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Setting the Scene: The Challenge of Climate Change

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1. Climate Science Update: What's happened since the IPCC Report?

The IPCC Report

The February 2007 IPCC Report[1] laid out everything the global science community could agree on, using peer-reviewed science published before late 2005. It is an inherently cautious and conservative document, based as it is on a consensus of established scientists. Even so, its conclusions were arresting. Key among them:

- The world is getting warmer at an accelerating rate, and this is principally due to anthropogenic forcing. For the next two decades, a warming of 0.2°C per decade is already wired in, and continued GHG (greenhouse gas) emissions at or above current rates would "cause further warming and induce many changes in the global climate system during the 21st century."
- Global average temperature is expected to rise between 1.1 and 6.4°C by 2100, depending on GHG scenarios and model uncertainties. Changes will be greatest at high latitudes.
- "Excluding future rapid dynamical changes in ice flow," sea levels are expected to rise 0.18m to 0.59m over the century. pH is expected to rise by 0.14 to 0.35 units.
- The intensity, if not frequency, of tropical storms is likely to increase,[2] as is the frequency of extreme events in general.

Events since then:

New measures of actual temperatures and sea level rise have turned out to be at the upper end of projected trajectories.[3] This and other observations, such as faster than anticipated polar ice melting, has given weight to theories that positive feedbacks may be more important than mainstream modeling would indicate.

One example is the possibility that inundation of the low-lying Arctic regions of Canada and Russia, by blanketing permafrost with relatively warm (~0°C) water instead of much colder air, could accelerate the release of methane (CH_4), a GHG 21 times as powerful as CO_2, from frozen muskegs and from frozen methane hydrates (clathrates) below the surface. This effect could be accelerated by a lowered albedo consistent with a change, at first seasonal, from snow or ice cover to water.

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[1] Intergovernmental Panel on Climate Change, *Climate change 2007: The physical science basis. Summary for policymakers*, World Meteorological Organization, Geneva, 5 February 2007. A superb non-technical introduction to the subject is by Kerry Emanuel in the Jan.-Feb. 2007 issue of the *Boston Review*: "Phaeton's reins: the human hand in climate change." http://bostonreview.net/BR32.1/emanuel.html

[2] K. Emanuel, "Increasing destructiveness of tropical cyclones over the last 30 years," *Nature* 436 (2005) 686-8; P.J. Webster, G.J. Holland, J.A. Curry and H.-R. Chang, "Changes in tropical cyclone number, duration and intensity in a warming environment," *Science* 309 (16 September 2005) 1844-46

[3] S. Rahmstorf, A. Cazenave, J.A. Church, J.E. Hansen, R.F. Keeling, D.E Parker and R.J.C. Somerville, "Recent climate observations compared to projections," *Science* 316 (4 May 2007) 709

There is no settled view on how fast the Greenland and Antarctic icecaps will melt, given the planet's continued excursion into realms of GHG concentration not experienced for more than 600,000 years. Greenland would add 7m to sea levels and Antarctica a further 25m. University of Victoria Prof. Andrew Weaver's current best guess is ~1700 years for Greenland, but the risks are all on the side of greater speed.

It has been difficult sorting normal variability from long-term secular change, but recent work indicates that temperature observations of the last few years have been suppressed because of normal variability and that at least half of the years after 2009 will be warmer than any now on record.[4]

New results on ocean acidification have appeared since the IPCC report. The ocean is the ultimate sink for almost all atmospheric CO_2, where it combines with water to form carbonic acid (H_2CO_3), lowering the pH of seawater. Its ultimate fate is geological immobilization, mostly in the form of limestone ($CaCO_3$), but the intervening process is capture by calcareous organisms. Some process the material to aragonite, a hydrated carbonate, some directly to calcite. The rates, however, are strongly affected by acidity. Work at Friday Harbor has shown echinoderm growth rates and time to sexual maturity to be slowed by modest changes in pH. There is fear that the world's corals are already affected by increasing acidity and may disappear in decades or a few centuries. The ecosystem services of corals support enormous ocean biodiversity.

The other main effect of global warming on the oceans is thermal expansion, which will continue to contribute to expected sea level rise. Sea levels have risen 7cm in the last 40 years, and about 2.5cm in the last decade.

One piece of good news is that the feared slackening of the North Atlantic meridional overturning circulation, which powers the Gulf Stream and accounts for mild winters in western Europe, now appears more robust in the face of increased amounts of fresh water entering the Arctic basin.[5]

Meanwhile it is still very much business as usual in the release of GHGs.[6] No meaningful reductions in GHG emissions have been made since the issue came to world notice ~20 years ago, and indeed the rapidly growing Asian economies, notably China and India, are coal-intensive. In 2007 China overtook the USA as the world's largest emitter.

Bottom line: all risks appear to be on the downside.

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[4] D.M. Smith, S. Cusack, A.W. Colman, C.K. Folland, G.R. Harris and J.M. Murphy, "Improved surface temperature prediction for the coming decade from a global climate model," *Science* 317:796-99 (10 August 2007)

[5] J.A. Church, "A change in circulation?" *Science* 317 (17 Aug 2007) 908-9; T. Kanzow *et al., Science* 317 (2007) 938; S.A. Cunningham *et al., Science* 317 (17 Aug 2007) 935

[6] M.R. Raupach, G. Marland, P. Ciais, C. Le Quéré, J.G. Canadell, G. Klepper and C.B. Field, "Global and regional drivers of accelerating CO_2 emissions," *PNAS Early Edition*, 22 May 2007, doi:10.1073/pnas.0700609104

2. Probable Impacts on BC

Results from global and regional climate modeling, and the filling in of important gaps, have recently been published by the Pacific Climate Impacts Consortium. The report[7] documents changes that have already taken place during the past century:

- Positive trends in annual daily minimum temperature (+1.0 to 2.5ºC), daily maximum temperature (+0.5 to 1.5ºC), and daily mean temperature (+0.5 to 1.5ºC) have been documented. In northern BC the trends in minimum wintertime temperature were up to 3.5ºC per century. For comparison, the *global*…trend of the mean temperature is +0.7ºC (between +0.6 and 0.9ºC).
- Trends in precipitation were also generally positive (+22% on average across BC) and some observations of +50% occurred in wintertime in the interior. However there were exceptions and some of the trends were reversed (negative) when a shorter record of 50 years was utilized.
- Climate variability had a pronounced influence of seasonal temperature and precipitation in BC, especially in the winter and spring seasons. During the warm phase of ENSO [El Niño-Southern Oscillation], the temperature was higher (+0.6 to 2.2ºC) and the precipitation was somewhat less (-6%) compared to the cool phase. There was also a comparable influence of the PDO [Pacific Decadal Oscillation] warm phase on temperature (+3ºC) and precipitation (-3%). The magnitude of climate variability was comparable to climatic trends over the century.

Snowpack has declined 25 to 50 percent over the last century and most, but not all, glaciers are receding. Lake ice duration is down 9 to 35 days, and spring break-up occurred 5 to 12 days earlier, depending on location. The peak of stream run-off has advanced 10 to 30 days where the regime is dominated by snowmelt, and both the mean annual streamflow and minimum daily average streamflow have decreased. Again, ENSO- and PDO-related variability has large effect.

All the above are measured changes, not model projections.

By the 2050s, "the average annual temperature in BC is projected using an ensemble of GCMs [Global Climate Models] to be warmer by +1.7ºC (+1.2 to 2.5ºC) compared to the GCM baseline (1961-1990) climate, and this shift is projected to occur in both summer and winter seasons." Small increases in total precipitation are projected, but with more pronounced seasonality: increases in winter, decreases in summer. The Canadian Regional Climate Model produces somewhat greater anomalies (+2.6ºC and +13%), with more seasonal and regional variation. The CRCM also projects "an extraordinary decline in snowpack" of up to 60 percent. Projections of growing degree days indicate a potential for agricultural expansion in the central and northeastern parts of the province, but probably with decreased soil moisture. A radical and probably permanent change in ground cover is already underway due to the Mountain Pine Beetle infestation, itself a consequence of warmer winters.

[7] D. Rodenhuis, K.E. Bennett, A. Werner, T.Q. Murdock and D. Bronaugh, "Hydro-climatology and future climate impacts in British Columbia," PCIC, Centre for Global Studies, University of Victoria, July 2007

Biological impacts are expected to be large. Anadromous fishes that depend on cold water and late-summer flows will be heavily affected. The lodgepole pine, once killed, is unlikely to regenerate for another turn, as soil moisture will be lower and temperatures higher over much of its current range. Grass and mesquite succession will in turn have impacts on soil moisture and streamflow. Along the south coast, species like red cedar, which require moist soils all year round, will not thrive. New microbes and insects may be expected. Some will be direct human pathogens.

Regionally, these impacts will be most visible where ecosystems are already near some climatic limit. Temperature anomalies will be higher in the north. Coastal BC will more and more resemble a Mediterranean or southern Californian climate, with drier summers and rainfall concentration in the winters.

Sea level rise in the present century is projected by the IPCC to be between 0.19 and 0.57m, but as noted there is the possibility of positive feedbacks that could raise this number. The moderating effect of local isostatic land rise is believed to be smaller by an order of magnitude, and in any case may be less than crustal downwarping under the Fraser delta. Average sea level needs to be modified by tidal and storm influences in order to assess threat. The coincidence of a neap tide with *seiches* – storm surges caused by the low pressure attendant on a Pacific storm – and storm waves can cause exceptional damage to coastal areas, as seen locally on February 4, 2006.

The probability of extreme events under climate change is a rapidly developing area in climate studies. For example, Abeysirigunawardena *et al*[8] have shown that the return period for a once-in-200-year event under base case (historical) conditions becomes once in 20 years under plausible climate change scenarios. This effect is magnified under a warm ENSO.

Serious changes in GHG emissions on a global scale could moderate a continuation of these impacts in the period beyond the 2050s, but these impacts, together with increasing acidification of the oceans, are not now avoidable.

3. Mitigation

A Global Problem

"Mitigation" is the term used for efforts to reduce atmospheric loadings of GHGs. Current levels are about 380 ppm CO_2, up ~100 ppm since the beginning of the Industrial Revolution. Most discussion centers on producing an upper asymptote of 450-550 ppm, on the theory that the climatic consequences of such concentrations, while serious, would still be tolerable by most human populations.

[8] See for example Dilumie Abeysirigunawardena, Eric Gilleland and Trevor Murdock, "Influence of climate variability and change on extreme total water levels in the south coast of British Columbia (Pt. Atkinson)," dr. MS., PCIC, September 2007

Tolerability is a slippery concept, however, with different meanings for humans in different circumstances. Even at the lowest target level, one not expected to be met, populations in low-lying coastal areas would have to relocate or build large flood control structures. These alternatives are not effectively available to the inhabitants of the deltas of the Ganges/Brahmaputra, Mekong, Nile, Yellow, Red and other rivers, or to the inhabitants of certain low-lying island states. Desiccation and heat, possibly associated with changes in Asian monsoonal precipitation patterns, will threaten the food supply of many more. Pushing degree days northward in North America and Siberia will not compensate, as soils are not as suitable for grains.

The effect on food supplies is exacerbated by the current rise in incomes in South and East Asia, which vastly increases the demand for meat, which in turn requires greatly increased grain production. To the degree that the current fashion for ethanol is made permanent by soft thinking and hard lobbying, there will be a further effect on grain demand. The sum of these effects will be higher food prices, which, through the effects of worldwide markets, will have their greatest impact on the poorest people in the world.

The GHG problem is a perfect example, on the grandest possible scale, of a common property resource problem. Avoiding severe consequences dictates that humanity reduces its GHG production by at least 50 and probably more like 80 percent. Elementary considerations of equity require that the developed world, which is principally responsible for the present situation and which consumes on a per capita basis so much more of the atmosphere-ocean disposal capacity, cut back more.

There is little doubt in the scientific community that the globe is warming at a pace not seen for hundreds of thousands of years, at least, and that the principal cause is human modification of the atmosphere. Some, however, argue that on balance things may all work out. More heat deaths, fewer cold deaths. Displacement of agricultural belts poleward, and perhaps a general increase in agricultural production with more CO_2, warmth, and water would call for adjustments over a matter of decades but nothing the world can't handle.[9] This is not realistic.

Other voices claim that Canada should live up to its Kyoto commitments, no matter how insouciantly undertaken.[10] It is often said that we can get from here to there through conservation, efficiency, and renewable energy. Nuclear energy is not to be contemplated, nor are fundamental changes in lifestyle. This is not realistic either. The potential contribution of novel sources was estimated in 1979 and has not changed in material ways.[11] For a more realistic exploration of some of the dislocations that might be

[9] Good example of this specious argument: Bjorn Lomborg, *Cool it*, 2007. Cf. the review by Alanna Mitchell, "The Pollyana of global warming," *Globe & Mail*, 29 Sept. 2007, D9. The *Wall Street Journal* and Fox News are reliable sources for arguments of this sort.

[10] Joan Bryden, "Former advisor admits Chrétien government was not ready to implement Kyoto," Canadian Press, 22 February 2007

[11] H.S. Swain, R. Overend and T.A. Ledwell, "Canada's renewable energy prospects," *Solar Energy* 23 (1979):459-70

required and a critique of Canada's actions, George Monbiot's angry book[12] or the recent account by Jeff Simpson *et al*[13] are better places to start.

The starting point for international action was the United Nations Framework Convention on Climate Change of 1992. From this came the Kyoto Protocol of 1997, under which many nations – 169, accounting for 62 percent of global GHG emissions, as of December 2006 – made formal commitments about reducing GHG emissions. Kyoto has several features that make it not especially effectual, even as an acknowledged first step. One, major emitters like the United States and China are not signatories. Two, some countries, Canada among them, committed to "aspirational" goals they had no means or intention of meeting. Three, some signatories, principally the transition economies of the former Soviet bloc, got a free ride because their economies had collapsed so far in the wake of the revolutions of 1989-90 that they had decades of headroom. Four, developing countries accepted loose or no targets. The combination of hypocrisy, inequity, and an aggregate effort that would not make much of a dent in the problem even if fulfilled has left many people feeling both righteous and angry – not a good frame of mind for negotiating the much more serious commitments that must follow 2012.

An alternative grouping of six nations, the Asia-Pacific Partnership on Clean Development and Climate, led by the US and including China, Australia and India and accounting for 65 percent of the world's coal production and 61 percent of cement, has been established to share technical information while avoiding binding commitments. These countries have said they will try to decrease the energy intensity of present and future economic activities, with the long-term goal of actually reducing GHG emissions. Canada has asked to join this group, which would make it the only member of both. Canada has notified the UNFCC that it will not meet its Kyoto commitments but instead will pursue intensity targets with a view to reducing GHGs by 60 percent by 2050.

Meanwhile the business of climate change has become quite an industry. Thousands of government officials, NGO members, salarymen and lobbyists now spend millions of hours every year seeking to solve the problem at someone else's expense, or seeking business opportunities in a rolling disaster. The quantification and certification of CDMs (Clean Development Mechanisms) and the operation of carbon "markets" now occupies thousands of people – more in Europe than North America, though that may change with a change of Administration in the US in 2009.

In the face of official gridlock a number of informal groups have sprung up to explore possible solutions. One, jointly organized by UVic's Centre for Global Studies and the Energy and Environmental Systems Group at the University of Calgary, is working at both national and international scales to develop negotiating processes and partial solutions. One aspect of their work is the involvement of former ministers and heads of government in simulated negotiations. Relaxing some of the constraints that operate at the intergovernmental level, such as the insistence that all countries reduce emissions

[12] George Monbiot, *Heat*, Doubleday, 2006
[13] Jeffrey Simpson, Mark Jaccard and Nic Rivers, *Hot air: meeting Canada's climate change challenge*, 2007.

simultaneously or equally, or the reluctance to invoke trade-offs outside the energy-environment nexus, may help find novel solutions.

The BC Case

British Columbia has fewer mitigation possibilities than other jurisdictions if only because its electricity sector is already comparatively clean. About 90 percent of the electricity consumed in BC comes from falling water. The remainder is principally coal-fired imports from Alberta, a situation that persists because of policy inaction in BC with respect to new generators for Mica and Revelstoke or the construction of Site C on the Peace. Were those (or nuclear alternatives) in place, it would be feasible to back out a lot of hydrocarbons.

For BC, moving away from coal and oil for electricity and transportation is challenging but still less problematic than it is for other states and provinces. The Premier's Climate Action Task Force is currently assessing upwards of 200 ideas for action by the provincial government alone.[14] It is widely accepted that any serious action will have to involve a real and steadily increasing price for GHG emissions.

4. Adaptation

Adaptation is the term used for actions to cope with the inevitable, and as such has failed to command the same attention as mitigation.[15] It is inherently local, and therefore does not offer the reputation-making sweep of the global mitigation problem. Sub-regions and local economic interests will be subject to idiosyncratic impacts that escape summaries at larger scales. Adaptation involves thousands of actions and possibilities at every level from the personal to the national: it is messy, in other words. A great deal of further work can be done in this area. Much of current work focuses on sectoral impacts, leaving integration as a task for local authorities and organizations.

A further difficulty stems from the nature of the underlying science, which in general is more reliable as the region under examination gets larger. The "pixel size" of many GCMs is on the order of 100 x 100 km, and a map has many pixels. One of the research frontiers in climate modeling is downscaling, so as to produce predictions on a geographical scale useful to planners at the regional and local levels. There is no escaping the paradox that as the scale of adaptive measures gets closer and closer to everyday human experience, the science gets moiré uncertain and less reliable.

Adaptation alternatives often have mitigation effects. As the price of oil and gas rises, for example, normal market forces would be expected to lead to changing consumer preferences with respect to automotive, truck and recreational vehicle efficiency, and to building envelope performance. The Ministry of Forests and Range must make plans

[14] Graham Whitmarsh, personal communication

[15] In practice, some actions have elements of both. A hybrid car may emit fewer GHGs per mile, and in a world of higher fuel prices may preserve household resources for further adaptation.

about forest succession in areas being ravaged by the mountain pine beetle. An adaptive plan will be resilient in the face of future environmental problems. It will also be mitigative, in that afforestation can lock up a great deal of CO_2. An overly strict separation is unnecessary, not widely understood by the public, and may tend to lessen public interest and participation. Among relatively pure adaptation possibilities the following offer considerable potential (large effect, modest cost, no regrets):

Forest Succession

As noted, the choices to be made about the composition of the future forests of BC will have to take into account climate change. For a resource whose crop rotation may be 60-100 years, the forecast conditions of the later periods become crucial.

Land Use

Zoning could become much stricter with respect to building in areas which will become more prone to flooding (tidal as well as stream-based), avalanches, and landslides.

Building Codes

New buildings of all sorts can be built to much higher energy performance standards with modest incremental cost, as well as being "green" in a number of other ways. Retrofitting the present stock is probably more expensive, but there are large numbers of small opportunities, again with positive internal rates of return. An energy services approach to planning may encourage a low-tech approach to solar water and space heating.[16]

Infrastructure Standards

There is a considerable demand, likely to grow as insurers differentiate among clients on the basis of their demonstrated risk-lowering practices, for new infrastructure standards to meet the expected weather conditions of the future. Roads and bridges (including those used for logging), airports, drainage and storage, dikes, water supply and sewage treatment, and power transmission all have very long lives. Minor adjustments to design and construction can avoid early obsolescence. As noted this rests on local or regional forecasts of extreme events, an offshoot of climate science and statistics that is still largely undeveloped. Provincial guidance in standard-setting used to be available in BC for some of these subjects but succumbed to budget cuts and the unavailability of trained personnel. Municipal engineers and other local leaders are aware of the problem and are looking to senior levels of government for assistance.

Water

Demand for water is likely to outstrip any modest increments in annual availability, especially on a seasonal basis. BC and other western jurisdictions with "FIT FIR" (first in time, first in right) allocation methods may want to revisit water pricing and allocation.

[16] See any of the works of Amory Lovins

Water for irrigation can be used much more carefully than is normal at present – note the drip irrigation schemes in the Okanagan vineyards, for example. Water use in industry, especially mining, oil and gas, and food production – would be more carefully used if prices reflected scarcity values. Municipally, metering should become all but universal, with volumetric pricing systems. Since a third or more of the operating cost of municipal water systems goes to electricity for pump operation, water conservation initiatives would also moderate electricity demand.

Outdoor Recreation

Ski resorts are already ascending the mountains in order to improve the likelihood of seasons long enough to be profitable. Swimmers may welcome warmer water in summer lakes, but the trout and salmon will not. Fishery-based recreation will likewise have to adapt to new species and changed abundances of old species.

Power

BC is fortunate in that about 90 percent of the electricity consumed here comes from falling water. But if electricity is to become a prime mover – a source for motive fuels, and something that can be transformed into an on-demand energy source – more electricity needs to be generated from non-carbonaceous sources. Mica and Revelstoke can provide capacity, wind can provide energy, and Site C on the Peace can provide both.

In 2014 the Columbia River Treaty is open for revision. As enormous as the costs and benefits of this development have been in the last half century, they will be multiplied in an era of greater demand for power, flood control, and increased precipitation peakiness. The negotiations over storage and the distribution of benefits will be contentious, not least on the Canadian side because of the need to coordinate the actions of Ottawa, Victoria, and BC Hydro so as to present a united front to the American side. This was a considerable challenge in the years before 1964.

Electricity-based Transport Fuels[17]

Electricity can directly replace diesel on the railroads through the Cordillera with positive if not juicy rates of return, and it can power batteries and provide hydrogen for fuel cells

[17] Other transport fuel alternatives present specific difficulties. Biodiesel, to the extent that its source material is waste cooking oils, is quantitatively limited, though moderately attractive as far as it goes. When the source becomes canola or soybean oil, or when as in the case of ethanol, cornstarch is the source, serious competition for food uses will appear as soon as the quantities become specific. This has distinctly happened with corn in the US, for instance, where upwards of half the corn crop is now dedicated to extending gasoline. But solutions such as corn-based ethanol which rely on large, market-distorting subsidies are unlikely to be stable. When, as is increasingly the case in the US, the conversion from cornstarch relies on coal-fired boilers, the system effect on GHGs can be decidedly negative. The bottom line is that biodiesel may lower emissions somewhat, but ethanol is not much more than a disguised subsidy for farmers that, depending on the power source used for conversion, actually increases the GHG burden.

and hybrids. These large opportunities underline the attractiveness of proceeding soon with BC's electrical generation potential.

Human and Ecosystem Health

A changing climate will bring the threat of new pathogens. Mountain pine beetle and West Nile disease are two current examples, and more are waiting in the wings. The public health authorities should be doing some anticipatory monitoring. The Forestry people, both provincial and federal, seem alert.

Research

Research leading to better long-term weather (seasonal climate) forecasting would have great pay-off with respect to mitigating the effects of extreme weather events and to setting new standards for the built environment. Every single one of the adaptive possibilities mentioned above are under-researched.

Mixed Cases

The classic mitigation approaches are also adaptive. One way or another, the price of burning carbon will have to rise. Taxes, technological regulation, or cap-and-trade systems are all possible mechanisms. Conversely, activities that sequester carbon, including petroleum field operations, carbon capture and storage and reforestation may be encouraged, as might conservation, renewables and nuclear energy. In fact, any sensible low-carbon energy policy will push conservation and distributed renewable energy as far as they can be seen to make economic sense, and a bit farther because of the externalities involved, before new investments in heavy hydro. There are industrial adjustment costs, but there will also be benefits through being inventors and early users of novel technologies. A particular role of taxation may be to socialize some of the unusual costs of capital turnover in industry. The steady pursuit of mitigation opportunities like these will also have the effect of increasing the resilience of the BC economy in the face of the adaptation challenge.

Climate Refugees

Over the longer term, we can expect to see climate change add to the pressures on the world's migration systems. Either globally or in developed countries, as in the case of Hurricane Katrina, it will be the poorest people who will take the brunt of agricultural failures and extreme weather events. It appears that one of the causes of the misery in Darfur is a shifting balance between people and food in a region undergoing desertification. Climate change will not be the sole cause of these miseries, but will likely be a contributor. The initial pressures will be to supply emergency aid, but ther question of whether to accept large numbers of destitute and unskilled refugees is likely to trouble future Canadian governments.

5. Strategic Issues

Lead (and bear costs) or be a free rider?

Canada, Alberta and Ontario have for the most part elected to be laggards in a necessary and probably inevitable process; BC, along with a few western US states, is at least rhetorically ahead of the game. No Canadian government has yet seriously engaged at the level – 50 to 80 percent decrements in GHGs – likely to be minimally necessary. There are costs either way. Leaders – out on the "bleeding edge," technologically, for instance – may bear costs that are higher than necessary because the learning curve is still ahead, because of premature investment in what turn out to be blind alleys, or because of overshooting. On the other hand, if adjustment is necessary, early adopters may find themselves in possession of saleable intellectual property as well as goods and services. Laggards may see their economies locked into dependence on rapidly obsolescing technologies and in the limit may find markets closed to them because the customers will not stand for the environmental externalities involved. Something to watch for will be attempts to expand the purview of international trade law, or the domestic laws of important traded partners, to take account of these costs in a way that would legitimize market closures. All this is beside the moral obloquy that may accrue to the international reputation of a country that likes to think of itself as offering leadership and a good example on matters of broad social concern.

First Nation Partnerships

Provincial and municipal governments are going to find their freedom of action circumscribed in adopting adaptive policies unless they can find ways of bringing Indian bands into partnership. The trend of Supreme Court decisions, based on the Charter, is to erect a constitutionally protected third order of government in Canada. It is already clear that Section 88 of the *Indian Act*, which says that laws of general application apply on reserve unless there is specific federal legislation to the contrary, does not apply to matters that go to the heart of "Indianness." The Court has not said what these might be, in any exhaustive sense, but has said that this large loophole applies to matters touching band governance. The legal argument is laid out in a 2006 report to the Minister of Indian Affairs with respect to the regulation of water on Indian reserves.[18] In brief, it is likely that courts will find in future that surface and groundwater on reserves, and possibly in the larger territories granted under treaty or self-government legislation, is not a matter for provincial legislation. (There are a number of other areas where the loophole applies and for which there is no federal legislation.) All of which is to say that dealing with adaptation insofar as it affects the lands, waters, or other basic concerns of BC's First Nations will require not just respectful consultation but a genuinely joint approach to their resolution.

[18] H. Swain, S. Louttit and S. Hrudey, *Report of the expert panel on safe drinking water for First Nations*, Department of Indian Affairs and Northern Development, Ottawa, November 2006, Vol. 2, Ch. 3.

Compensating Losers

Any large-scale process of social and economic adjustment will create costs and benefits whose incidence fall unequally on individuals and groups. An important policy question for governments is the degree to which losers are compensated, which is to say the degree to which the costs of adjustment are socialized.

Evaluation

Assessing mitigation options is essentially straightforward: one wants to rank alternatives in terms of their costs, in all senses, per tonne of GHGs foregone. For adaptation, the measure of virtue is less clear. How much is increased social or economic resilience worth, and how can it be measured? The invention of an evaluation framework which could help sort the important from the trivial is a research frontier that could repay attention handsomely.

6. Conclusion

A number of biophysical changes to the BC environment due to changes in global atmospheric chemistry can now be predicted with a reasonable degree of certainty. As with all forecasts, the uncertainties mount with time. But waiting for precision should not be an excuse for inaction. Both in respect to mitigation and adaptation, there are a large number of possible actions that would have meaningful effects at modest cost. The larger the period of time available for capital turnover and other forms of adjustment, the lower the aggregate costs. This is so even if – especially if – the total transformation that is needed is of huge proportions.

Adaptation is local. There are fruitful actions that can be taken by the province, municipalities, firms, civil society groups, and individuals. For every decision making entity it is necessary to erect some sort of evaluation framework which will guide people toward actions that have the biggest bang, in terms of lowered GHG emissions or adaptive capacity, for the buck.