Alberta in the Anthropocene

Kent A. Peacock
Department of Philosophy
University of Lethbridge

The Public Professor
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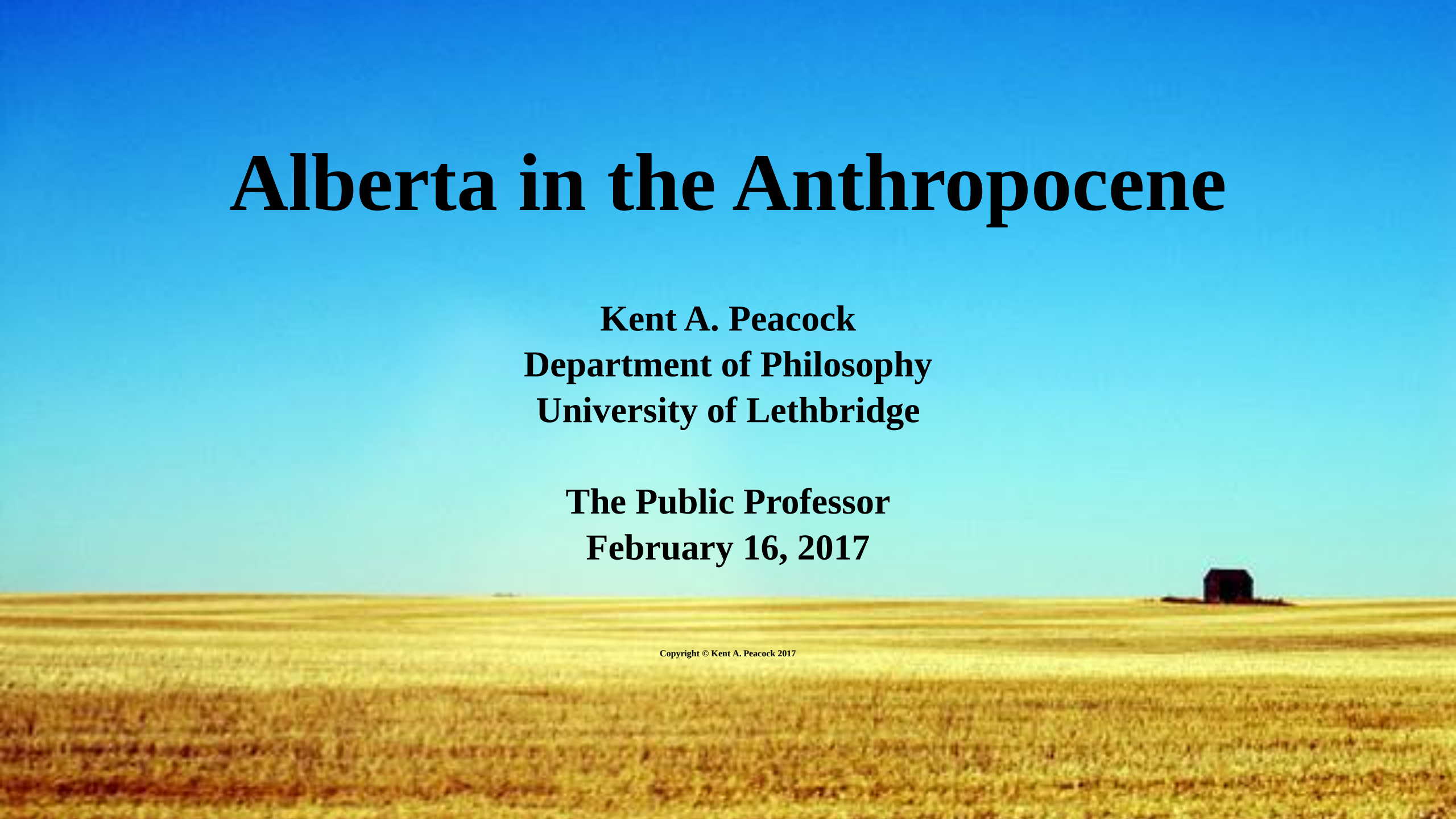


“We can’t shut down the oil sands tomorrow. We need to phase them out. We need to manage the transition off our dependence on fossil fuels.”

— Prime Minister Justin Trudeau, Jan. 13/17

“Today I was asked about the future of the oil sands – how long into the future will the world need oil? Here’s what I'd like to say. Oil and gas will help power the global economy for generations to come. … Alberta’s oil and gas industry and the people who work in it are the best in the world and we’re not going anywhere any time soon.”

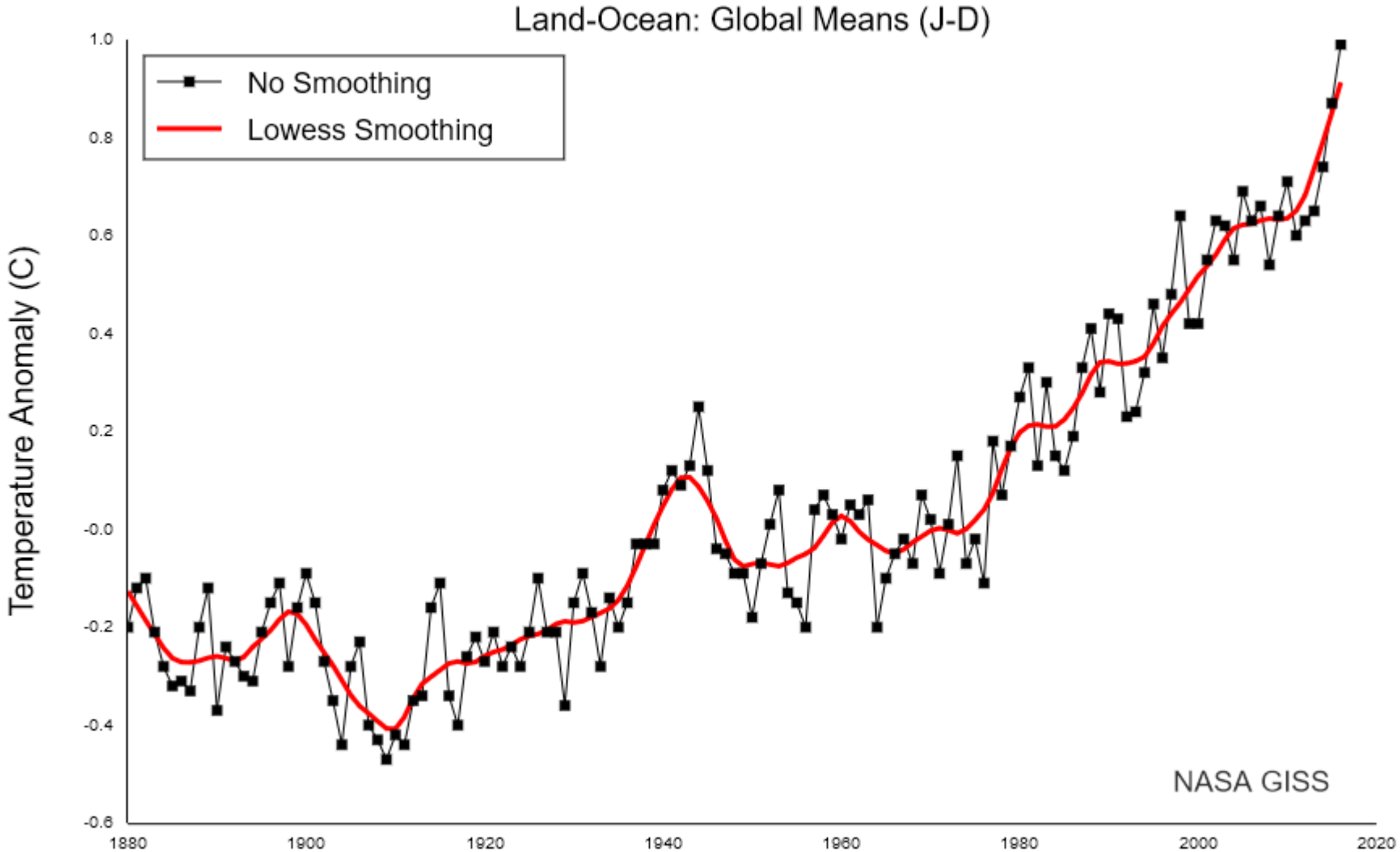
— Alberta Premier Rachel Notley, in response.

“Trudeau’s speculation on how and when to shutdown the oil sands can only be seen as a direct attack on Alberta…”

— Wildrose Leader Brian Jean

Current Consensus, More or Less…

- Carbon dioxide is the long-term "control knob" for global temperature, because of its contribution to the greenhouse effect.
  - Some other greenhouse gases (such as water vapour) are more powerful greenhouse agents in the short term.
  - But CO_2 is the slow, steady burn.
- The planet has been warming since the early 20th century, such that we are now about 1.0 to 1.1°C above pre-industrial levels.
  - (Depends upon exactly how one defines the pre-industrial baseline.)
  - In early 2016 we were about 1.35°C over due to intense La Niña, but fortunately that has settled down a bit…



Temperature date from NASA Goddard, Feb. 13/17.

Further Points of Consensus

- The current warming is caused mostly by CO_2 emissions from the combustion of fossil fuels, though deforestation plays a role as well.
  - It was *not* caused by increases in solar output, volcanic emissions of CO_2, cosmic rays, clouds, orbital variations, or random variation in the climate system.
  - All of these possibilities have been *exhaustively* checked.

Arctic Amplification

- The temperature increase is not spread around uniformly over the globe, but it is two to three times higher in the Arctic.
  - The Arctic ice cap is melting much faster than modelling had predicted.
  - This melting forms a powerful positive feedback to warming since open sea water absorbs two to three times as much solar energy as ice.
  - Methane (a powerful greenhouse agent) is being released from melting permafrost and Arctic continental shelves; a further positive warming feedback.
  - What happens in the Arctic does not stay in the Arctic.

The Oceans…

- About 90% of the excess heat has actually gone into the oceans, not the atmosphere.
  - This poses severe though not fully understood threats to the stability of the ice caps.
- Excess CO_2 is increasing oceanic acidity to the point at which it is a threat to many marine organisms, especially the tiny calcareous species at the base of the food chain.

High Water

- It is virtually certain that there will be *at least* a half metre to a metre of sea level rise by the end of this century, even if emissions are drastically curtailed in the near future.
  - IPCC sea level predictions were very conservative because they did not take into account ice sheet dynamics.
  - Sea level rise is the wild card.

The “Guardrail”

- If global mean atmospheric temperature gets much above 2°C there will be dangerous if not catastrophic consequences for humanity.
  - There is still uncertainty about how quickly those consequences will befall us, and precisely what they would be.
  - Many scientists feel that the 2°C limit is too high.
    - Canada agreed to an “aspirational” limit of 1.5°C, but emissions will have to be much further curtailed to have a hope of reaching this goal—which could still be too high.

Paris Was Only a Start

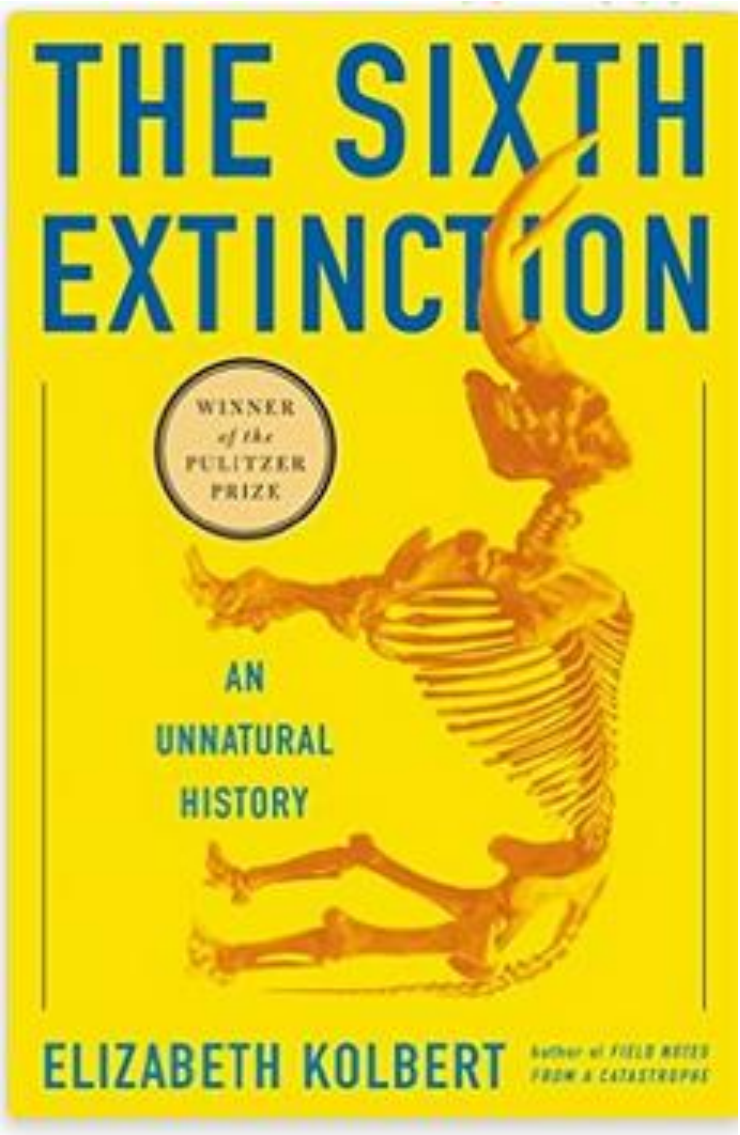
- The emissions reductions agreed to by the signatories in the 2015 Paris Conference are only sufficient to hold the temperature increase to about 3ºC.
  - Much stronger emissions cuts are needed, soon.
  - But it remains uncertain whether major industrial countries (including Canada!) are going to make their INDCs.
    - (“Intended Nationally Determined Contributions”)

The Anthropocene

- A new geological epoch defined by the human impact on the earth system.
- If we all disappear tomorrow morning, the traces of our brief but impactful history will be left in the geological record for as long as the planet persists.

Grand Canyon, Arizona

The lines between those beautiful strata often represent mass extinctions.

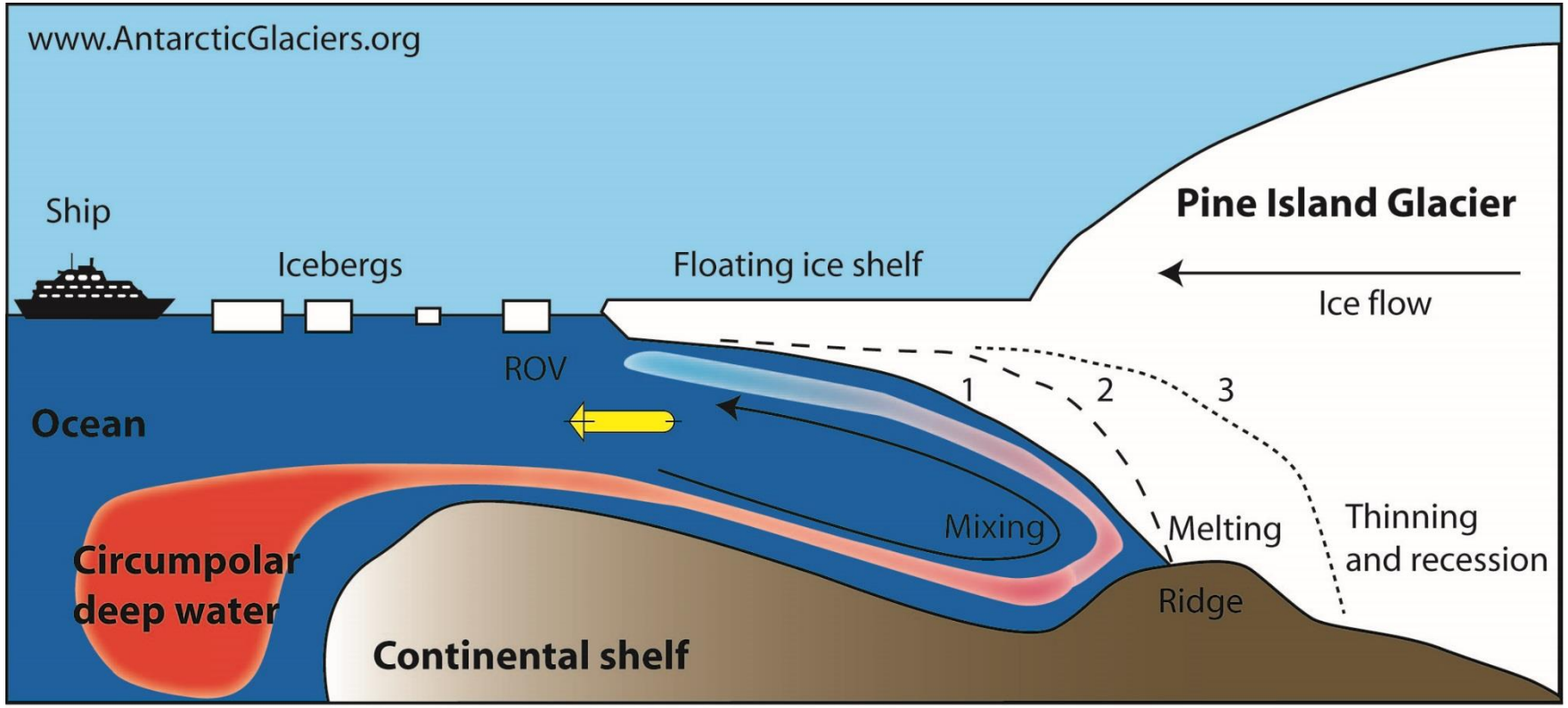


- For an authoritative and moving account of the current human-caused "sixth extinction," see Elizabeth Kolbert's *Sixth Extinction*.
- Read and weep!
- What the term "Anthropocene" means is that we own one of those lines in the strata—one of those extinctions is *ours*.

“Marine Ice Sheet Instability”

- This does get technical…
- Short version:
  - Grounded marine ice sheets (such as West Antarctica) can be stable for thousands of years so long as they are protected by ice shelves.
  - Paleoclimate, geological evidence, and physics show that they can collapse *very* rapidly if exposed to open seas, warmer water.
  - Under current warming conditions, there is a near-certainty that they will collapse slowly over a period of a few centuries, and a chance (how big??) that they could collapse suddenly, within weeks or months, within this century.
  - Scientists cannot predict exactly *when* this would occur, but they know that the risk is steadily increasing.

The Weak Underbelly of WAIS



1. Early 1970s. Pine Island Glacier is grounded at a bedrock ridge.
2. Warm, inflowing Circumpolar Deep Water melts the base of the glacier. The glacier steepens and accelerates.
3. Present day, observed by a remotely operated vehicle (ROV). Glacier is thinning and receding.

Major Calving Event on PIG, Nov. 13/13

NASA Sat photo; B-31 was about 20 km x 45 km.

Good Philosophy from a Glaciologist

- “Nature’s best thermometer, perhaps its most sensitive and unambiguous indicator of climate change, is ice. When ice gets sufficiently warm, it melts. Ice asks no questions, presents no arguments, reads no newspapers, listens to no debates. It is not burdened by ideology and carries no political baggage as it crosses the threshold from solid to liquid. It just melts.”

  — Henry Pollack (*A World Without Ice*, Penguin/Avery, 2009, 114)

Message From Mother Nature…

- We humans live in a vast physical universe that has its own rules (which we only partially understand).
- **It does not schedule events in accordance with what would be economically or politically convenient for the province of Alberta, Canada.**

Message from the Eemian

- The last interglacial (about 120,000 years ago):
  - CO2 was < 300 ppm
  - Temperature was the same or just slightly higher than today….
  - Sea level was 6 to 9 metres higher!
- We are at or close to late-Eemian conditions *now*.
- Therefore, what happened 120,000 years ago has direct implications for economic policy *today*.

Message from the Pliocene

- Pliocene (3 to 5 million years ago):
  - CO_2 around 400 ppm (our present value), sea level 15 to 25 m higher!
- In order to prevent catastrophic sea level rise and the equatorial regions becoming nearly uninhabitable by large vertebrates, it is increasingly evident that it is *not* good enough to stabilize CO_2 at 400 to 450 ppm.
- It is imperative that we reduce CO_2 to 350 or even 300 ppm as soon as possible.
  - *How do we do that*?

Is It Already Too Late?

- Problem is that there is a huge amount of excess heat in the seas (90%+ of excess heat is in the seas, not the atmosphere).
  - The warm seas will continue to eat away at the marine ice sheets from below, even if we totally stop emissions today—which is not going to happen.
- Many scientists argue that we need "negative emissions"—some technique of pulling Gigatons of CO_2 out of the atmosphere, to get levels down at least as low as 350 ppm and preferably lower.
  - Problem: this technology does not yet exist! (Planting trees is a good idea, but it could not pull down nearly enough CO_2 in time required.)

From Crude to Crud

- Most of the best-quality oil (the “low-hanging fruit”) has already been burned.
- We are forced to move increasingly to higher-carbon fuels (such as coal, bitumen) which increase carbon intensity; “recarbonization” of industrial society.
  - There is still a fair bit of natural gas, but we flare off vast amounts of it or waste it refining bitumen.
- Hence, the decline in quality of fossil fuel supplies is another factor that tends to increase climate change.
  - (Coal use has recently declined, but in favour of fracked natural gas, which has a very short future!)

The World Won't Wait For Alberta…!

- The rest of the world is *not going to wait politely until we have amortized our investments in our oil sands operations*!
- My guess (can't *prove* it): the oil sands will be completely obsolete long before the resource itself is depleted.
  - The salvage and clean-up will provide hundreds or thousands of jobs for a generation or more.
  - If we handle this proactively, this will not cause an economic collapse, but more likely steady, predictable prosperity as we re-invest in replacements for oil.
  - If we deny reality then, yes, we are setting ourselves up for another bust.

Getting Back to What the PM Said…

- Yes, it would be very difficult to shut down the oil sands right now.
- But we do have to phase them out in the foreseeable future—inevitable, IMHO.
- From the viewpoint of protecting the ice sheets, the only responsible level of tar sands emissions in 2030 is 0.

The Gamble

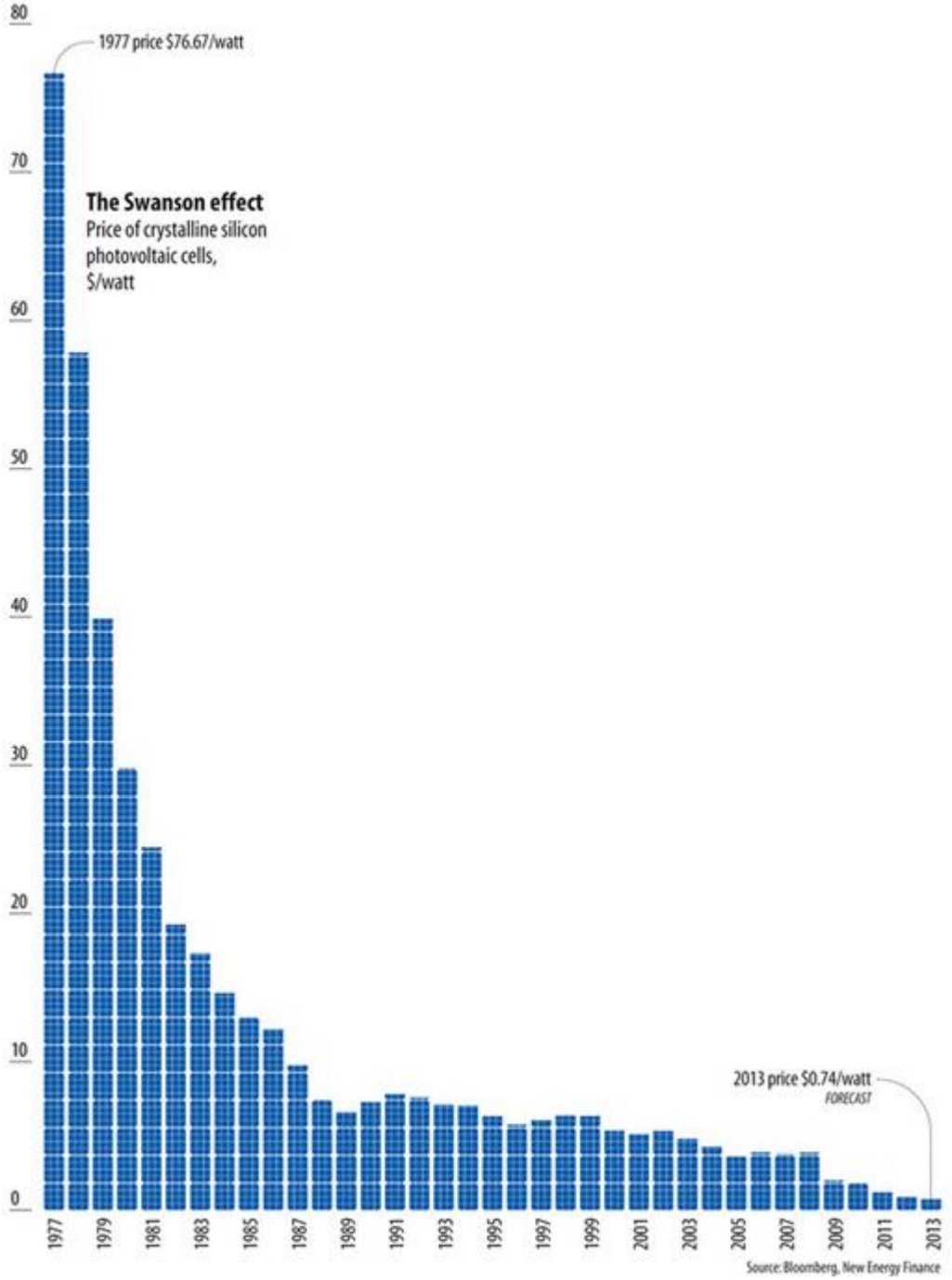
- Everything we do has to be framed by the awareness that we are gambling with the ice sheets (and methane release in the Arctic).
  - Our gamble: we can maintain Business as Usual *a little longer* until we develop alternatives *at a comfortable pace*.
  - We have all our chips on the table for this round—we are *all* in.
  - In the immortal words of Dirty Harry (played by Clint Eastwood), “How lucky do you feel today?”

Shifting the Odds in Our Favour

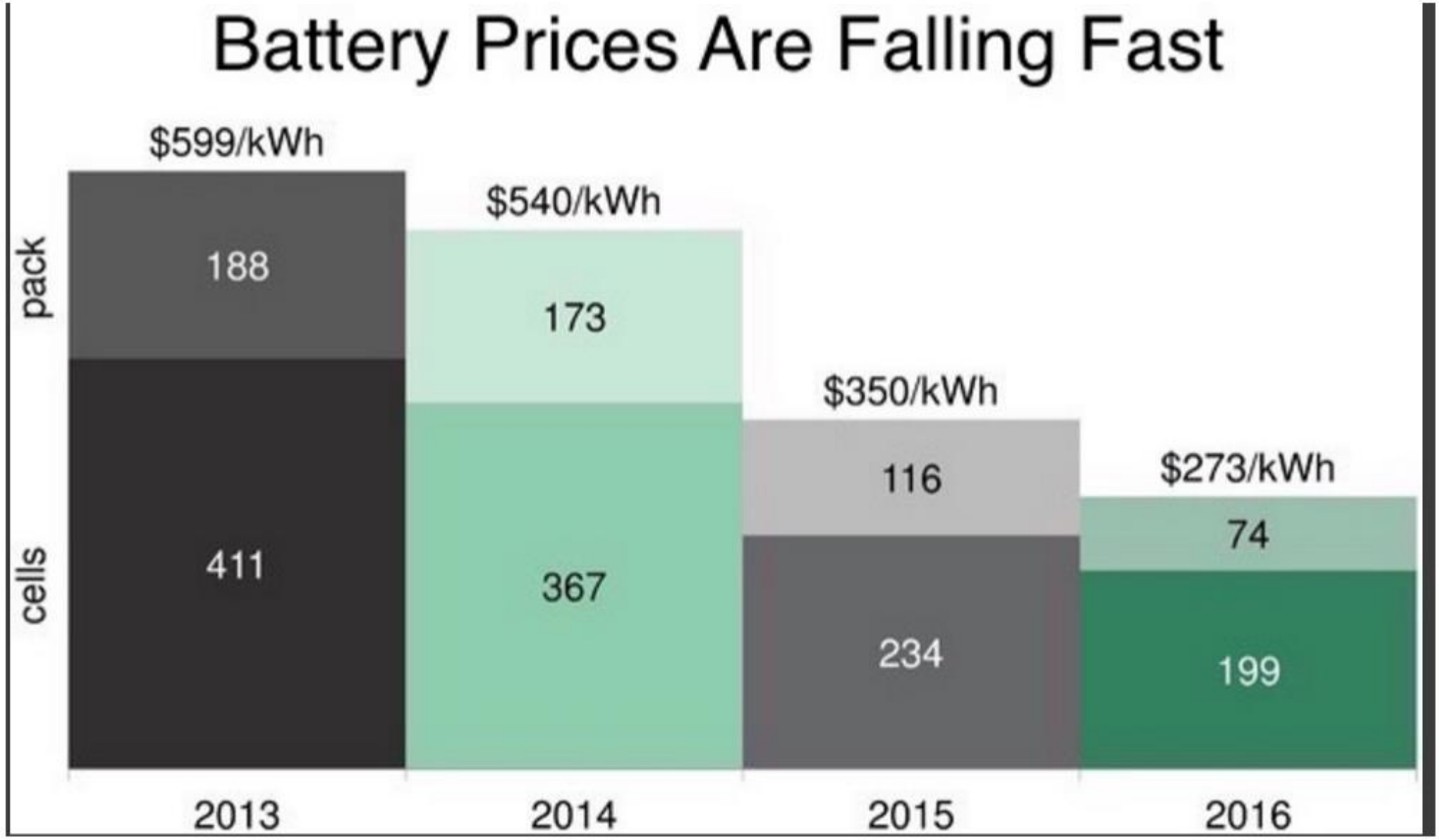
- There is a lot we can do to shift the odds in our favour, so long as we are absolutely honest with ourselves.
  - We have to innovate, innovate, *innovat*e!
  - And it has to be real innovation in the ways we produce, transmit, and store energy, not just better ways to recycle coffee cups.
  - But how do we incentivize innovation?

Push and Pull

- The carbon tax is a *push* away from use of fossil fuels.
- We also need incentives to *pull* us toward non-fossil energy sources.
- A good incentive is lowering the cost of alternatives.
  - EVs are *already* cheaper to run than gasoline/diesel alternatives—but the initial cost of the vehicles is prohibitive for most of us.
  - (E.g., Tesla S costs 94,000 CAD.)
  - When EVs cost about the same as a Kia or Mazda 3, and when there are enough charging stations, why would anyone drive anything else?
  - (Sure, we will still need diesel for heavy equipment—for a while.)



Price of photovoltaic cells, 1977—2013


Battery Prices Are Falling Fast
$599/kWh
$540/kWh
$350/kWh
$273/kWh
pack
cells
188
173
116
74
411
367
234
199
2013
2014
2015
2016

Some Suggestions to Create *Pull*

- Subsidies for EVs.
- Lots more charging stations.
- Bullet trains along the Lethbridge/Edmonton corridor, perhaps elsewhere (all renewable-powered!).
- Use proceeds from C tax for renewable infrastructure, R & D.
- More education, training.
  - Engineering faculty at U of L focused on renewables and other aspects of environmental engineering? (A work in progress…)
- *Human ingenuity is our greatest resource—let us do everything we can to put it to work on this huge problem.*

The Big Picture

- “We have to think globally and act locally.”
- True—but we also have to *think globally and act globally*.
  - Alberta is and can be a global player and leader in the movement out of the fossil fuel era.
- Or we can wait for someone else to do it for us, and then pick up the pieces afterwards… our call…!