to https://msuweb.montclair.edu/~franker/FrankeTompkinsWeekly.htm) We can most easily grasp feedback and its significance for systems thinking by dividing it into two main types: negative feedback and positive feedback.

Stabilizing Systems: Negative Feedback

Systems are by their nature self-regulating. The main mechanism for self-regulation in systems is called "negative feedback." In negative feedback, something in the system responds to any increases or decreases in amounts of matter or

energy in the system that are going beyond the limits of that system and sets the amounts back in the other direction. Negative feedback mechanisms (described as "feedback loops" in many writings) are found throughout the world. The heating and cooling systems in a home or car are regulated by a thermostat: when the temperature gets a little too cold or a little too warm, the thermostat turns on the heat or the air conditioning to keep the system operating within a certain (narrow) range. In non-diabetics, sufficient amounts of insulin are released from the pancreas after meals in order to move sugars and carbohydrates from the blood into the liver, muscle and fat tissues from where they are later recalled as needed to maintain blood sugar levels within a certain range (and to perform other functions).

Some negative feedbacks are complex and many are controversial. According to some economic theories, when jobs are scarce, the Federal Reserve lowers interest rates to stimulate the economy through investments; if the stimulation begins to cause inflation, the Fed raises the rates to discourage borrowing and slow business expansion. In this way – in theory at least – the Federal Reserve System stabilizes the economy over time. The essential point about negative feedbacks is that they tend to maintain or stabilize the systems in which they act.

Destabilizing a System: Positive (or reinforcing) Feedback

Positive feedback occurs when something going on in a system reinforces itself rather than maintaining or stabilizing the system. A snowball rolling downhill picks up more snow – which makes it heavier so it rolls faster – which makes it pick up more snow – which….

In terms of sustainability, some of the most important positive feedbacks appear to be occurring with climate change. The arctic ice sheet is normally part of a negative feedback mechanism driven by a feature of ice called "albedo," or "the albedo effect." As the sun's energy hits the ice, more of it is reflected back into space than occurs over open ocean water. Over arctic ice, about 80% of solar radiation is reflected back. However, ocean water has an albedo of less than 1%, meaning that water absorbs most of the heat from the sun's rays as they hit the water (Kolbert 2006:30). Arctic ice sheets are melting, however. According to research by the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL), between 1979 and 2005, perennial Arctic sea ice shrank by 250 million acres, "an area the size of New York, Georgia, and Texas combined" (Kolbert 2006:26). At least some of this melting is almost certainly driven by the increases in CO_2 in the atmosphere – an example of one driver causing another driver to intensify. As the ice disappears, more open ocean is exposed to the sun, causing more warming and thus more ice to melt. This results in less albedo which means more warming. As CRREL scientist Donald Perovich puts it, "it just kind of builds on itself" (Kolbert 2006:31; Carey 2012).

A similar – and parallel – climate change process may also be occurring with frozen methane. It is now thought that enormous amounts of frozen methane – also called methane hydrates – is locked up under the soil in the tundra regions and under the seabed along the continental coasts. Former NASA director of the Goddard Institute for Space Studies and well-known climate spokesperson James Hansen (2009:163) reports estimates of up to 5,000 gigatons (one gigaton equals one billion tons) of methane hydrates locked in the earth – possibly a 2,000 year supply (Caveney 2006:15). This huge amount could be either mined and burned as natural gas (which is what methane is) or it could be released through warming driven by the current release of CO_2 and other greenhouse gases in a positive feedback cycle. Hansen argues (2009:150−164) that an earlier feedback scenario led to a hot earth period about 65 million years ago called the Paleocene-Eocene Thermal Maximum in which sea level was 250 feet higher than it is today (Hansen 2009:160).

Here is a plausible but more complex positive feedback that connects to climate change. A Red Cross study in 2007 estimated that 25 to 50 million persons already could be considered climate refugees. Many of these refugees come from the Caribbean region or Mexico to the U.S. and Canada. They come in part because global warming has raised water temperatures in the sea leading to larger and more devastating hurricanes. However, on arrival in the cooler U.S. and Canada they have to live in heated buildings. The authors note that the average CO_2 per capita in Canada in 2001 was 4.35 tons while in Mexico it was 1.01 tons. Thus every time a person is forced out of Mexico by the effects of global warming and moves to Canada, that person's carbon footprint quadruples. This causes more global warming which causes even stronger and more devastating hurricanes which cause more migration out of the Caribbean and Mexico towards the U.S. and Canada. When a positive feedback gets out of control, it is sometimes called "runaway positive feedback." This can lead to overshoot or to system disturbance or even collapse. It might not be wise to let things just sort of build on themselves.

1065 words

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