19.4.3. Conservation through community involvement

The last several decades have seen continued interest in natural resource monitoring that involves both scientists and local stakeholders (Gofman 2010, Huntington 2011). This partnership, often referred to as community based monitoring (CBM), or community-based observations, continues to evolve and exert increased influence on decision making and resource management (Gofman 2010). The scope of CBM is diverse and complex and continues to develop as experiences of integration are shared. Moreover, the overwhelming connection of Arctic peoples to the land provides opportunities for strong conservation partnerships, for example initiatives related to ecological monitoring, food security or sacred sites.

In essence, CBM seeks to improve the ability to share observations and understanding of local changes that are occurring in a vast and remote region through the eyes of Arctic residents. The idea is that intimate and multi-generational knowledge held by local stakeholders can help governments and local organizations identify and address serious environment and development challenges at early stages (Harremoës *et al.* 2001).

19.4.3.1. Monitoring approaches

Monitoring approaches in all Arctic countries have some level of local involvement, and examples of CBM exist throughout the Arctic. These monitoring approaches range from programs involving local stakeholders only in data collection (citizen science) with the design, analysis and interpretation undertaken by professional researchers, to entirely autonomous monitoring schemes run by local people (see Gofman 2010 for full discussion).

The level of involvement by local peoples beyond project development and planning to include analysis can contribute to longer-term capacity and implementation benefits beyond just the collected data (Tab. 19.3). Although local residents can unquestionably monitor and report on certain observed changes, their interpretation of the changes and any policy implications they may have are sometimes left aside. However, this is not a problem limited to CBM. From a policy implementation perspective, opportunities to involve Arctic peoples in knowledge production, in an open and transparent manner, is critical when considering managing individual and commercial activities in the North.

19.4.3.2. Validity of CBM data

The struggle to break through the perceived limitations surrounding CBM is often linked to the approaches and skepticism at the heart of western approaches to knowledge production. Scientists have documented Arctic community members' detailed knowledge of key components of their environment, such as sea-ice (Laid-

Table 19.3. Arctic and sub-Arctic natural resource monitoring schemes across a spectrum of possible monitoring approaches based on the relative participation of different actors (modified from Danielsen *et al.* 2009).

Category of monitoring	Arctic examples	Description
Fully autonomous local monitoring	Customary conservation regimes, e.g. in Canada (Ferguson *et al.* 1998, Moller *et al.* 2004)	The whole monitoring process – from design, to data collection, to analysis, and finally to use of data for management decisions – is carried out autonomously by local stakeholders
Collaborative monitoring with local data interpretation	Arctic Borderlands Ecological Knowledge Co-op, Canada (Eamer 2006, Russell *et al.* 2013); Community-based monitoring by Inuvialuit Settlement region, Canada (Huntington 2011); Opening Doors to the Native Knowledge of the Indigenous Peoples of the Nenet Autonomous Okrug, Russia (The Association of the Nenets People Yasavey and RAIPON); Piniakkanik Sumiiffinni Nalunaarsuineq, Greenland (Danielsen *et al.* in press)	Locally based monitoring involving local stakeholders in data collection, interpretation or analysis, and management decision making, although external scientists may provide advice and training. The original data collected by local people remain in the area being monitored, but copies of the data may be sent to professional researchers for in-depth or larger-scale analysis
Collaborative monitoring with external data interpretation	Community Moose Monitoring Project, Canada (Gofman 2010); Integrated Ecosystem Management (ECORA), Russia (Larsen *et al.* 2011)	Local stakeholders involved in data collection and monitoring-based management decision making, but the design of the scheme and the data analysis and interpretation are undertaken by external scientists
Externally driven monitoring with local data collectors	Bering Sea Sub Network, Alaska and Russia (Gofman & Smith 2009); Environmental Observations of Seal Hunters, Finland (Gofman 2010); Fávllis Network, Norway (Gofman 2010); Monitoring of breeding common eiders, Greenland (Merkel 2010); The Piniarneq fisheries catch and hunting report database, Greenland	Local stakeholders involved only in data collection stage, with design, analysis and interpretation of monitoring results for decision-making being undertaken by professional researchers, generally far from the site
Externally driven, researcher executed monitoring	Multiple scientist-executed natural resource monitoring schemes with no involvement of the local stakeholders	Design and implementation conducted entirely by professional scientists who are funded by external agencies and generally reside elsewhere

ler 2006), weather patterns (Weatherhead *et al.* 2010) and caribou (Ferguson *et al.* 1998, Russell *et al.* 2013). Nevertheless, we know of no studies that have examined the accuracy of community-based monitoring of natural resources in the Arctic. Studies from other parts of the world provide cautious support for the idea that monitoring by community members can yield results that can be as reliable as those derived from professional, scientist-conducted monitoring (e.g. Danielsen *et al.* 2005, Jones *et al.* 2008, Rist *et al.* 2010).

Whereas scientists aspire to be impartial (Beardsley 2010), some fishermen, hunters and environmentally interested people may have a conflict of interest in their assessment of the status of those resources on which they depend for their livelihoods or that they are otherwise interested in (Root & Alpert 1994). For instance, a special local interest in certain resources or a preoccupation with certain challenges to resource management may influence which attributes are recorded, when and where. The community perspective is relevant too. Indigenous communities often view scientific initiatives with suspicion, if the scientists do not possess social and cultural skills to appreciate context and locality, creating a need to establish credibility in both directions.

Many of the potential limitations of CBM can be overcome by careful planning, by explicit consideration of likely biases, and by thorough training and supervision of the participants (Danielsen *et al.* 2009, Gofman 2010, Luzar *et al.* 2011). It is a challenge, however, that community monitoring can superficially appear low-tech and therefore primitive in a high-tech world. There remains a huge unexplored potential for strengthening monitoring efforts across the Arctic by engaging more communities and encouraging linkages with scientific monitoring programs (Huntington 2008). Often, an investment to build capacity to collect, interpret and manage data are central to maximizing such monitoring efforts (Gofman 2010).

19.4.3.3. Challenges

As the CBM record evolves and demonstrates continued improvement of accessible information on Arctic biodiversity, it is anticipated that there will be a delay between information production and use, accessibility and integration. In northwestern Canada and northeastern Alaska, for example, the reporting by the Arctic Borderlands Ecological Knowledge Co-op of CBM data on population health and body condition of the Porcupine caribou herd were largely dismissed and undervalued in favor of scientific models projecting substantive

population declines (Gofman 2010, Russell *et al.* 2013). Moreover, such projected declines prompted government and decision makers to push for and build harvest regimes that limited northern residents' ability to harvest. Indeed in 2012, several years after the CBM results were released, scientific population surveys revealed record numbers of caribou actually existed. In this case, CBM would have limited harvest concerns and supported improved access to northern food. However, the combination of the potential for conflict of interest and the lack of demonstrable validation capacity may have contributed to placing limited value on the information from this source.

Such examples suggest that efforts to emphasize analysis and integration between the two knowledge production approaches should continue. Indeed, more recent biodiversity monitoring planning processes are proposing ways of integrating and coordinating the methods for knowledge co-production (Gofman 2010, Vongraven *et al.* 2012). The Circumpolar Biodiversity Monitoring Program's (CBMP) strategy for bridging some of the structural challenges over the next few years includes improving the access to CBM data via improved provision of and access to metadata, modeling and demonstrating integration examples of CBM with scientific monitoring processes (Gill *et al.* 2011, Culp *et al.* 2012).

19.4.3.4. Contributions to biodiversity monitoring

Full participation in biodiversity monitoring programs continues to be a challenge for many Arctic peoples. Greenland's effort to increase involvement of CBM with management provides one of the promissong stories becoming more common in the Arctic. The Greenland government is piloting a natural resource monitoring system whereby local people and local authority staff are directly involved in data collection, interpretation and resource management. The scheme is called *Piniakkanik sumiiffinni nalunaarsuineq* (Opening Doors to Native Knowledge). Four communities in Disko Bay and Umanak/Uummannaq Fjord are involved: Akunnaaq, Kitsissuarsuit, Qaarsut and Jakobshavn/Ilulissat.

As in other parts of the Arctic, the communities in Greenland are widely distributed over a vast territory, and the opportunities for environmental monitoring and for implementing hunting and fishing regulations on the ground are limited. It has long been a priority of the Greenland government to increase the involvement of local citizens in the decision-making process related to natural resources (Greenland Government 1999, Haaland *et al.* 2005). However, there is limited funding available for monitoring Greenland's resources, and many species and populations are thus monitored infrequently or not at all (Nielsen 2009). There is therefore insufficient knowledge available about some wildlife populations to guide government decision making and consequently a need to supplement the existing scientist-led monitoring programs with low-cost monitoring, for example through CBM.

The following are examples of how the influence and impact of the data are increasing when it comes to Arctic resource management. In each of the examples, local community observations were central to effecting changes to management regimes.

Conservation of marine habitat: In Akunnaaq, Greenland, the Natural Resource Committee (NRC) recorded trawlers fishing for shrimp in a shallow sea area adjacent to their village on a daily basis. There were 4-5 vessels almost every day throughout April and May 2010. This number was the same as in 2009 but higher than in previous years. Moreover, the vessels were larger and used heavier fishing gear. The NRC in Akunnaaq was worried that potential degradation of the seafloor might affect the breeding and production of Atlantic wolf-fish *Anarhichas lupus*. The NRC therefore proposed that the municipality should issue an ordinance to restrict the size of vessels in the area.

Influencing marine harvest techniques: One of the attributes recorded by Qaarsut NRC concerned their catch of Greenland halibut *Reinhardtius hippoglossoides* in Umanak/Uummannaq Fjord. On the basis of their catch-and-effort data from long-line fishery, they estimated that the local Greenland halibut population was the same in May 2010 but higher in June-September 2010 than in the same months of 2009. Nevertheless, the NRC was concerned that many nets were being set over their longlines and that some nets were left at sea when the sea froze over. This resulted in many rotting fish, which attracted Greenland sharks *Somniosus microcephalus*. The NRC therefore proposed that the municipality should issue an ordinance to restrict net fishing in Umanak/Uummannaq Fjord. The fisheries legislation in Greenland allows municipalities – subject to ministerial approval – to prohibit the use of certain vessels and equipment in specific areas (Greenland Government 1996).

Influencing goose harvest pressure: Members of the Qaarsut NRC have observed that, over the past decade, the population of Canada goose *Branta canadensis* has risen sharply. Canada goose may out-compete the threatened Greenland white-fronted goose *Anser albifrons flavirostris* (Boyd & Fox 2008 *versus* Raundrup *et al.* 2012). Hunting seasons in Greenland are decided by the Ministry of Fisheries, Hunting and Agriculture on the basis of advice from scientists and from public input during a hearing process. The current hunting season for Canada goose is 15 August to 15 October (Department of Fisheries, Hunting and Agriculture 2011). The NRC proposed that the municipality should suggest to the Ministry that the hunting season for Canada goose be extended, for example by two weeks, to help keep the population from expanding further. However, a recent study has not found such competition between Canada geese and Greenland white-fronts during molt (Raundrup *et al.* 2012).

In all three examples, it is noteworthy that the proposals if implemented will benefit the people having put them forward. International experiences however suggest that

CBM also often leads to people suggesting restrictions in their own take of resources (Danielsen *et al.* 2007). CBM encourages people to take a long term perspective on the use of resources through facilitating agreements at community and municipal level to increase or reduce the use of resources.

19.4.3.5. Future prospects

The Arctic environment is rapidly changing (e.g. Hinzman *et al.* 2005, CAFF 2010) and there is increasing pressure on its natural resources. There is therefore also an increased need for monitoring. To date, many examples exist of Arctic peoples describing the changes they witness related to climate, sea ice and especially to harvested wildlife species. There is a persistent need for more CBM that can detect change, interpret and integrate results, and lead to prompt decision-making to help tackle environmental challenges at operational levels of resource management (Huntington & Fox 2005, Danielsen *et al.* 2010).

Representatives of indigenous communities practice wildlife management guided by their indigenous knowledge, realizing that indigenous knowledge and western scientific knowledge are based on different knowledge generation systems or epistemologies (e.g. Agrawal 1995, Huntington *et al.* 2004). Through CBM, however, it may be possible to find a suitable means of cooperation and collaboration in which monitoring can be based on local observations and knowledge (Pulsifer *et al.* 2010, van der Velden 2010) and, at the same time, follow principles of data handling and data management in accordance with Western concepts of scientific accuracy (Yoccoz *et al.* 2001), which is what national government agencies and international conventions require. Several Arctic programs (including the CBMP) and Arctic peoples have already started to implement strategies to bridge this gap by building structures such as inventories and metadatabases to better access, use and integrate CBM knowledge in the arctic (e.g. Pulsifer *et al.* 2012).

In combination, the increased need for data and the necessity of promoting locally relevant knowledge and management actions suggest that there are substantial prospects in the coming decades for more CBM around the Arctic, and that such an increase will contribute to effective local conservation actions.

REFERENCES

Agrawal, A. 1995. Dismantling the divide between indigenous and scientific knowledge. Dev. Change 26: 413-439.

AMAP 1998. Arctic Pollution Issues: a State of the Arctic Environment Report. Arctic Monitoring and Assessment Programme, Oslo.

AMAP 2007. Arctic Oil and Gas 2007. Arctic Monitoring and Assessment Program, Oslo.

AMSA 2009. Arctic Marine Shipping Assessment 2009 Report. Protection of the Arctic Marine Environment, Ottawa, Canada.

Barry, T. & McLennan, D. 2010. Changes in protected areas. In: CAFF. Arctic Biodiversity Trends 2010 – Selected Indicators of Change, pp 96-98. CAFF International Secretariat, Akureyri.

Beardsley, T.M. 2010. Emotions and engagement. BioScience 60: 775.

Bellamy, D., Radforth, J. & Radforth, N.W. 1971. Terrain, traffic and tundra. Nature 231: 429-432.

Betts, R.A. 2000. Offset of the potential carbon sink from boreal forestation by decreases in surface albedo. Nature 408: 187-190.

Bliss, L.C. 1970a. A biologist explains why we must plan now to protect the Arctic. Science Forum 3(8): 3-8.

Bliss, L.C. 1970b. Oil and the ecology of the Arctic. In: The tundra environment. Transactions of the Royal Society of Canada, Series IV, 7: 1-12.

Boyd, H. & Fox, A.D. 2008. Effects of climate change on the breeding success of White-fronted Geese *Anser albifrons flavirostris* in west Greenland. Wildfowl 58: 55-70.

CAFF 2004. The conservation value of sacred sites of indigenous peoples of the Arctic: a case study in Northern Russia. Report on the state of sacred sites and sanctuaries. CAFF Technical Report No. 11. CAFF International Secretariat, Akureyri.

CAFF 2010. Arctic Biodiversity Trends 2010 – selected indicators of change. CAFF International Secretariat, Akureyri.

Callaghan, T.V., Björn, L.O., Chapin III, F.S., Chernov, Y., Christensen, T.R., Huntley, B. *et al*. 2005. Arctic tundra and polar desert ecosystems. In: ACIA. Arctic Climate Impact Assessment, pp 243-352. Cambridge University Press, Cambridge.

Cameron, R.D., Smith, W.T., White, R.G. & Griffith, B. 2005. Central Arctic caribou and petroleum development: distributional, nutritional and reproductive implications. Arctic 58: 1-10.

Canadell, J.G. & Raupach, M.R. 2009. Land carbon cycle feedbacks. In: M. Sommerkorn & S.J. Hassol (eds.). Arctic Climate Feedbacks: Global Implications, pp 69-80. WWF International Arctic Programme, Oslo.

CARMA 2010. Threats to Caribou. www.carmanetwork.com/display/public/Threats [accessed 12 December 2010]

Chapin, F.S. III, Sturm, M., Serreze, M.C., McFadden, J.P., Key, J.R., Lloyd, A.H. *et al*. 2005. Role of land-surface changes in arctic summer warming. Science 310: 657-660.

Chapin, F.S. III, Carpenter, S.R., Kofinas, G.P., Folke, C., Abel, N., Clark, W.C. *et al*. 2009a. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. Trends in Ecology and Evolution 24: 241-249.

Chapin, F.S. III, Kofinas, G.P. & Folke, C. (eds.) 2009b. Principles of Ecosystem Stewardship Springer, New York.

Christie, P. & Sommerkorn, M. 2012. RaCeR: Rapid assessment of circum-arctic ecosystem resilience, 2nd ed. WWF Global Arctic Programme, Ottawa.

Crawford, R.M.M. (ed.) 1997. Disturbance and Recovery in Arctic Lands: An Ecological Perspective. Kluwer Academic, Dordrecht.

Culp, J.M., Lento, J., Goedkoop, W., Power, M., Rautio, M., Christoffersen, K.S. et al. 2012. Developing a circumpolar monitoring framework for Arctic freshwater biodiversity. Biodiversity 13: 215-227.

Danielsen, F., Burgess, N.D. & Balmford, A. 2005. Monitoring matters: examining the potential of locally-based approaches. Biodiv. Conserv. 14: 2507-2542.

Danielsen, F., Mendoza, M.M., Tagtag, A., Alviola, P.A., Balete, D.S., Jensen, A.E. *et al*. 2007. Increasing conservation management action by involving local people in natural resource monitoring. Ambio 36: 566-570.

Danielsen, F., Burgess, N.D., Balmford, A., Donald, P.F., Funder, M., Jones, J.P.G. *et al.* 2009. Local participation in natural resource monitoring: a characterization of approaches. Conserv. Biol. 23: 31–42.

Danielsen, F., Burgess, N.D., Jensen, P.M. & Pirhofer-Walzl, K. 2010. Environmental monitoring: the scale and speed of implementation varies according to the degree of peoples involvement. J. Appl. Ecol. 47: 1166-1168.

Danielsen, F., Topp-Jørgensen, E., Levermann, N., Løvstrøm, P., Schiøtz, M., Enghoff, M. *et al.* in press. Counting what counts: using local knowledge to improve Arctic resource management. Polar Geography.

Department of Fisheries, Hunting and Agriculture 2011. dk.nanoq.gl/Emner/Erhverv/Erhvervsomraader/Fangst_og_Jagt/Jagttider.aspx [accessed 20 January 2012]

DFO 2008. Canada/Greenland Joint Commission on Narwhal and Belugas. www.dfo-mpo.gc.ca/CSAS/Csas/Publications/SAR-AS/2008/SAR-AS2008_035_E.pdf [accessed 14 June 2011]

Dowsley, M. 2010. The value of a polar bear: evaluating the role of a multiple-use resource in the Nunavut mixed economy. Arctic Anthropology 47: 39-56.

Dudley, N. (ed.) 2008. Guidelines for Applying Protected Area Management Categories. IUCN, Gland.

Eamer, J. 2006. Keep it simple and be relevant: the first nine years of the Arctic Borderlands Ecological Knowledge Co-op. In: W.V. Reid, F. Berkes, T. Wilbanks & D. Capistrano (eds.). Bridging Scales and Knowledge Systems, pp 185-206. Island Press, Washington DC.

Euskirchen, E.S., McGuire, A.D. & Chapin, F.S. III 2007. Energy feedbacks of northern high-latitude ecosystems to the climate system due to reduced snow cover during 20th century warming. Global Change Biology 13: 2425-2438

Euskirchen, E.S., McGuire, A.D., Chapin, F.S. III, Yi, S. & Thompson, C.C. 2009. Changes in plant communities in northern Alaska under scenarios of climate change 2003-2100:

Implications for climate feedbacks. *Ecological Applications* **19**: 1022-1043.
Euskirchen, E.S., McGuire, A.D., Chapin, F.S. III & Rupp, T.S. 2010. The changing effects of Alaska boreal forests on the climate system. Canadian Journal of Forest Research 40: 1336-1346.
Ferguson, M.A.D., Williamson, R.G. & Messier, F. 1998. Inuit Knowledge of Long-term Changes in a Population of Arctic Tundra Caribou. Arctic 51: 201-219.
Forbes, B.C. 1995. Tundra disturbance studies. III. Short-term effects of aeolian sand and dust, Yamal Region, northwest Siberia, Russia. Environmental Conservation 22: 335-344.
Forbes, B.C. 1997. Tundra disturbance studies. IV. Species establishment on anthropogenic primary surfaces, Yamal Peninsula, Northwest Siberia, Russia. Polar Geography 21: 79-100.
Forbes, B.C. & Kumpula, T. 2009. The ecological role and geography of reindeer (Rangifer tarandus) in northern Eurasia. Geography Compass 3/4: 1356-1380.
Forbes, B.C. & McKendrick, J.D. 2002. Polar tundra. In: M. Perrow & A.J. Davy (eds.). Handbook of Ecological Restoration, Vol. 2: Restoration in Practice, pp 355-375. Cambridge University Press, Cambridge.
Forbes, B.C., Ebersole, J.J. & Strandberg, B. 2001. Anthropogenic disturbance and patch dynamics in circumpolar arctic ecosystems. Conservation Biology 15: 954-969.
Forbes, B.C., Stammler, F., Kumpula, T., Meschtyb, N., Pajunen, A. & Kaarlejärvi, E. 2009. High resilience in the Yamal-Nenets social-ecological system, West Siberian Arctic, Russia. Proceedings of the National Academy of Sciences 106: 22041-22048.
Forbes, B.C., Macias-Fauria, M. & Zetterberg, P. 2010. Russian Arctic warming and 'greening' are closely tracked by tundra shrub willows. Global Change Biology 16: 1542-1554.
Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D.W. *et al*. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. IPCC Fourth Assessment Report WG1. Cambridge University Press, Cambridge.
Gilders, M.A. & Cronin, M.A. 2000. North Slope oil field development. In: J.C. Truett & S.R. Johnson (eds.). The Natural History of an Arctic Oil Field – Development and the Biota, pp 15-33. Academic Press, San Diego.
Gill, M., Crane, K., Hindrum, R., Arneberg, P., Bysveen, I., Denisenko, N.V. *et al*. 2011. Arctic Marine Biodiversity Monitoring Plan (CBMP-MARINE PLAN), CAFF Monitoring Series Report No. 3, April 2011, CAFF International Secretariat, Akureyri, Iceland.
Gofman, V. 2010. Community based monitoring handbook: lessons from the Arctic. CAFF CBMP Report No. 21. CAFF, Akureyri.
Gofman, V. & Smith, M. 2009. Bering Sub-Sea Network Pilot Phase Final Report. CAFF Monitoring Series Report No. 2. CAFF, Akureyri.
Goldenberg, S. 2011. BP's Gulf of Mexico oil spill was 'caused by cost-cutting'. The Guardian Weekly 14 January 2011, p 17.
Graham, B. & Reilly, W.K. 2011. Deepwater: The Gulf Oil Disaster and the Future of Offshore Drilling. Report to the President. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Washington.
Greenland Government 1996. Landstingslov nr. 18 af 31. oktober 1996 om fiskeri. www.lovgivning.gl/gh.gl-love/dk/1996/Ltl/ltl_nr_18-1996_dk.htm [accessed 20 January 2012]
Greenland Government 1999. Landstingslov nr. 12 af 29. oktober 1999 om fangst og jagt, §2 stk. 3. dk.nanoq.gl [accessed 20 February 2012]
Haaland, H., Skogen, K., Landa, A., Loeks, D., Andersen, O., Aastrup, P. *et al*. 2005. Uddelegering af forvaltningsansvar – levende ressourcer i Grønland. NINA Rapport 6.
Harremoës, P., Gee, D., MacGarvin, M., Stirling, A., Keys, J., Wynne, B. *et al.* (eds.) 2001. Late Lessons from Early Warnings: The Precautionary Principle 1896-2000. Environmental Issue Report 22. European Environment Agency, Copenhagen.
Haskell, S.P., Nielson, R.M., Ballard, W.B., Cronin, M.A. & McDonald, T.L. 2006. Dynamic responses of calving caribou to oilfields in northern Alaska. Arctic 59: 179-190.
Heiskanen, J., Nilsson, B., Mäki, A-H., Allard, A., Moen, J., Holm, S. *et al*. 2008. Aerial photo interpretation for change detection of treeline ecotones in the Swedish mountains. www.resgeom.slu.se/resana/NILS/Publikationer/arb_rapp_242.pdf [accessed 15 June 2011]
Helldin, J.O., Jung, J., Neumann, W., Olsson, M., Skarin, A. & Widemo, F. 2012. The impacts of wind power on terrestrial mammals: a synthesis. Report 6510. Swedish Environmental Protection Agency, Stockholm.
Henry, G. & Elmendorf, S. 2010. Greening of the Arctic. In: CAFF. Arctic Biodiversity Trends 2010: Selected Indicators of Change, pp 62-64. CAFF International Secretariat, Akureyri.
Hinzman, L.D., Bettez, N.D., Bolton, W.R., Chapin, F.S., Dyurgerov, M.B., Fastie, C.L. *et al.* 2005. Evidence and implications of recent climate change in Northern Alaska and other Arctic regions. Clim. Change 72: 251-298.
Hu, F.S., Higuera, P.E., Walsh, J.E., Chapman, W.L., Duffy, P.A., Brubaker, L.B. & Chipman, M.L. 2010. Tundra burning in Alaska: Linkages to climatic changes and sea ice retreat. Journal of Geophysical Research 115: 1-8.
Hummel, M. & Ray, J. 2008. Caribou and the North: A Shared Future. Dundurn Press, Toronto.
Huntington, H. 2008. A Strategy for Facilitating and Promoting Community-Based Monitoring Approaches in Arctic Biodiversity Monitoring. CAFF CBMP Report No. 13.
Huntington, H.P. 2011. Arctic science – the local perspective. Nature 478: 182-183.
Huntington, H. & Fox, S. 2005. The changing Arctic: indigenous perspectives. In: ACIA. Arctic Climate Impact Assessment, pp 61-98. Cambridge University Press, Cambridge.
Huntington, H., Callaghan, T., Fox, S. & Krupnik, I. 2004. Matching traditional and scientific observations to detect environmental change: A discussion on Arctic terrestrial ecosystems. Ambio 13: 18-23.
Jernelöv, A. 2010. How to defend against future oil spills. Nature 466: 182-183.
John, E. & Turkington, R. 1997. A 5-year study of the effects of nutrient availability and herbivory on two boreal forest herbs. Journal of Ecology 85: 419-430.
Jokinen, M. (ed.) 2005. Poronhoidon ja suojelun vaikutukset Mallan luonnonpuistossa. Metsäntutkimuslaitoksen tiedonantoja [Finnish Forest Research Institute Research Papers] 941.
Jones, J.P.G., Andriamarovolona, M.M., Hockley, N.J., Gibbons, J.M. & Milner-Gulland, E.J. 2008. Testing the use of interviews as a tool for monitoring trends in the harvesting of wild species. J. Appl. Ecol. 45: 1205-1212.
Jorgenson, M.T., Racine, C.H., Walters, J.C. & Osterkamp, T.E. 2001. Permafrost degradation and ecological changes associated with a warming climate in central Alaska. Climate Change 48: 551-579.
Kevan, P.G., Forbes, B.C., Kevan, S.M. & Behan-Pelletier, V.M. 1995. Vehicle tracks on high Arctic tundra: their effects on the soil, vegetation, and soil arthropods. Journal of Applied Ecology 32: 655-667.
Key, S.L. & Stohl, A. 2007. Arctic air pollution: Origins and impacts. Science 315: 1537-1540.
Khitun, O. 1997. Self-recovery after technogenic and natural disturbances in the central part of the Yamal Peninsula (Western Siberian Arctic). In: R.M.M. Crawford (ed.). Disturbance and Recovery in Arctic Lands: An Ecological Perspective, pp 531-562. Kluwer, Dordrecht.
Khitun, O. & Rebristaya, O. 2002. Anthropogenic impacts on habitat structure and species richness in the West Siberian Arctic. In: A.E. Watson, L. Alessa & J. Sproull (eds.). Wilderness in the Circumpolar North, pp 85-95. USDA-FS, Rocky Mountain Research Station, Ogden.
Kumpula, T., Pajunen, A., Kaarlejärvi, E.M., Forbes, B.C. & Stammler, F. 2011. Land use and land cover change in arctic Russia: ecological and social implications of industrial development. Global Environmental Change 21: 550-562.

Kumpula, T., Forbes, B.C., Stammler, F. & Meschtyb, N. 2012. Dynamics of a coupled system: multi-resolution remote sensing in assessing social-ecological responses during 25 years of gas field development in Arctic Russia. Remote Sens. 4: 1046-1068.

Laidler, G.J. 2006. Inuit and scientific perspectives on the relationship between sea ice and climate change: the ideal complement? Climate Change 78: 407-444.

Larsen T. & Stirling, I. 2009. The Agreement on the Conservation of Polar Bears – its History and Future. Rapportserie Nr. 127, Norsk Polarinstitutt, Tromsø.

Larsen, T.S., Kurvits, T. & Kuznetsov, E. 2011. Lessons learned from ECORA – An integrated ecosystem management approach to conserve biodiversity and minimize habitat fragmentation in the Russian Arctic. CAFF Strategy Series Report No. 4.

Lassuy, D. & Lewis, P.N. 2010. Invasive species (human-induced). In: CAFF. Arctic Biodiversity Trends 2010: Selected Indicators of Change. CAFF International Secretariat, Akureyri.

Lawrence, D.M., Slater, A.G., Tomas, R.A., Holland, M.M. & Deser, C. 2008. Accelerated Arctic land warming and permafrost degradation during rapid sea ice loss. Geophysical Research Letters 35: L11506

Lemieux, C.J. & Scott, D.J. 2005. Climate change, biodiversity conservation and protected area planning in Canada. Canadian Geographer 49: 384-399.

Light, B., Grenfell, T.C. & Perovich, D.K. 2008. Transmission and absorption of solar radiation by Arctic sea ice during the melt season. Journal of Geophysical Research 113: 1-19.

Livingston, D. 2011. Circumpolar Protected Areas Monitoring. Arctic Protected Areas Monitoring Scheme Background Paper. CAFF International Secretariat, CAFF Monitoring Series Report Nr. 5.

Lloyd, A.H., Rupp, T.S., Fastie, C.L. & Starfield, A.M. 2003. Patterns and dynamics of treeline advance on the Seward Peninsula, Alaska. Journal of Geophysical Research 108: 1-15.

Luzar, J.B., Silvius, K.M., Overman, H., Giery, S.T., Read, J.M. & Fragoso, J.M.V. 2011. Large-scale environmental monitoring by indigenous people. BioScience 61: 771-781.

Macias-Fauria, M., Forbes, B.C., Zetterberg, P. & Kumpula, T. 2012. Eurasian Arctic greening reveals teleconnections and the potential for structurally novel ecosystems. Nature Climate Change 2: 613-618.

Margesin, R. & Schinner, F. 1999. Biotechnological Applications of Cold-Adapted Organisms. Springer-Verlag, Heidelberg.

McGuire, A.D., Chapin, F.S. III, Walsh, J.E. & Wirth, C. 2006. Integrated regional changes in Arctic climate feedbacks: Implications for the global climate system. Annual Review of Environmental Resources 31: 61-91.

McGuire, A.D., Anderson, L.G., Christensen, T.R., Dallimore, S., Guo, L., Hayes, D.J. *et al*. 2009. Sensitivity of the carbon cycle in the Arctic to climate change. Ecological Monographs 79: 523-555.

McGuire, A.D., Chapin, F.S. III & Ruess, R.W. (eds.) 2010. Dynamics of change in Alaska's boreal forests: resilience and vulnerability in response to climate warming. Can. J. For. Res. 40(7).

Meek, C.L. 2011. Putting the US polar bear debate into context: the disconnect between old policy and new problems. Journal of Marine Policy 35: 430-439.

Meltofte, H., Piersma, T., Boyd, H., McCaffery, B., Ganter, B., Golovnyuk, V.V. *et al.* 2007: Effects of climate variation on the breeding ecology of Arctic shorebirds. – Meddr. Grønland, Biosci. 59: 1-48.

Merkel, F. 2010. Evidence of recent population recovery in common eiders breeding in Western Greenland. Journal of Wildlife Management 74: 1869-1874.

Meschtyb, N.A. 2008. Aleuts. In: L. Sillanpää (ed.). Awakening Siberia – From Marginalization to Self-Determination: the Small Indigenous Nations of Northern Russia on the Eve of the Millennium. Acta Politica No. 33. Department of Political Science, University of Helsinki, Helsinki.

Moller, H., Berkes, F., Lyver, P.O. & Kislaioglu, M. 2004. Combining science and traditional ecological knowledge: monitoring populations for co-management. Ecology and Society 9(3), article no. 2.

Mustonen, T. 2009. Karhun väen ajast-aikojen avartuva avara. Tutkimus kolmen euraasialaisen luontaistalousyhteisön paikallisesta tiedosta pohjoisen ilmastonmuutoksen kehyksessä. University of Joensuu.

Mustonen, T. 2012. Metsäveri – Aslak Ola Aikion elämää ja tarinoita. Snowchange Cooperative.

Myers-Smith, I.H., Arnesen, B.K., Thompson, R.M. & Chapin, F.S. III. 2006. Cumulative impacts on Alaskan Arctic tundra of a quarter century of road dust. Écoscience 13: 503-510.

Myhre, G. 2009. Consistency between satellite-derived and modeled estimates of the direct aerosol effect. Science 325: 187-190.

National Research Council 2003. Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope. National Academies Press, Washington.

Nellemann, C. Kullerud, L., Vistnes, I., Forbes, B.C., Husby, E., Kofinas, G.P. *et al*. 2001. GLOBIO Global methodology for mapping human impacts on the biosphere: the Arctic 2050 scenario and global application. UNEP/DEWA Technical Report 3. United Nations Environment Programme, Nairobi.

Nielsen, M.R. 2009. Is climate change causing the increasing narwhal (*Monodon monoceros*) catches in Smith Sound, Greenland? Polar Research 28: 238-245.

Novikova, N.I. 2008. Eskimos. In: L. Sillanpää (ed.). Awakening Siberia – From Marginalization to Self-Determination: the Small Indigenous Nations of Northern Russia on the Eve of the Millennium. Acta Politica No. 33. Department of Political Science, University of Helsinki.

NSIDC (National Snow and Ice Data Center) 2010. nsidc.org [accessed 12 January 2010]

NY Times 2011a. Failure in the Gulf. New York Times 7 January 2011: A22.

NY Times 2011b. The verdict on the spill. New York Times 11 January 2011: A22.

Olofsson, J., Oksanen, L., Callaghan, T., Hulme, P.E., Oksanen, T. & Suominen, O. 2009. Herbivores inhibit climate-driven shrub expansion on the tundra. Global Change Biology 15: 2681-2693.

Oozeva, C., Noongwook, C., Noongwook, G., Alowa, C. & Krupnik, I. 2004. Watching ice and weather our way. Arctic Studies Center, Smithsonian Institution, Washington, DC.

Pedersen, C.A., Roeckner, E., Lüthje, M. & Winther, J.-G. 2009. A new sea ice albedo scheme including melt ponds for ECHAM5 general circulation model. J. Geophys. Res. 114, D08101.

Perovich, D., Meier, W., Tschudi, M., Gerland, S. & Richter-Menge, J. 2012. Arctic report card: update for 2012: sea ice. www.arctic.noaa.gov/reportcard/sea_ice.html [accessed 7 December 2012]

Post, E. & Pedersen, C. 2008. Opposing plant community responses to warming with and without herbivores. PNAS 105: 12353-12358.

Pulsifer, P.L., Laidler, G.J., Taylor, D.R.F. & Hayes, A. 2010. Towards an Indigenist data management program: reflections on experiences developing an atlas of sea ice knowledge and use. Can. Geog. 55: 108-124.

Pulsifer, P., Gearheard, S., Huntington, H.P., Parsons, M.A., McNeave, C. & McCann, H.S. 2012. The role of data management in engaging communities in Arctic research: overview of the Exchange for Local Observations and Knowledge of the Arctic (ELOKA). Polar Geography 35: 271-290.

Rasmussen, R.O, & Koroleva, N.E. (eds.) 2003. Social and Environmental Impacts in the North. Kluwer, Dordrecht.

Raundrup, K., Levermann, N. & Poulsen, M. 2012. Overlap in diet and distribution of two goose species suggests potential for competition at a common moulting area in West Greenland. Dansk. Orn. Foren. Tidsskr. 106: 93-100.

Regehr, E.V., Lunn, N.J., Amstrup, S.C. & Stirling, I. 2007. Effects of earlier sea ice breakup on survival and population size of polar bears in Western Hudson Bay Journal of Wildlife Management 71: 2673-2683.

Regehr, E.V., Hunter, C.M., Caswell, H., Amstrup, S.C. & Stirling, I. 2010. Survival and breeding of polar bears in the Southern Beaufort Sea in relation to sea ice. Journal of Animal Ecology 79: 117-127.

Riordan, B., Verbyla, D. & McGuire, A.D. 2006. Shrinking ponds in subarctic Alaska based on 1950-2002 remotely sensed images. J. Geophys. Res. 111: 1-11.

Rist, J., Milner-Gulland, E.J., Cowlishaw, G. & Rowcliffe, M. 2010. Hunter Reporting of Catch Per Unit Effort as a Monitoring Tool in a Bushmeat-Harvesting System. Conserv. Biol. 24: 489-499.

Root, T. & Alpert, P. 1994. Volunteers and the NBS. Science 263: 1205.

Rouse, W.R., Oswald, C.J., Binyamin, J., Spence, C., Schertzer, W.M., Blanken, P.D. *et al*. 2005. The role of northern lakes in a regional energy balance. J. Hydrometeorology 6: 291-305.

Russell, D.E., Svoboda, M., Arokium, J. & Cooley, D. 2013. Arctic Borderlands Ecological Knowledge Cooperative: can local knowledge inform caribou management? Rangifer 33(21): 71-78.

Schuur, E.A.G, Bockheim, J., Canadell, J., Euskirchen, E.S., Field, C., Goryachkin, S. *et al*. 2008. The vulnerability of permafrost carbon to climate change: implications for the global carbon cycle. Bioscience 58: 701-714.

Scott, D.A. 1998. Global Overview of the Conservation of Arctic Migratory Breeding Birds outside the Arctic – 1998. Wetlands International Publication No. 45. CAFF Technical Report No. 4. CAFF, Akureyri.

Shindell, D. & Faluvegi, G. 2009 Climate response to regional radiative forcing during the twentieth century. Nature Geoscience 2: 294-300.

Smith, L.C., Sheng, Y., MacDonald, G.M. & Hinzman, L.D. 2005. Disappearing arctic lakes. Science 308: 1429.

Stammler, F. & Forbes, B.C. 2006. Oil and gas development in the Russian Arctic: West Siberia and Timan-Pechora. IWGIA Newsletter Indigenous Affairs, Arctic Oil and Gas Development 2-3/06: 48-57.

Stroeve, J., Holland, M.M., Meier, W., Scambos, T. & Serreze, M. 2007. Arctic sea ice decline: Faster than forecast. Geophysical Research Letters 34: 1-5.

Sturm, M., Racine, C.R. & Tape, K. 2001. Increasing shrub abundance in the Arctic, Nature 411: 546-547.

Sturm, M., Douglas, T., Racine, C. & Liston, G.E. 2005. Changing snow and shrub conditions affect albedo with global implications. Journal of Geophysical Research 110, G01004.

Tarnocai, C., Canadell, J.C., Schuur, E.A.G., Kuhry, P., Mazhitova, G. & Zimov, S. 2009. Soil organic carbon pools in the northern circumpolar permafrost region. Global Biogeochemical Cycles 23: 1-11.

van der Velden, M. 2010. Design for the contact zone. In: F. Sudweeks, H. Hrachovec & C. Ess (eds.) Proceedings Cultural Attitudes Towards Communications and Technology 2010, pp 1-18. Murdoch University, Australia.

Vistnes, I. & Nellemann, C. 2008. The matter of spatial and temporal scales: a review of reindeer and caribou response to human activity. Polar Biology 31: 399-407.

VNIPIGazdovycha 2005. Baseline for Investments in the Development of Bovanenkovo Deposit on the Yamal Peninsula and Gas Transport, Vols. 3 and 7 (in Russian). VNIPIGazdovycha, Saratov and VNIIGaz, Moscow.

Vongraven, D., Aars, J., Amstrup, S., Atkinson, S., Belikov, S., Born, E. *et al*. 2012. A circumpolar monitoring plan for polar bears. Ursus 23(2):1-66.

Walker, D.A. 1996. Disturbance and recovery of arctic Alaskan vegetation. Ecological Studies 120: 35-71.

Walter, K.M., Smith, L.C. & Chapin, F.S. III. 2007. Methane bubbling from northern lakes: present and future contributions to the global methane budget. Philos. Trans. Royal Society 365: 1657-1676.

Wang, M. & Overland, J. 2009. A sea ice free summer Arctic within 30 years? Geophys. Res. Lett. 36: L07502.

Weatherhead, E., Gearheard, S. & Barry, R.G. 2010. Changes in weather persistence: Insight from Inuit knowledge. Global Environ. Change 20: 523-528.

Wiig, Ø., Aars, J. & Born, E.W. 2008. Effects of climate change on polar bears. ScienceProgress 91: 151-173.

Wild, R. & McLeod, C. (eds.) 2008. Sacred Natural Sites: Guidelines for Protected Area Managers. IUCN, Gland.

Yoccoz, N.G., Nichols, J.D. & Boulinier, T. 2001. Monitoring of biological diversity in space and time. Trends Ecol. Evol. 16: 446-453.

Zhang, T., Frauenfeld, O.W., Serreze, M.C., Etringer, A., Oelke, C., McCreight, J. *et al*. 2005. Spatial and temporal variability in active layer thickness over the Russian Arctic drainage basin. Journal of Geophysical Research 110, D16101.

Zhuang, Q., Melillo, J.M., Sarofim, M.C., Kicklighter, D.W., McGuire, A., Felzer, B.S. *et al*. 2006. CO_2 and CH_4 exchanges between land ecosystems and the atmosphere in northern high latitudes over the 21st century. Geophysical Research Letters 33: L17403.

Zöckler, C., Hla, T.H., Clark, N. & Morozov, V. 2010. Spoon-billed Sandpiper. Recovery Team News Bulletin No 4 (May). www.shorebird-network.net/PDFs/Sbs-news-bulletin-May-2010.pdf [accessed 15 June 2011]