Rediscovering and resampling historic research sites and information to extend the time series of environmental observations in the Arctic

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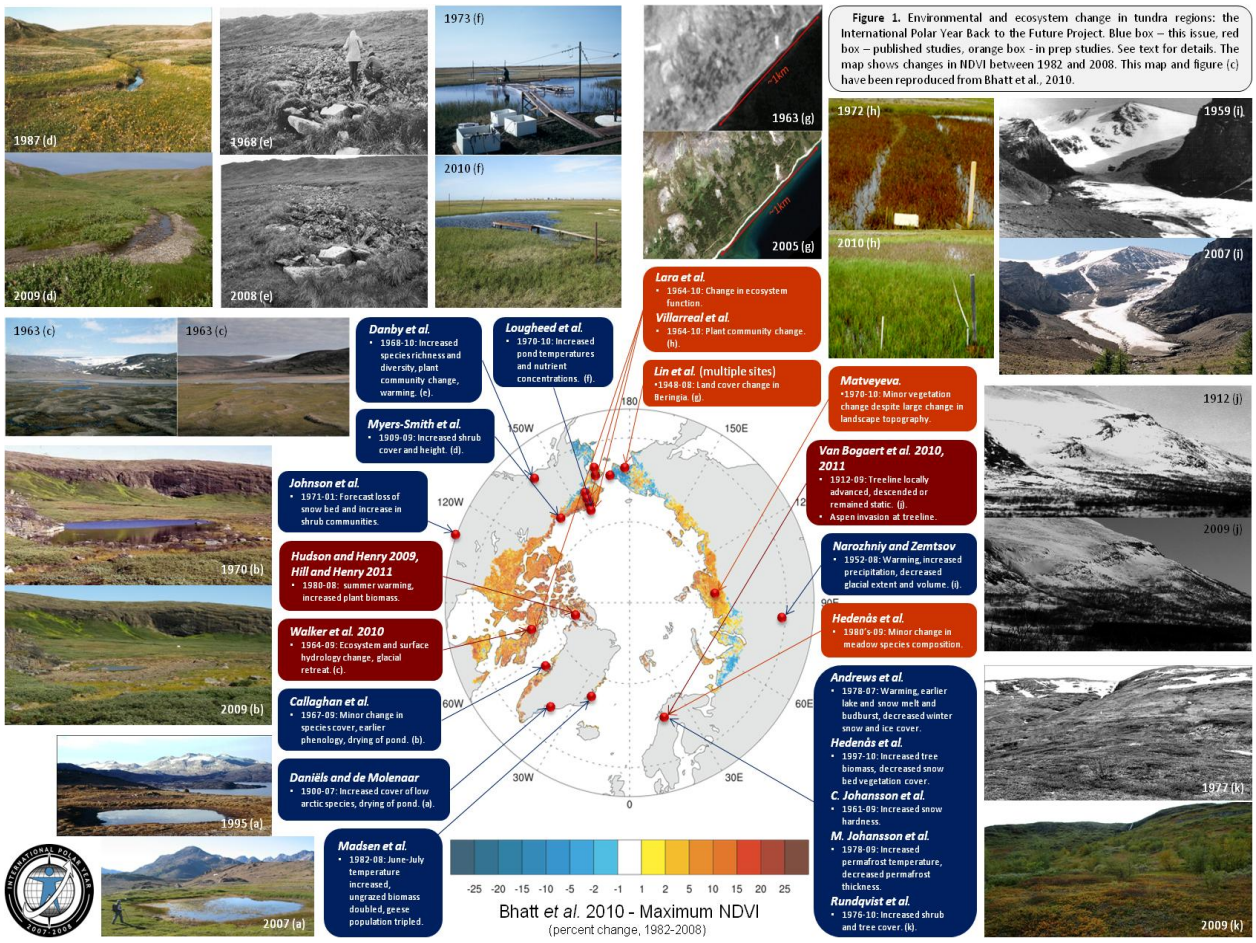
An overarching goal of the Sustained Arctic Observing Network (SAON) is to extend time series observations of biophysical properties and processes. Such observations are required for analyses that help tease apart spatiotemporally heterogeneous and interactive drivers of change (Callaghan et al. 2010, Callaghan et al. in press); determine trajectories of environmental change (Johnson et al. 2011); assess species and plant community change (Hedenås et al. 2012, Van Bogaert et al. 2011, 2010, Villarreal et al. 2012); validate models and remotely sensed observations (Lara et al. 2012, Zhenlin et al. 2012a,b); verify the integrity of experimental manipulations (Elmendorf et al. 2012); assess the impact of extreme events relative to long term change (Van Bogaert et al. 2009, Villarreal et al. 2012); allow for inter-comparison of science and TEK/LEK-derived observations (Riseth et al. 2010); and examine the impact of changes in policy and management (NRC 2006). For the majority of the Arctic, such time series observations are lacking (ISAC 2010), spatiotemporal variability of observations is substantial (Callaghan et al. 2011a, Zhenlin et al. 2011), and in many situations a great deal of uncertainty surrounds future system states forecast from models (McGuire et al. 2012). Hence there is a need for SAON to improve and extend time series observations of biophysical and societal properties and processes.

In many instances, knowledge of decadal time scale change is best sought by rescuing historic data or other information, rediscovering and securing sampling locations associated with these data, and resampling (Callaghan et al. 2011b). During the 2007-09 International Polar Year (IPY), a collaboration of international researchers affiliated with the *Back to the future Project* (IPY project #512) rescued historical data and sites and resampled many of these to assess decadal time scale change in a range of environmental phenomenon and processes (Callaghan et al. 2011a). This project was highly productive and many of the BTF studies demonstrate a propensity for the BTF-approach to enhance the development of SAON (*see* Callaghan et al. 2011b). Here, we briefly highlight several poignant characteristics resulting from BTF activities that we believe are essential for further developing and implementing SAON:

1. The BTF approach can be applied to multiple disciplines and different types of data (*see* Fig. 1 from Callaghan et al. 2011b below).
2. BTF activities principally require site and/or data/information rescue. Historic sites in many instances remain intact and suitable for extant SAON activities. When archived, data extend time series observations and complement recent observational time series (e.g. Elmendorf et al. 2012) and model output (Zhenlin et al 2012a).
3. For some studies, new hypotheses of past and future environmental change have been formulated (e.g. Johnson et al. 2011; Lin et al. 2012) and have been shown to be testable with ongoing monitoring (Ebert-May et al. in prep.).
4. Some IPY-BTF studies showed substantial change (e.g. Villarreal et al. 2012) whereas others showed little change (Callaghan et al. 2011b). Thus improved knowledge of the spatiotemporal variability of change was documented by BTF and some patterns of change contrast with other published work, which appears to in be partially biased towards reporting studies that documented change only.

5. Many of the BTF studies to date have been generated from resampling sites initiated by large international collaborative efforts such as the International Biological Program (e.g. Johnson et al. 2011, Lara et al. 2012, Villarreal et al. 2012). With more sites from such programs yet to be rescued and resamped, there is potential to embrace legacies of international collaboration within BTF.
6. Many of the products derived from BTF studies are highly visual and tractable by the general public (e.g. repeat photographs). They are also poignant because they typically demonstrate change within the career/ life time of a single investigator.
7. The majority of IPY-BTF studies were relatively low cost and value-adding – in most cases, extant funding during the IPY supported the acquisition of only half the data – the historic data had already been collected but its value in all cases has been deepened through the resampling effort.
8. IPY-BTF typically required students to work with both middle-aged faculty and senior (sometimes retired) scientists, and thus provided greater than average cross-generational exchange of information and knowledge and life experience. IPY-BTF not only stimulated the career development of young researchers, it has stimulated the revisitation of established and in some cases unreported ideas, and the rekindling of new and old international collaborations and research activities.
9. Finally, there is a great need of urgency for BTF studies. Senior researchers are retiring and ageing and historic data and other information is being lost with them. If we do not act now, much of the original and arguably most valuable historical data collected in the arctic will be lost over the coming decade.



A second phase of BTF-related studies (BTF2) is currently under development and is being coordinated through the EU-funded project INTERACT (www.eu-interact.org). BTF2 will be strongly engaging of the Association of Early Polar Career Scientists (APECS) and focus on coupling junior and senior scientists. Endorsement for this initiative has been received from the Circumarctic Biodiversity Monitoring Program (CBMP) and also the International Arctic Science Committee (IASC). Although BTF2 will largely be focused at arctic and alpine terrestrial field stations (particularly in Russia), broader participation is welcome.

References:

Callaghan, T. V., Jonasson, C., Thierfelder, T., Zhenlin, Y., Hedenås, H., Johansson, M., Molau, U. , Van Bogaert, R., Michelsen, A., Olofsson, J., Gwynn-Jones, D., Bokhorst, S., Phoenix, G., Bjerke, J. W. Tømmervik, H., Christensen, T. R. Hanna, E., Koller, E. K., Sloan, V. L. In Press. Ecosystem change and stability over multiple decades in the Swedish sub-Arctic: complex processes and multiple drivers. Phil. Trans. R. Soc. B.

Callaghan, T.V., Tweedie, C. E., Webber, P. 2011a. Multi-decadal changes in tundra environments and ecosystems: the International Polar Year-Back to the Future Project (IPY-BTF). *Ambio, 40*(6), 555-557.

Callaghan, T.V., & 52 other authors. 2011b. Accepted-a Multi-decadal changes in tundra environments and ecosystems: synthesis of the International Polar Year – Back to the Future Project (IPY-BTF). *Ambio, 40*(6), 705-716.

Callaghan, T. V, Bergholm, F,. Christensen, T. R,. Jonasson, C, . Kokfelt, U. and M. Johansson. 2010. A new climate era in the sub-Arctic: Accelerating climate changes and multiple impacts Geophys. Res. Lett., 37, L14705, doi:10.1029/2009GL042064

Ebert-May, D., Johnson, D., Webber, P.J., Tweedie, C. E. In Preparation. Plant community change over four decades at Niwot Ridge, Colorado. *Journal of Ecology*.

Elmendorf, S. & 57 other authors. 2012. Plot-scale evidence of tundra vegetation change and links to recent summer warming. *Nature Climate Change*. DOI: 10.1038/NCLIMATE1465.

Hedenås, H., Carlsson, B.Å., Emanuelsson, U., Jonasson, C., Svensson, B.M., Headley, A. & Callaghan, T. V. 2012 Changes and homeostasis in alpine and sub-alpine vegetation over three decades in the sub-Arctic' perspective Ambio 41, 187-196.

ISAC. 2010. http://www.arcticchange.org/storage/ISAC%20Science%20Plan%20Final%20Publication.pdf

Johnson, D., Ebert-May, D., Webber, P., Tweedie, C. E. 2011. Forecasting alpine vegetation change using repeat sampling and a novel modeling approach. *Ambio, 40*, 693-704.

Lara, M., Villarreal, S., Johnson, D., Hollister, R., Webber, P., Tweedie, C. E. 2012. Estimated change in tundra ecosystem function near Barrow, Alaska between 1972 and 2010. *Environmental Research Letters, 7*, 10pp.

Lin, D., Johnson, D., Andresen, C., Tweedie, C. E. 2012. High spatial resolution decade-time scale land cover change at multiple locations in the Beringian Arctic (1948–2000s). *Environmental Research Letters, 7*, 14pp.

McGuire, A.D., Christensen, T. R., Hayes, D., Heroult, A., Euskirchen, E., Yi,Y., Kimball, J.S., Koven, C., Lafleur, P., Miller, P.A., Oechel, W., Peylin, P., and Williams,M.: An assessment of the carbon balance of arctic tundra: comparisons among observations, process models, and atmospheric inversions, Biogeosciences Discuss., 9, 4543-4594, doi:10.5194/bgd-9-4543-2012, 2012.

NRC. 2006. *Toward an Integrated Arctic Observing Network*. The National Academy Press, Washington D.C. Pp115.

Riseth, J.Å., Tømmervik, H., Helander-Renvall, E., Pohjola, V., Labba, N.T., Labba, N., Niia, E.A., Kuhmunen, H., Schanche, A., Jonasson, C., Johansson, C., Sarri, L-E., Bjerke, J.W., Malnes, E. and Callaghan, T.V submitted (2010) "Snow and Ice" Sami TEK and Science in concert for understanding climate change effects on reindeer pasturing. Polar Record. 47,202-217.

Van Bogaert, R., Haneca, K., Hoogesteger, J., Jonasson,C., De Dapper, M. and T.V. Callaghan. 2011. A century of tree line changes in sub-Arctic Sweden show local and regional variability and only a minor role of 20th Century climate warming. Journal of Biogeography, 38, 907-921

Van Bogaert R. , Jonasson C., De Dapper M. & T. V. Callaghan. 2010. Range expansion of thermophilic aspen (*Populus tremula* L.) in the Swedish Subarctic. Arctic, Antarctic and Alpine Research 42, 362-375.

Van Bogaert, R., Jonasson, C., De Dapper, M. & T. V. Callaghan. 2009. Competitive interaction between aspen and birch moderated by invertebrate and vertebrate herbivores and climate warming. Plant Ecology and Diversity vol 2 (3), 221 – 232.

Villarreal, S., Hollister, R., Johnson, D., Lara, M., Webber, P., Tweedie, C. E. 2012. High spatial resolution decade-time scale land cover change at multiple locations in the Beringian Arctic (1948–2000s). *Environmental Research Letters, 7*.

Zhenlin, Y., Hanna, E., Callaghan, T. V. & Jonasson, C. 2012a How can meteorological observations and microclimate simulations improve understanding of 1913–2010 climate change around Abisko, Swedish Lapland? Meteorological Applications, 19, 454-463.

Zhenlin, Y., Sykes, M.T., Hanna, E. and Callaghan, T. V. 2012b Linking fine scale sub-Arctic vegetation distribution in complex topography with surface-air-temperature modeled at 50 m resolution. Ambio 41, 292-302.

Zhenlin, Y., Hanna, E. and Callaghan, T.V. (2011). Modelling surface-air-temperature variation over complex terrain around Abisko, Swedish Lapland: uncertainties of measurements and models at different scales. *Geografiska Annaler: Series A, Physical Geography*, 93(2), 89-112. doi:10.1111/j.1468-0459.2011.00005.x