

## The World in 2050: Four Forces Shaping Civilization's Northern Future

### Are There Workable Agricultural Responses to Climate Change?

#### Summary

This whitepaper analyzes the material presented in the book "The World in 2050: Four Forces Shaping Civilization's Northern Future" ("2050") by Laurence Smith, UCLA. The author presents his predictions for the effects of climate change on the northern parts of the planet. Professor Smith's book describes the anticipated climate changes over the time period from 2010 to 2050. The major prediction is that the northern parts of the planet will see a significant warming trend over this time period. What gives his arguments real credence is that the predicted warming trend has already started and is documented for the time period 1990-2006.

The climate change projections made in "2050" suggest that the northern parts of the planet will warm up relative to today and will also receive increased rainfall. This combination should provide for a northerly march of agricultural production to areas, such as Greenland, which are not today considered as productive farming areas. This agricultural movement is compounded by the projections that the present "wheat/corn belts" will become warmer and much drier.

Consideration of the projected climate change consequences led to suggestions that there will be investment opportunities in the more northerly areas which are presently not amenable to productive agricultural operations. The opportunities could be both direct, i.e., in agricultural operations, farming operations, or indirect such as grain marketing companies or even into transportation operations in the north.

Another area for potential investment in the north is energy. The warming of the northern areas will make some areas more accessible for resource exploration. One area pointed out is the gas hydrate resource which, if resource size estimates are credible (USGS), will dwarf the current estimates put on other natural gas resources in the US.

Further elaboration of opportunities will require more exploration of both climate change and the commercial opportunities identified. Discussion of all of the above projections will be needed for avenues of pursuit for more detailed analyses.

#### BACKGROUND

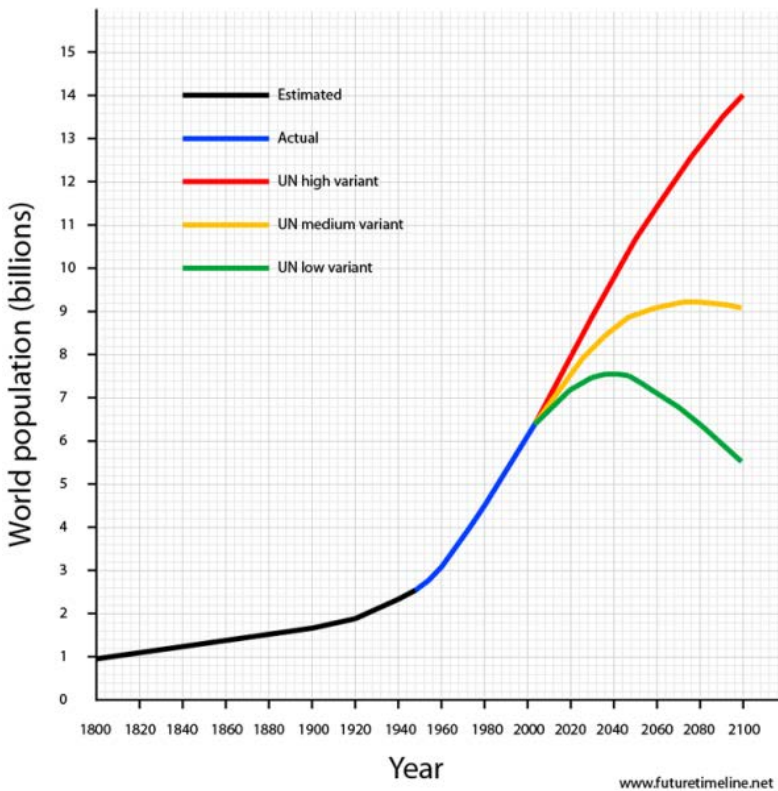
Professor Smith, in the Geography Department at UCLA makes some eye-opening projections, in this recent book<sup>1</sup>, regarding the consequences of climate change through 2050. He looks at four forces operating in the world as change agents in this time period. These are identified as: demography, i.e., population changes; demands on resources; globalization; and, climate change. This whitepaper is an interim response to the projected consequences of climate change. At this point in time only the deliberately blind are ignoring the global climate change occurring around us.

The projections regarding climate change made by Professor Smith are focused on the northern rim countries (NORC) of the planet. The NORC countries are: (by size<sup>2</sup>) Russia, Canada, Greenland (Denmark, mostly under ice or water), Norway and Alaska (United States). While

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the projected effects of climate change will bring dramatic changes to these northern landmasses affecting all aspects of life, the indigenous peoples, particularly in Canada, are not pessimistic. Rather, they are equipping themselves to prosper in the coming decades by buying ships, offshore rigging and shipping properties. All of these changes open up opportunities for investment and will be detailed in additional documents. This interim whitepaper is devoted to a first look at what investment opportunities are possible in the agricultural arena.

The changing population sizes and locations around the world are also to be kept in mind in considering climate change effects on agriculture. The world hit the 7 billion population mark



late last year and will continue to grow even as the growth rates level off in major population centers in the world such as China, Japan, and most of western Europe. A perspective for the population growth in the world in the coming decades is shown in Figure 1<sup>3</sup>. There are some surprising countries which have large population growth rates now, among the fastest growing<sup>4</sup> are the NORC states of Canada (31%), United States (27%), Iceland (24%), and Norway (22%) over the time period of this projection. The only NORC country expected not to see population growth is Russia; rather than growth it is projected to see a 17% decline in population in the same time frame.

Figure 1: Projected World Population Growth Through 2100

## CLIMATE CHANGE AND NORC AGRICULTURE

Agriculture is how we feed the people of the world. Successful agricultural activities require good fertile soils, sufficient water and the right amounts of both heat and light. The exact needs for water, heat and light vary with each individual plant group. For example, tomatoes, for optimal productivity, need to be grown between 13C (55F) and 38C (100F); growing temperatures outside of this range can result in poor to no fruit set. Such optimal growing temperature ranges are seen for all crop varieties. Climate change projections predict that California's Central Valley may have temperature changes which will ultimately preclude large scale tomato farming (Ouch).

These temperature requirements are why, today, we see more corn grown in Iowa<sup>5</sup> and less corn grown in Minnesota<sup>6</sup> and virtually no corn grown in Saskatchewan<sup>7</sup>. The primary controlling temperature for plant viability is the winter (cold) minimum temperature range. The USDA

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publishes a temperature zone map which can be taken as a guide for determining the viability of growing crops of interest by location. The 2003 map is shown in Figure 2<sup>8</sup>.

The 2003 map is out of date. The USDA climate zone map is undergoing changes in zone location as climate change data are incorporated in each revision. A striking graphic showing the northward creep of the climate zones from 1990 to 2006 can be seen at <http://www.arborday.org/media/mapchanges.cfm>. This website, **a must see**, shows the 1990 map morphing into the 2006 hardiness map along with a difference map as the climate changes.

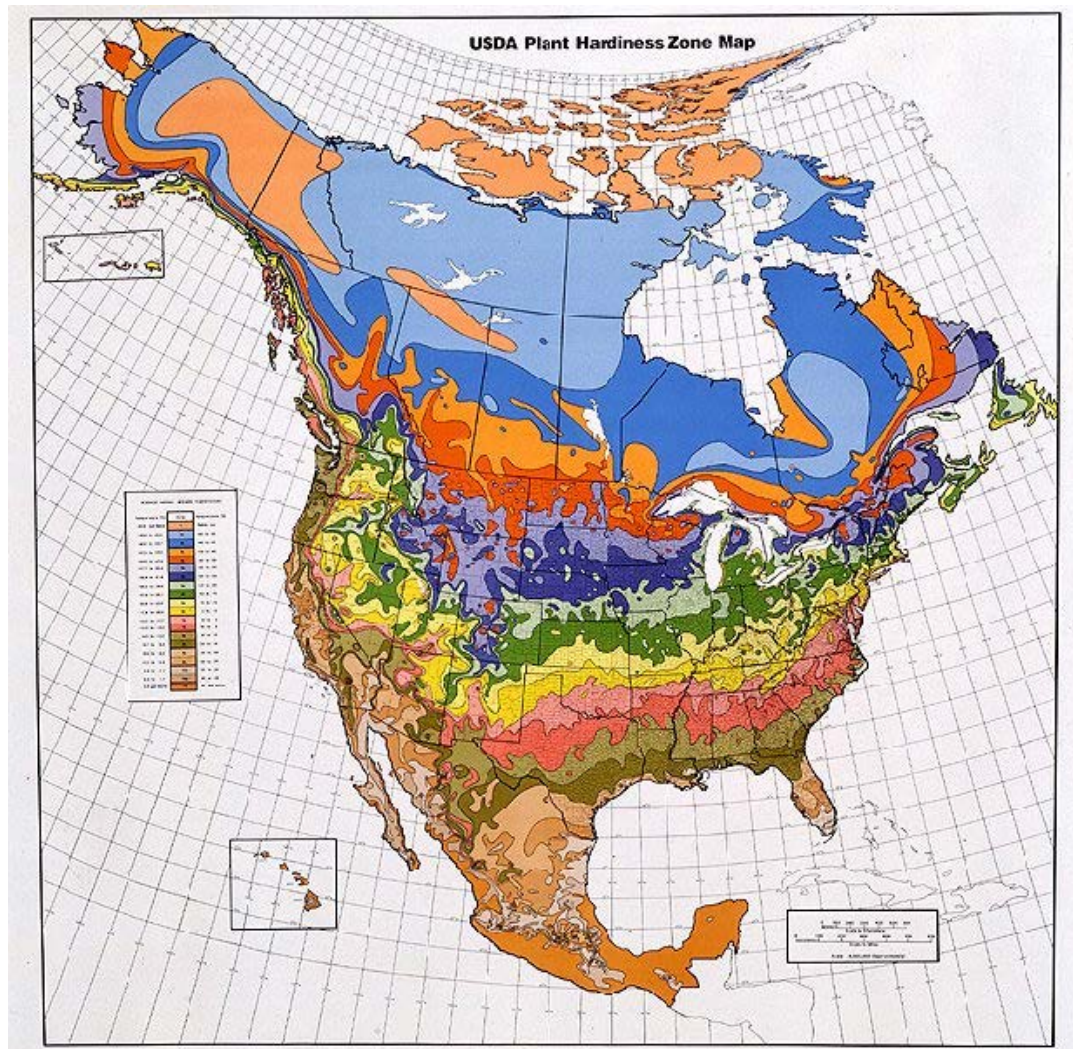


Figure 2: USDA 2003 Plant Hardiness Zone Map

There is anecdotal evidence that climate change is being observed on a local level as well. In discussions with winery personnel in Mendocino County last year, they reported that their vineyard operations were selling a quite a bit more premium wine grapes to major Napa Valley wine producers than they have in the past. These increased sales were attributed to the higher temperatures that Napa Valley was experiencing during the last several summers which led to decreased grape quality<sup>9</sup> there. A more rigorous examination of projected climate change effects on the premium wine industries in California, Oregon and Washington has been reported by Diffenbaugh<sup>10</sup>, et. al.

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Another, more dramatic, example of climate change and agriculture in “strange” places is occurring in Greenland as reported by Professor Smith<sup>11</sup>. People in Narsaq, Greenland (77.3 N and -68.85 W) were observed harvesting a reasonably good-looking crop of potatoes in plain view of floating ice. Also reported growing there were broccoli and radishes. If one can do these crops, one can also do cabbage, lettuce and other cool weather vegetative crops. I suspect that beans, squash and tomatoes would still be a stretch in Greenland.

In addition to the projected changes in agricultural activities presented by climate change, Professor Smith identified other changes likely to occur in the far north which will affect all of the NROC countries. The last several years has seen a shrinking of the floating ice in the Arctic Seas with a partial opening of the Northwest Passage (Canada and US north borders) allowing for commercial traffic to service the commercial areas across the “top”. The ice never completely goes away, although it may look like it to some polar bears, so that it is expected that there will be no large sea going traffic diversions from other routes soon.

While the ice melt has allowed for some sea transport, there has been observable retreating and softening of the permafrost in some locations. The latter has retarded land transport over the northern reaches which has impacted the aboriginal populations from traditional activities, e.g., hunting. The aboriginal population, mostly in Nunavut, has, for the most part, reacted positively to the changes and has greatly expanded their commercial activities. Nunavut is about 1/5 of Canada’s land mass and covers a large part of the north, see Figure 3.



Figure 3: Nunavut and its Place in Canada

The importance here is that it is anticipated that there will be large petroleum (oil) and gas reserves in the northern areas just waiting for exploitation. The hydrocarbon types are split with those off the north coast of Russia expected to be largely natural gas as are those off Nunavut. The reserves off Alaska are thought to be oil. Gas hydrates are to be found in all areas. Development of these resources will be challenging owing to the still cold and ice over the water and softening of the permafrost on land and the issues with getting gas values south to the customers. Oil transport is thought to be easier owing to the Alaska pipeline.

### CLIMATE CHANGE AND AGRICULTURE

The northward movement of warmer climate zones should open up investment opportunities in agriculture and related commercial activities. It should be fairly straightforward to list investment opportunities in the more northerly states and provinces which will see their agricultural options dramatically increase over past crop choices. However, there is another

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side to the thinking about investment opportunities in agriculture not covered in the above discussion concerning the northerly march of the climate zones. Namely, what's happening in the states "left behind"?

Do the NORC's have enough light if local climates become more temperate (warmer) for significant agricultural activities? In Appendix A, the results of some solar insolation models<sup>12</sup> for Minneapolis, MN; Saskatoon, SK; Churchill, MB; and Narsaq, Greenland, were calculated for June 12, March/September 21 and December 21. Additionally, a calculation for April 25 for Narsaq was included as this is the last day having a "night". While the more northerly locations, Churchill and Narsaq, would have very little to no daylight around Dec 21, there is sufficient daylight for a reasonable growing season centered around June 21 if the temperatures are right.

Revisit the Arbor Day website showing the zone changes from 1990-2006 (<http://www.arborday.org/media/mapchanges.cfm>) and look south. The southern plains will become hotter and dryer as will many portions of the southwest. Agricultural activities will become more difficult in these areas; see Reference 13 which discusses the changes in the western wine growing areas.

## AREAS FOR CONSIDERATION:

### The Southern World

There is no discussion here about regions south of the United States. The projections of "2050" for Mexico are much like the ones for the US Southwest; hotter and drier, almost calling for a "permanent" drought. There is very little discussion of the regions south of the equator. That said, the climate change predictions for these southern regions need also to be considered. With the unsettling projections for California's Central Valley, the world will need areas with increased agricultural productivity to replace/augment this cornucopia of food.

It doesn't appear that moving north a bit, say to Oregon's Willamette Valley, would help even if the zone changes elevated the temperatures a bit there. This Oregon valley, with a length of 150 miles and a width of 60 miles, is much smaller<sup>13</sup> than CA's Central Valley. Also, the projections of the Oregon Climate Change Research Institute predict about a 50% decrease in the mountain snowpack which would make for irrigation water shortages for agriculture<sup>14</sup> there.

In particular, Argentina and even parts of Australia could see increases in precipitation along with some temperature increases which could make these areas considerably more productive for agriculture. The probabilities of such events occurring need to be better quantified. These regions may represent investment opportunities with a component of geographic diversity.

### The NORC World

The NORC world could have a variety of investment opportunities as the effects of climate change intensify and do some real change to local environments. In addition to agriculture, the transportation sector will have to undergo considerable change as the ice coverage becomes thinner and shorter in duration and as the permafrost is no longer permanent over the year, at on the surface which would disrupt traditional transportation methods.

### Transportation

There are already 2 good examples of transportation infrastructure changes made in the Canadian north. Northern Transportation Company Ltd<sup>15</sup>. is a wholly Inuvialuit owned company

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which is part of the Inuvialuit Development Corporation (private, native owned holding company<sup>16</sup>). It is a large marine transportation company which services the north coasts of Canada and the US. While an old company, it has expanded operations along the “ice” coast to include shipbuilding, oil field services and air transport.

The other investment in Canada north, was made by OmniTRAX<sup>17</sup>, a Denver based investment company, which purchases small railroad lines and their ancillary services. Their northern investment includes the purchase of the Port of Churchill, on Hudson’s Bay, and the Hudson Bay Railway Company. The railroad connects Churchill with the Canadian National Rail system. What they are, and will be doing more of, is shipping grain out of Churchill to Europe when the ice is out. This route is much shorter than say shipping from Thunder Bay on Lake Superior, which also gets ice bound. As the ice covering diminishes in thickness and length of coverage time, this port should become a major grain shipping place. Recent weather has not been kind to the OmniTRAX company., this northern roadbed has been extensively damaged by flooding. The line is out of service now with no time estimate given for restoration of service to Churchill.

Other railroads operating in the northern part of the hemisphere include the Canadian National Railway (CN:NYSE) and the Canadian Pacific Railway (CP:NYSE). One railroad here is the Burlington Northern Railway; now a subsidiary of Berkshire Hathaway, Inc., Buffet has his model train set. Following the BNR purchase, the company abandoned a lot of trackage across the northern states, Mt, ND, & MN of interest here. In this “vacuum” a number of small private railroads were established each appearing to service local grain elevators with ultimate connection to BNR. CP does have a major footprint in the grain growing areas of US and Canada<sup>18</sup> as shown in Figure 4. This service area can only grow as the ag zones move north. CN’s footprint is shown in Figure 5<sup>19</sup>; CN can directly move grain to the Gulf since it purchased the Illinois Central Railroad. See discussion on Wheat Board, below.



Figure 4: CP Rail Grain Traffic Flow

### Agricultural Investments

Direct agriculture investments could include the purchase of farm lands, an area for which the author claims no expertise. A check of one reference indicated that cattle ranches or bare land have the lower prices<sup>20</sup>. A high confidence level in the warming part of the climate change saga would lead one to bare land or ranches rather than to existing grain growing properties. Absentee landlord issues, however, play strongly in this scenario.

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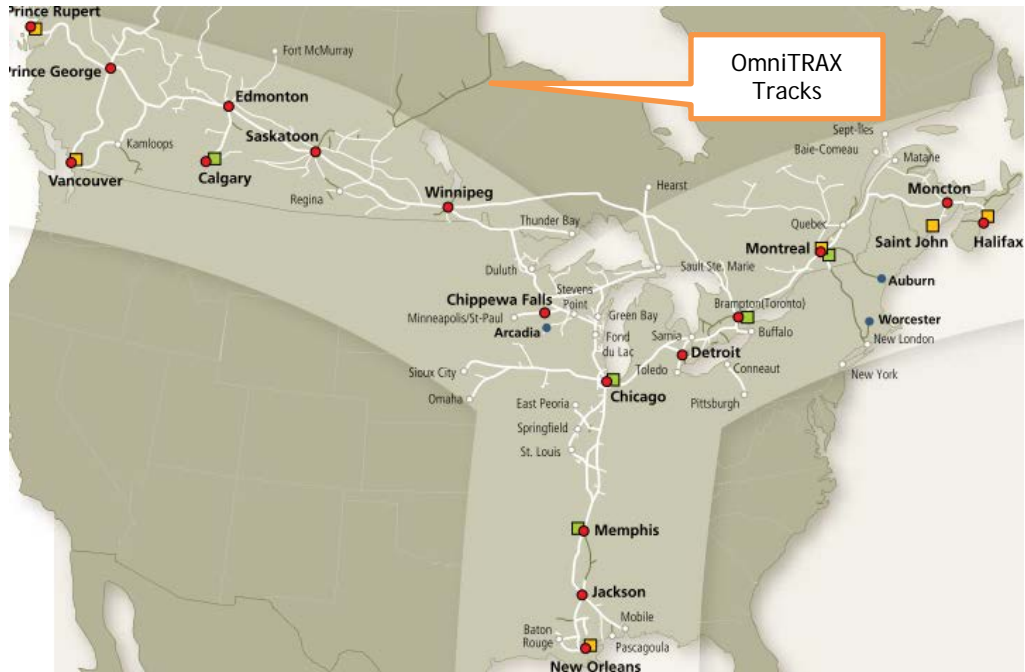


Figure 5: The CN Railway System

In Canada, the Canadian Wheat Board<sup>21</sup>, a government agency, controls the wheat and barley markets for Alberta, Saskatchewan, Manitoba and parts of British Columbia. However, the old conservative government intended to end the monopsony<sup>22</sup> of the Wheat Board. Time will tell if the Wheat Board's life is ended. (Note: Probably not with the end of the Harper government.)

The Wheat Board would prefer to ship grain from Churchill rather than through Thunder Bay as Churchill is closer and the grain can be directly loaded into larger vessels. Vessel size is limited at Thunder Bay by the size limitations of the Welland Canal (bypass around Niagara Falls). From the context of the Wheat Board's note on transportation the author inferred that the wheat in vessels coming from Thunder Bay is reloaded into larger vessels at ports downriver from the Welland Canal. This preference for Churchill would make CN a better bet than CP Rail as CN has the connection to OmniTRAX in Manitoba. (Probably not a go now or any time soon.)

## Energy

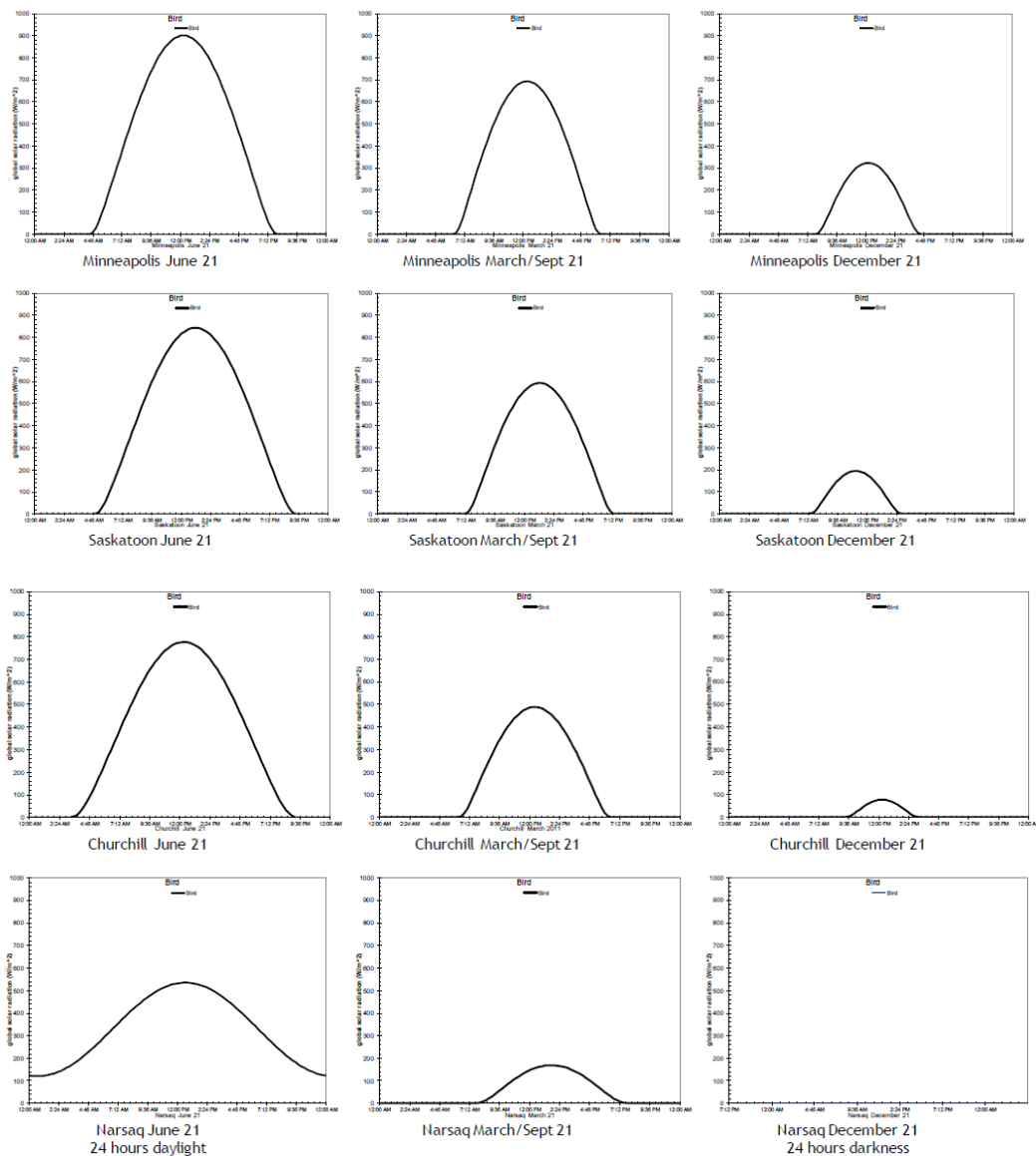
The energy resources explorations off the NORC's north coast will be conducted by the usual corporations, all of which are familiar. The outlier is that it is stated that there are gas hydrate resources in these waters, especially in the Canadian areas. Methane hydrates fall into the category of clathrates in which a gaseous molecule can be trapped by a "cage" of solid water molecules (ice). In the case of methane, the solid clathrate contains a fair amount of methane. One m<sup>3</sup> cubed of the clathrate contains 164 m<sup>3</sup> cubed of gaseous methane<sup>23</sup>.

From a very recent NETL Report<sup>24</sup>: "Gas hydrates are a naturally-occurring combination of methane gas and water that form under specific conditions of low temperature and high pressure. Once thought to be rare in nature, gas hydrates are now known to occur in great abundance in association with arctic permafrost and in the shallow sediments of the deep-water continental shelves. The most recent estimates of gas hydrate abundance suggest that they contain perhaps more organic carbon than all the world's oil, gas, and coal resources combined."

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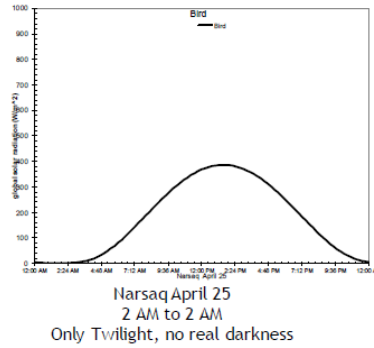
It would appear that the natural gas “revolution” may only just be beginning. From the ongoing research it appears that there is no consensus on methods to recover the natural gas values in the hydrate fields. Right now, ConocoPhillips and the Office of Fossil Energy NETL<sup>25</sup> are conducting experiments at a test well on the North Slope<sup>26</sup>. Other companies’ organizations involved in gas hydrate investigations include: Japan Oil Gas and metals National Corporation (with ConocoPhillips); BP Exploration Alaska, in Prudhoe Bay; and, Chevron (Joint Industry Partnership, operating in the Gulf)<sup>27</sup>. See Appendix B for a visual representation of the estimated gas hydrate resource in Alaska.

**Appendix A:** A comparison of calculated solar insolation times at Minneapolis, Saskatoon SK, Churchill MN and Narsaq, Greenland for June 21, March/Sept 21, and December 21. The April 25 calculation for Narsaq is also included as this date is the beginning of 24 hours of daylight. Vertical axes all scaled identically for ease of comparison; all graphs have identical heights.



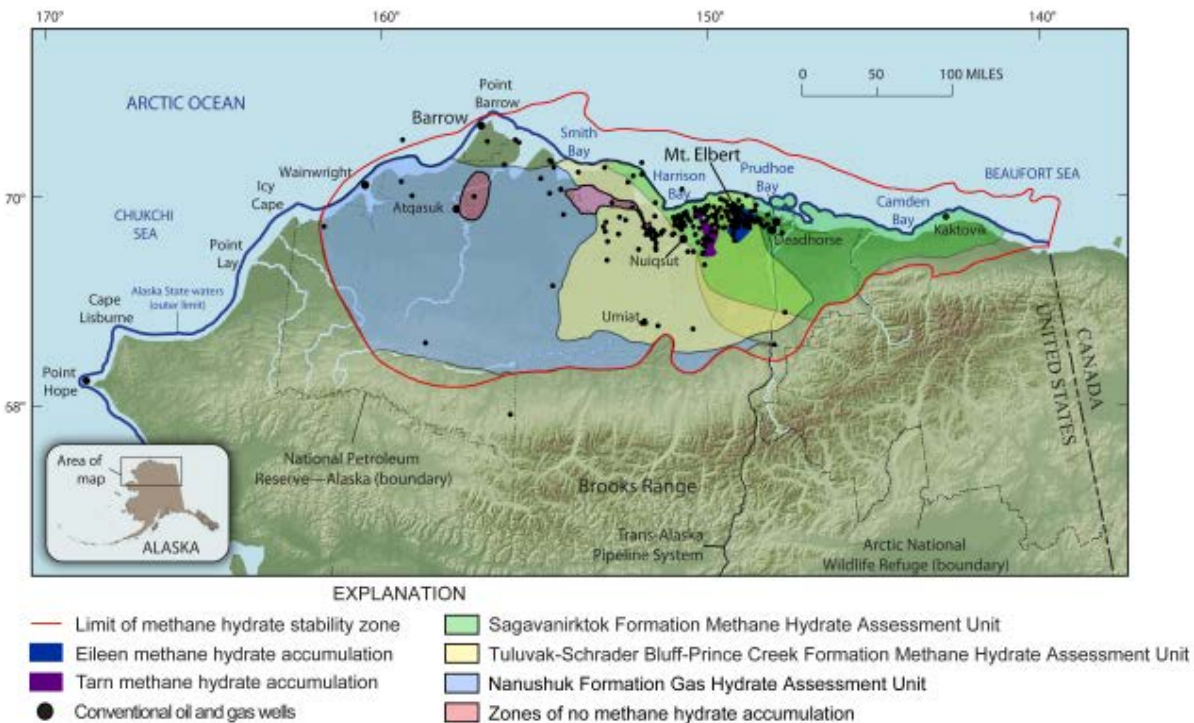


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## Appendix B:

The Northern Alaska Methane Hydrate Total Petroleum System: The hydrate stability zone is given by the red line. The USGS assessment predicts the total mean undiscovered technically recoverable methane to be 85 TCF<sup>28</sup>.



<sup>1</sup> Laurence C. Smith, "The World in 2050: Four Forces Shaping Civilization's Northern Future", A Plume Book, Penguin Group, NY, NY, 2011.

<sup>2</sup> Size includes their offshore claims to territoriality under the UN Convention on the Law of the Sea (UNCLOS). Interestingly, the author notes that all disputes in this arena have been settled by negotiation and he does not expect that approach to change.

<sup>3</sup> <http://www.futuretimeline.net/subject/society-demographics.htm>

<sup>4</sup> See Reference 1, page 173, for the time period 2010-2050.

<sup>5</sup> [www.agclassroom.org/ia](http://www.agclassroom.org/ia)

<sup>6</sup> Su Ye, Minnesota Department of Agriculture, 2011

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<sup>7</sup> [www.agriculture.gov.sk.ca/](http://www.agriculture.gov.sk.ca/)

<sup>8</sup> <http://www.usna.usda.gov/Hardzone/ushzmap.html>

<sup>9</sup> Personal communication, Handley Cellars in the Anderson Valley, Mendocino County

<sup>10</sup> N S Diffenbaugh, et. al., Environ. Res. Lett. 6 (2011) 024024 <http://stacks.iop.org/ERL/6/024024>

<sup>11</sup> Reference 1, page 141 and picture

<sup>12</sup> Solarad.xls by Garry Pelletier, Washington State Department of Ecology, full details at: <http://www.srrb.noaa.gov/highlights/sunrise/azel.html>

<sup>13</sup> [http://oregonwine.org/Explore\\_Wine\\_Regions/Willamette\\_Valley/Willamette\\_Valley/](http://oregonwine.org/Explore_Wine_Regions/Willamette_Valley/Willamette_Valley/)

<sup>14</sup> <http://occri.net/ocar>

<sup>15</sup> <http://www.ntcl.com/>

<sup>16</sup> <http://www.idc.inuvialuit.com/about-us/our-vision/>

<sup>17</sup> <http://www.omnitrax.com/about/history> It is a private company.

<sup>18</sup> <http://www.cpr.ca/en/invest-in-cp/investor-book/Documents/2011-cp-investor-book.pdf>

<sup>19</sup> <http://www.cn.ca/documents/Investor-Factbook-current/2011-IFB-en.pdf>

<sup>20</sup> (<http://www.farmmarketer.com/canadianfarmreality/index.cfm?page=2> )

<sup>21</sup> [http://en.wikipedia.org/wiki/Canadian\\_Wheat\\_Board](http://en.wikipedia.org/wiki/Canadian_Wheat_Board) and <http://www.cwb.ca/public/en/>

<sup>22</sup> <http://www.investopedia.com/terms/m/monopsony.asp#axzz1jNYaCuUy>

<sup>23</sup> <http://fossil.energy.gov/programs/oilgas/hydrates>

<sup>24</sup> <http://www.netl.doe.gov/publications/factsheets/program/Prog099.pdf>

<sup>25</sup> National Energy Technology Laboratory

<sup>26</sup> [http://fossil.energy.gov/news/techlines/2011/11022-North\\_Slope\\_Well\\_to\\_Test\\_Hydrate\\_P.html](http://fossil.energy.gov/news/techlines/2011/11022-North_Slope_Well_to_Test_Hydrate_P.html)

<sup>27</sup> Reference 25

<sup>28</sup> NAS Report: Realizing the Energy Potential of Methane Hydrate for the United States, 2010. Available online at [http://www.nap.edu/catalog.php?record\\_id=12831](http://www.nap.edu/catalog.php?record_id=12831)