

Multi-decadal Changes in Tundra Environments and Ecosystems: The International Polar Year-Back to the Future Project (IPY-BTF)

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Abstract Polar and alpine environments are changing rapidly due to increases in temperature, which are amplified in the Arctic, as well as changes in many local factors. The impacts on ecosystems and their function have potential consequences for local residents and the global community. Tundra areas are vast and diverse, and the knowledge of geographical variation in environmental and ecosystem change is limited to relatively few locations, or to remote sensing approaches that are limited mostly to the past few decades. The International Polar Year, IPY, provided a context, stimulus and timely opportunities for re-visiting old research sites and data sets to collate data on past changes, to pass knowledge from old to new generations of researchers and to document environmental characteristics of sites to facilitate detection and attribution of future changes. Consequently, the project “Retrospective and Prospective Vegetation Change in the Polar Regions: Back to the Future,” BTF, was proposed and endorsed as an IPY activity (project #512). With national funding support, teams of researchers re-visited former sites and data sets throughout the Arctic and some alpine regions. These efforts have amounted to a gamut of “BTF” studies that are collectively geographically expansive and disciplinary diverse. A selection of these studies are introduced and presented in the current issue together with a brief synthesis of their findings.

Keywords IPY · Glaciers · Permafrost ·
Snow stratigraphy · Tundra vegetation · Limnology ·
Shrubs · Treeline · Goose grazing

INTRODUCTION

Polar and alpine environments are changing rapidly due to increases in temperature that are amplified in the Arctic

(Anisimov et al. 2007): glaciers are receding in general, permafrost is becoming warmer in most areas, snow cover and snow characteristics are changing (SWIPA 2011), and there are corresponding impacts on terrestrial and freshwater ecosystems (ACIA 2005; Post et al. 2009; Bhatt et al. 2010; SWIPA 2011). Changes in arctic and alpine ecosystems affect resources for local residents (provisioning ecosystem services) and land–atmosphere processes such as changes in surface energy balance and exchange of trace gases that have the potential to affect global climate (regulatory ecosystem services) (Chapin et al. 2005). Furthermore, changes in snow regime and glacier mass balance have the potential to affect the water resources of hundreds of millions of people.

Arctic and alpine tundra areas are vast and diverse, and the knowledge of geographical variation associated with recent environmental and ecosystem change is limited to relatively few locations, or to remote sensing approaches (e.g. Bhatt et al. 2010). Furthermore, environmental records in many of these areas are relatively short and insufficiently long to represent major fluctuations in climate during the warm and cool periods of the twentieth century. Where changes in ecosystems have been detected, attribution is often difficult because the primary drivers of change vary from site to site and even within a site (Van Bogaert et al. 2011), and/or capacities for ground-based validation of remote sensing products is severely limited. Although the explicit underlying driver for research into change is climate warming in cold regions (e.g. the International Polar Year, IPY, 2007–2008—Krupnik et al. 2011), there are currently many drivers of environmental and ecosystem change operating, particularly in the Arctic, e.g. UV-B radiation, long-range contaminants, habitat fragmentation and land use.

Between 1964 and 1974, a network of International Biological Programme (IBP) Tundra Biome sites was

established in both Polar Regions and in some temperate alpine locations (Bliss et al. 1981). Intensive investigations of primary production, production processes, decomposition, plant community structure, and soil fauna were carried out together with studies of freshwater ecosystems. These sites and many of the original researchers represent one example of a unique asset for detecting environmental change over a multi-decadal time scale that is under-represented in the current literature. Furthermore, the IBP and similar sites were established before climate change was accepted as a major issue, and the sites selected were therefore, independent of the possible bias of selecting sites that were experiencing change. Thus, they offer an important sampling framework to advance understanding of modern challenges such as the geographical variation associated with the “greening of the Arctic” (Bhatt et al. 2010).

The International Polar Year, IPY, provided a context, stimulus and timely opportunities for rescuing and collating data, documenting past changes and using the latter to forecast future change. Perhaps most importantly given the magnitude and global significance of change in the Arctic, the wealth of historic research activities that were initiated and/or pioneered by an ageing group of researchers, and the scant nature of sustained environmental monitoring in this region, the IPY presented a generationally unique opportunity for older researchers to pass knowledge, data, and site stewardship to a new generation of researchers. Consequently, the project “Retrospective and Prospective Vegetation Change in the Polar Regions: Back to the Future,” BTF, was proposed as an IPY activity and was endorsed as IPY Project number 512.

GOALS

The goals of the proposed IPY-BTF project were:

1. To assess multi-decadal past changes in the structure and function of polar terrestrial and freshwater ecosystems and environments in relation to diverse drivers of change
2. To assess the current status of polar ecosystems and their biodiversity
3. To permanently record precise locations of old sites in order to perpetuate platforms for (a) the assessment of future changes in polar ecosystems and their environments and (b) sampling for polar research and assessment programmes.

APPROACH

Initially, BTF was to focus on former International Biological Programme, IBP, sites in both Polar Regions that

were to be re-visited, documented, and located with survey-grade global positioning systems. IBP Tundra Biome alpine and temperate upland sites were to be included to give increased information and biogeographical context on the environmental controls of tundra ecosystem processes. The cold, temperate sites were considered particularly relevant as they represent analogues of future, warmer, polar sites. BTF also intended to include appropriate non-IBP polar and sub-polar sites. Investigations of primary production, production processes, decomposition, plant community structure, and soil fauna were to be repeated using the original techniques. Additional measurements (biological and non-biological) were to be made following meetings of the BTF group and representatives of linked projects (e.g. ITEX International Tundra Experiment—<http://www.geog.ubc.ca/itex/>, and the IPA (International Permafrost Association—<http://ipa.arcticportal.org/>) to maximise the field logistics and to ensure cross-disciplinary connections.

BTF intended to link to remote sensing projects that provide a larger geographical context (e.g. GOA—Greening of the Arctic—<http://www.geobotany.uaf.edu/goa/>) and provide baseline information on vegetation structure from space. The sites were also to provide validation for the modelling community. Other mechanisms for retrospective analysis of ecosystems (e.g. repeating photographic records from the late 1960's) and populations (e.g. retrospective growth analyses of plants) were also proposed, as were contributions to a range of synthesis efforts. The project was to be implemented by younger researchers interacting with older generations. Data and metadata were to be registered with recognized IPY Project Data Bases.

OUTCOMES

Many groups around the Arctic in particular contributed to the BTF project. Site and data re-sampling efforts were conducted in Alaska (multiple sites on the Seward Peninsula and North Slope), Canada (Baffin Island, Herschel Island, Southwest Yukon), Greenland (central mid-west, south-east, mid-east), Svalbard, Sweden (Abisko area), and Russia (Taymyr Peninsula). Some alpine sites were also included, such as Niwot Ridge, Colorado, and the Altai Mountains of Siberia. Within the project, the time horizon re-sampled varied from about 200 years (Van Bogaert et al. 2011) to 13 years (Hedenås et al. 2011 [this issue]), but most studies involved measurements over a period of about 40 years. Some studies have already been published (e.g. Van Bogaert et al. 2011), whereas others are in progress.

In the present issue, we gather studies that represent the BTF project's diversity of approaches used to assess environmental and ecosystem change (glaciers, snow

stratigraphy, permafrost temperature, limnology, vegetation structure, plant and animal species ranges and population processes, ecosystem function) and also the geographical spread of site and data resampling (Alaska, Canada, Greenland, Sweden, northern and southern Siberia, and the Rocky Mountains of Colorado, USA). We follow a sequence in the Special Issue to address multi-decadal abiotic changes and multi-decadal changes in mid- and high-Arctic and sub-arctic and alpine plant communities. We end with a brief synthesis of the BTF studies presented in this issue.

Acknowledgments This study is part of the IPY project 512, “Back to the Future” (<http://www.btf.utep.edu/>). We thank all the contributors to this issue and those that have published previously or are in the process of publishing—particularly the many graduate students who have contributed to and benefited from this project. The project would have been impossible without the formative studies of many researchers who established the IBP Tundra Biome project and other long-term studies exploited in the BTF study. The co-ordination of the project was financed by a grant from the Swedish Science Research Council (Vetenskapsrådet grant number 327-2007-833) to TVC and the US National Science Foundation (ANS-0732885, OPP-9906692) to CT. TVC also gratefully acknowledges support from the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas grants numbered 214-2008-188 and 214-2009-389). Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of NSF.

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