IPY: Greening of the Arctic (GOA): North American Arctic Transect (NAAT)

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A. PROJECT SUMMARY

The relevance to IPY: A primary objective of IPY and SEARCH is to characterize and model the circumpolar patterns of carbon, water and energy. The Greening of the Arctic (GOA) IPY initiative will determine the spatial and temporal variability of on-going large-scale changes in the abundance and distribution of plant biomass in the Arctic – a factor that directly or indirectly affects all three elements of the Arctic System. The initiative's central theme is to explore the potential linkages and feedbacks between changes in sea-ice distribution and the changes to tundra biomass. GOA consists of four separately funded projects that in total are addressing IPY themes 1 (Current State), 2 (Change), 3 (Teleconnections), 4 (New Frontiers), and 6 (Human Societies). The North American Arctic Transect portion of GOA is addressing themes 1, 2, and 4. ***Objectives:*** (1) *Create a legacy dataset of baseline information along the North American Arctic Transect (NAAT) that represents the full range of zonal vegetation types in the Arctic.* (2) *Coordinate the science and data management of numerous projects interested in using the NAAT within the context of IPY.* (3) *Communicate the results of the studies through a three-part education/outreach component that includes an Arctic Field Ecology course, contributions to a new "Arctic Geobotanical Atlas" web site, and a field trip for the 9th International Conference on Permafrost.* The biomass data are critical to understanding the causes of a recent large increase the greenness of the Arctic that has been detected with satellite-based sensors. Biomass, leaf-area, spectral data and other site information will be collected from each site to provide a baseline against which to monitor future changes. The NAAT will be a component of the Arctic Observing Network (AON) affiliated with the flagship observatory at Toolik Lake, AK. The project will serve as a magnet for other studies interested in examining all aspects of change along the Arctic climate gradient. ***Intellectual merit of the project:*** The project will help answer the following science questions: "Is the Arctic terrestrial system moving to a new state?" and "How will the plant biomass of the Arctic change if the Arctic Ocean becomes seasonally ice free as indicated by present trends in sea ice?" The information collected is essential to characterize and model the current energy, water, and carbon balance of the Arctic. Our primary goal is to determine how plant biomass and the NDVI covary with land surface temperatures, summer sea-ice proximity, climate patterns, and a suite of terrain and site factors at three primary scales. Extensive changes in shrub cover and NDVI have already been detected in Alaska and elsewhere, but surprisingly, there are few long-term replicated studies of tundra biomass that can be used to calibrate space-based observations of NDVI with changes in biomass, particularly in the northernmost bioclimate subzones. Among other activities, we are proposing an international workshop to develop a standardized protocol for biomass collection, sorting, and reporting. The majority of the field research will focus on the northern end of the transect at Isachsen and Mould Bay, Canada in collaboration with proposed Canadian, German, and US IPY projects. This region is understudied and is perhaps the most sensitive to climate changes. Another component will focus at Toolik Lake to take advantage of a hierarchic geographic information system and a biomass dataset collected there 15 years ago. Other already-funded parts of the GOA initiative will synthesize 23+ years of data from Earth-orbiting satellites in combination with a host of climate and terrain data in a GIS to determine if changes in sea-ice concentrations have affected the NDVI patterns across the Arctic and how these are affecting human use of these systems. We are using vegetation-change models (BIOME4 and ArcVeg) to determine if the greening detected so far can be used to project future patterns of vegetation change in the Arctic. One component is examining the effects of greening on the Nenets reindeer herders in Russia. ***Broader impacts:*** The IPY Joint Committee identified GOA as a core IPY project. GOA is recognized in the SEARCH Implementation Plan as a priority area of terrestrial hydrologic and cryospheric observation activities, and the Circumpolar Arctic Fauna and Flora (CAFF) program has also endorsed the project. Through the coordination and data management activities we will link a group of IPY projects together to achieve a broad understanding of the suite of interrelated atmospheric, oceanic, sea-ice, and terrestrial processes that are undergoing change. Education and outreach activities include field courses, involvement of the local communities, web sites, and virtual and actual tours of the NAAT during IPY.

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C. PROJECT DESCRIPTION

INTRODUCTION

One of the major questions facing Arctic terrestrial ecologists at the moment is, "What will happen to the tundra regions if the Arctic Ocean becomes seasonally ice free as indicated by current trends in sea ice?" (ARCSS 2004, Overpeck et al. 2005). The Arctic tundra is essentially a maritime biome (Fig. 1). The vegetation of this biome is not directly affected by changes in sea-ice distribution, but is affected indirectly because of the sea-ice influence on Arctic climate (Fig. 2). Changes to the vegetation will have major implications for the permafrost, snow, hydrology, soils, wildlife, biodiversity, and people who live in the Arctic (Sturm et al. 2003, Hinzman et al. 2005). These changes also have global implications because of albedo and trace-gas feedbacks to the global climate system (Chapin et al. 2000, Beringer et al. 2001, Chapin et al. 2005). One of the goals of the Study of Environmental Arctic Change (SEARCH) and the International Polar Year (IPY) is to document the rapid and dramatic changes to terrestrial vegetation that are expected to occur across the circumpolar Arctic as a result of climate change (SEARCH 2005). Changes in green biomass can be expected across the entire bioclimate gradient from treeline to the coldest parts of the Arctic.

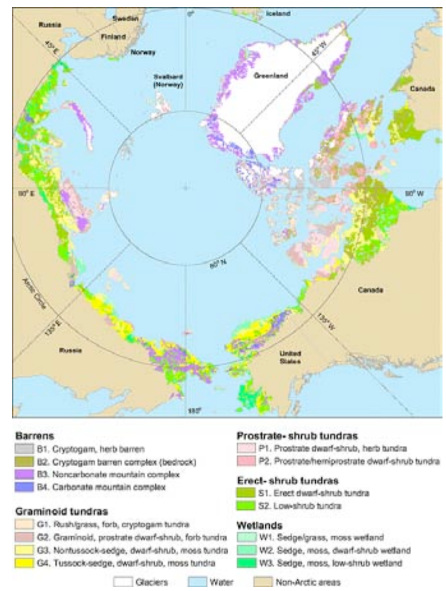

Fig. 1. The Arctic biome. The southern boundary of the mapped area is tree line. Note the close proximity of all parts of the biome to perennially or seasonally frozen seawaters: 80% of the biome is within 100 km of the ocean and 100% is within 350 km. Modified from the Circumpolar Arctic Vegetation Map (Walker et al. 2005).

THE GREENING OF THE ARCTIC INITIATIVE

The strength of the linkage between sea-ice and vegetation is currently unknown and is being investigated with the Greening of the Arctic (GOA) IPY initiative. GOA consists of a group of an international group of scientists in the US, Canada, Russia, Finland, Sweden, Germany, and Switzerland who are examining the circumpolar spatial and temporal trends of plant biomass accumulation in the Arctic, and how these trends are affected by changing climate, distribution and longevity of sea ice in the Arctic Ocean, and various terrain-related variables (Fig. 2). The GOA initiative has been endorsed by the IPY Joint Committee as a core project. It is also endorsed by the Conservation of Arctic Flora and Fauna (CAFF) program, and several other proposed IPY activities that would also like to work along the transect (see attached letters of commitment). The total project currently consists of four components, the first three of which have already been funded:

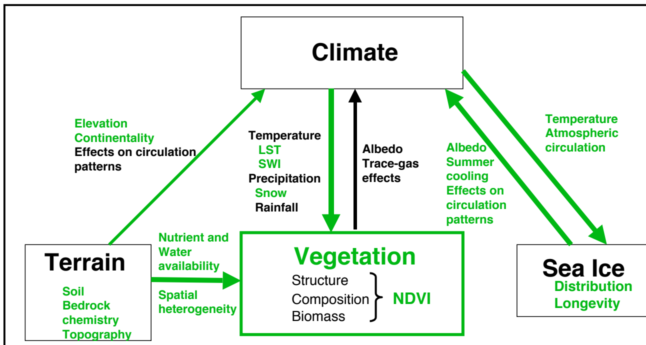

Fig. 2. The climate–sea-ice–terrain–vegetation system. Topics and linkages highlighted in green are the main foci of the overall GOA initiative.

Component I: Synthesis and models to examine the effects of climate, sea-ice, and terrain on circumpolar vegetation change (NSF ARC-0531180, 2005-2007)

This component is an NSF Synthesis of Arctic System Science (SASS) project. It is examining the 24-year record of greenness across the entire circumpolar Arctic as measured by the normalized difference vegetation index (NDVI) using satellite imagery (AVHRR and MODIS). It is documenting the historical trends in NDVI, areas of major increases or decreases in the NDVI, and how these are correlated with changes in sea-ice distribution, land-surface-temperatures (LSTs), snow-cover, bioclimate subzones, vegetation type, glacial history, and other variables in a circumpolar GIS database that is part of the Circumpolar Arctic Vegetation Map (CAVM). Modeling studies will use the BIOME4 and ArcVeg models to predict future vegetation and NDVI patterns. It is important to note that this a Synthesis of Arctic System Science (SASS) project that uses only existing data in the project. There is no field effort in this component.

Component II: Application of space-based technologies and models to address land-cover/land-use change problems on the Yamal Peninsula, Russia (2006-2008)

This project is part of the NASA/USDA Land Cover Land-Use Change (LCLUC) program. It is examining Human-NDVI-ecosystem relationships along a transect in Russia that is similar to the North American Arctic Transect (NAAT). The Eurasian study is examining biomass across all five arctic bioclimate subzones on the Yamal Peninsula and Franz Josef Land. The study is linked to the Circumpolar Arctic *Rangifer* Monitoring and Assessment (CARMA) project and the Cold Land Processes in NEESPI (Northern Eurasia Earth Science Partnership). NEESPI is a broad suite of studies sponsored by NASA and other agencies to examine, model, and predict the long-term consequences of landscape changes in Russia. A major focus of our project is the analysis of changes to the patterns of forage conditions of the Nenets reindeer herds, including patterns of greening, shrubification, grassification, and desertification. The study is also examining the effects on the culture of the Nenets people.

Component III: Arctic Geobotanical Atlas (NSF ARC 0425517, 2005-2007)

This project is an outreach/education component of the GOA initiative to develop a web-based Arctic Geobotanical Atlas (AGA) that will use a variety of tools to help students, educators, scientists, land managers, and the public to understand issues related to the greening of the Arctic. Users will be able to download and use online GIS data from the Circumpolar Arctic Vegetation Map and other maps at several sites along the GOA transects, in combination with other remote-sensing products. Educational applications of the AGA in the classroom will be developed through the University of the Arctic.

Component IV: The North American Arctic Transect (NAAT) (this proposal)

The work proposed here is the final essential component of the GOA initiative. The four major goals of this compoent are:

(1) ***Establish the North American Arctic Transect (NAAT) as part of the Arctic Observatory Network.*** The 1800-km long transect of terrestrial observatories was established with previous funding through NSF Biocomplexity in the Environment program. The transect has seven research sites in northern Alaska and four in Canada; it is anchored at the southern end at the Toolik Lake flagship environmental observatory. We specifically request funds to establish two 20-person field camps at Isachsen and Mould Bay during the IPY years 2007 and 2008. These camps would be established in collaboration with Canada as the Western Transect of the proposed "Climate impacts on Canadian Arctic Tundra" (CiCAT) IPY project. It is the only transect that would extend into bioclimate subzone A (see Figure 5).

(2) ***Build legacy biomass, climate, snow, and geobotanical datasets at key sites along the Arctic climate gradient.*** An international group of scientists will study the present-day spatial transitions of vegetation and other system parameters along the climate gradient. This legacy database will serve to document present-day patterns of vegetation, biomass, and other geobotancial parameters along the transect. This will be a baseline against which to measure future changes in these regions. We will build on climatic, geophysical, and biological databases that already exist at these locations. For the biomass portion of the research, an essential first step will be a workshop to develop a protocol and manual for sampling plant biomass, leaf-area index (LAI), and the normalized difference vegetation index (NDVI) in order to document future changes in biomass.

(3) ***Coordinate GOA with other SEARCH, IPY, and LTER activities.*** A variety of other projects have shown strong interest in the NAAT, and if funded would collaborate in the field research. We will help coordinate the field activities and research efforts of an integrated suite of projects related to climate, sea ice, atmospheric contaminants, permafrost, active layer, invertebrates, soils, and vegetation at sites along the Western Transect in Canada (Green Cabin, Mould Bay, Isachsen and Meighen Island). These data will form the core of a legacy dataset from the transect and be

used to document ongoing changes to the terrestrial system. The coordination would be in part achieved through collaboration with CEON (Circumarctic Environmental Observatory Network) and COMAAR (Consortium for coordination of observation and monitoring of the Arctic for assessment and research).

(4) ***Educate the public and train students regarding arctic systems and IPY.*** The activities along the NAAT will be involved in three major outreach activities: (a) An Arctic Field Ecology course that will provide in-depth field training and introduce students to Arctic System Science and the International Polar Year; (b) a web-site as part of the Arctic Geobotanical Atlas that will use EarthSLOT visualization software to "fly" along the transect and stop at each of the research locations to educate the public about the nature of the climate gradient, greening of the Arctic, and potential impacts; and (c) a field trip for the 9th International Conference on Permafrost in 2008.

ORGANIZATION OF THIS PROPOSAL

We first provide an overview of the scientific stimulus for the Greening of the Arctic initiative, including a review of the trends of decreased sea ice and increased land-surface temperatures, increased greening in Alaska and North America. Along with these reviews we present several questions that are driving our research. We then describe the need for long-term ground-based studies of tundra biomass across the full arctic climate gradient. We then describe the major parts of the project: (1) the plan for the North American Arctic Transect (logistics, coordination, management), (2) biomass and mapping activities and protocols (field activites along the NAAT, workshops, field manual, data management), (3) coordination with other IPY activities (collaborating projects), (4) education and outreach activities (Arctic Field Ecology course, contributions to the Arctic Geobotanical Atlas, International Conference on Permafrost field trip).

STIMULUS FOR THIS RESEARCH AND MAJOR QUESTIONS

Trends of decreased sea ice and increased land surface temperatures

General circulation models (GCMs) predict that the Arctic will warm on an area average of between 3.2 and 6.6 ˚C when CO_2 in the atmosphere is double that of preindustrial levels (Holland and Bitz 2003) which is predicted to occur within the next 26 to 60 years (New 2005). Records from 1978 to 2005 indicate that the perennial ice in the Arctic Ocean has declined at a rate of 9.8 ± 1.5% per decade (Comiso 2006). Concurrently, the Arctic surface temperatures rose steadily over much of the Arctic landmasses over the same period. Land-surface temperatures (LSTs) over North America north of 60˚N show a 0.84 ± 0.18 ˚C decade^{-1} warming resulting in an increase of the melt season of 5.5 days decade^{-1} (Comiso 2006). The large positive trends in surface temperatures are thought in part to be caused by more open water surfaces due to the retreat of the perennial ice cover as suggested by models showing an amplification of warming over the Arctic Ocean (Holland and Bitz 2003). Interdecadal cyclical patterns of sea-ice extent are other possible contributing factors (Proshutinsky and Johnson 1997, Thompson and Wallace 1998, Polyakov et al. 2003, Overland and Wang 2005). Surface temperatures are most highly correlated with sea-ice concentration in the seasonal sea-ice regions, the portion of the ice pack that melts annually. The ice in the northern Bering Sea, Beaufort Sea north of Alaska, and the Laptev Sea north of Siberia retreated most dramatically, and these regions have warmed particularly strongly (Comiso 2006) and are demonstrating major shifts in the marine ecosystem (Grebmeier et al. 2006).

Greening of the Arctic

Surface temperature changes have been linked to a wide variety of phenomena in the Arctic, including altered permafrost temperatures (Romanovsky et al. 2002, Osterkamp 2005), earlier snow melt (Groisman et al. 1994, Stone et al. 2002), shrub expansion (Sturm et al. 2001, Tape et al. 2006) and advancing treelines (Lloyd and Fastie 2002, Shiyatov 2003). Summaries of system-wide changes are reported in several references (Serreze et al. 2000, Hassol 2004, Hinzman et al. 2005, Overpeck et al. 2005). With respect to tundra vegetation, the normalized difference vegetation index is an index of vegetation greenness that has been the most widely used means of monitoring global changes of biomass, leaf-area index (LAI), intercepted photosynthetic radiation (IPAR), and other biophysical parameters that are used to model global land-cover changes (NDVI, box at right).

Detection of greenness using the NDVI

Detection of global-scale long-term trends of vegetation biomass has relied mostly on the Advanced Very High Resolution Radiometer (AVHRR) sensors aboard the NOAA-6 through NOAA-16 weather satellites. The AVHRR sensors record reflectance in five portions of the electromagnetic spectrum: Ch_1 is the channel in the visible portion of the spectrum; Ch_2 is in the near-IR portion; and channels 3 through 5 are in thermal IR portions of the spectrum. Green vegetation absorbs visible light for photosynthesis and strongly reflects near-IR radiation. Studies have used difference in the reflectance of Ch_2 and Ch_1 is an index of plant photosynthetic activity (Tucker and Sellers 1986). When normalized by the sum of the reflectance in the same channels, the influence of variation in illumination conditions caused by variation in slope or clouds is minimized. Thus, $NDVI_{AVHRR} = (Ch_2 – Ch_1)/(Ch_2 + Ch_1)$ (Lillesand and Kiefer 1987). Higher NDVI values are indicative of greater photosynthesis and have been correlated with tundra biomass, leaf area index, and other plant biophysical properties such as CO_2 and methane flux (Reeburgh et al. 1998, Oechel et al. 2000, Jia et al. 2004, Stow et al. 2004).

An increase in biomass is expected with warming, as suggested by many lines of evidence, including results from warming experiments (Shaver et al. 2000), modeling studies (Gilmanov 1997, Williams et al. 2000); patterns of biomass and NDVI along natural arctic temperature gradients (Jia et al. 2002, Lucht et al. 2002), and observations of recent shrub increases in northern Alaska (Sturm et al. 2001). The length of the AVHRR NDVI record is now sufficient to show meaningful trends of increased production associated with the warming trends in parts of the Arctic. For example, observations between 1980 and 2001 in northern Alaska showed that the NDVI increased an average 17% across the whole Arctic Slope (Fig. 3a) (Jia et al. 2003b). The increase in NDVI occurred during a period when the summer warmth index (SWI) measured at ground stations across northern Alaska increased by 0.16-0.34˚C yr^{-1} (Fig. 3b). (The SWI is equivalent to thawing degree months or the sum of the mean monthly temperatures greater than 0˚C.) NDVI apparently responds very quickly in warm years; higher NDVI values generally correspond to years of higher temperatures and vice versa (red and blue arrows in Figs. 3a, b). The trend is consistent with greening patterns observed elsewhere in the north (Myneni et al. 1997, Zhou et al. 2001, Lucht et al. 2002; Zhou and Myneni 2004; Goetz et al. 2005). The 17% NDVI change in northern Alaska is greater than that for the North American Arctic as a whole (10% increase according to Zhou and Myneni 2004 and Goetz et al. 2005), which suggests that rapid vegetation change is especially strong in northern Alaska, consistent with the simultaneous rapid changes in sea-ice concentrations in the Beaufort Sea and the strong warming of the land surface in northern Alaska (Comiso 2005).

The Jia et al. (2003) study was the primary impetus behind the GOA initiative. GOA will extend the region of the NDVI-biomass studies from northern Alaska to the circumpolar region. Major questions that we are addressing in other parts of the GOA initiative include: *(1) Do greening and production in the Arctic correspond to sea-ice fluctuations and land-surface-temperature trends? (2) Are the detected trends in NDVI due entirely to greening of the vegetation or are other factors involved? Are there persistent instrument and calibration problems? How do other factors such as bioclimate subzones, precipitation,*

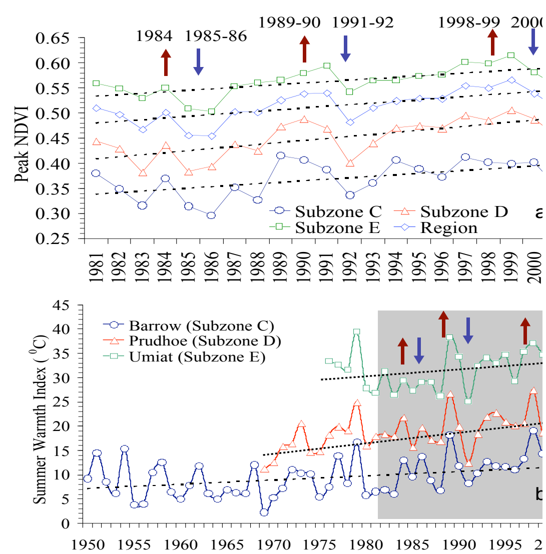

Fig. 3 (a) Time series of peak NDVI derived from 8-km resolution AVHRR data from 1981 to 2001 among the bioclimate subzones and for the whole Arctic Slope. (b) Summer warmth index (SWI) over the past 22-50 years at meteorological stations in each bioclimate subzone. Dashed lines are linear regressions. The shaded area in (b) highlights the period of SWI covered by the NDVI data in (a). The arrows show years of corresponding increases (red) and decreases (blue) in NDVI and SWI. From Jia et al. (2003).

regional floras, landscape age, substrate type, and topography influence the trends in NDVI? (3) Has the greening occurred evenly across broad landscapes, or has it been confined to local areas of greater warmth, moisture, or nutrient flux, such as south-facing slopes, water tracks, and stream margins?

LINKING CIRCUMPOLAR NDVI TO BIOMASS AND OTHER KEY BIOPHYSICAL PARAMETERS

> *"Should we believe in the NDVI trend? There are no "ground truth" measurements of photosynthesis at northern high latitudes over the same period, and so the accuracy of the trend cannot be established unambiguously…. It will be a challenge for ecologists to explain how photosynthesis could possibly have increased by approximately 10% from 1981 to 1991."* (Fung 1997)

Although NDVI is clearly correlated with chlorophyll absorption by arctic foliage, it is not clear what long-term changes in NDVI correspond to in terms of increases in plant biomass, LAI, IPAR, or other key biophysical parameters. There are several concerns about using AVHRR-derived NDVI values for circumpolar monitoring of biomass, including: (1) the lack of onboard calibration and differences in the instruments, orbital characteristics, and compositing methods used over the history the AVHRR observations; (2) the limited set of spectral bands that reduces the accuracy of atmospheric parameters retrieval and correction (water vapor and aerosols); and (3) orbital drift that leads to variation in the solar geometry throughout the mission (El Saleous et al. 2000). The coarse resolution of the AVHRR data (1.1 km pixels) also make it difficult to relate NDVI response with specific site locations at an individual pixel level. The spatial grain covers an extensive area that may be cloud contaminated or a mixture of several vegetation types, water, and bare soil, which can cause uncertainties in detecting greenness changes at fine scales. Furthermore, in very green areas, changes in biomass are difficult to detect because the sensors are saturated at high-reflectance values. The NDVI/biomass curve tends to flatten out at NDVI values above about 0.65. Tundra areas are in some ways good areas to use satellite-derived NDVI to monitor biomass trends because the AVHRR NDVI of most tundra areas are well below 0.65 (see Fig. 4).

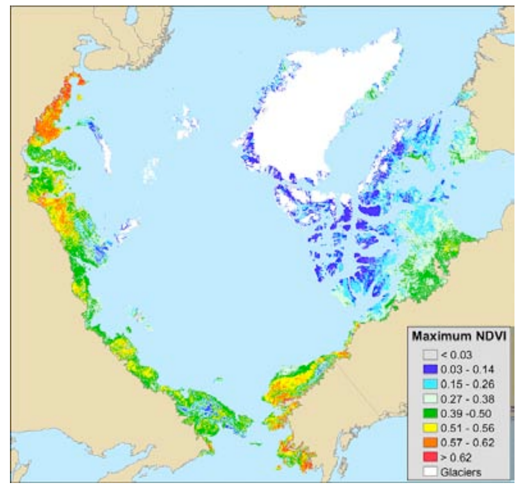

Fig. 4. Maximum NDVI of the Arctic. From Walker et al. (2003). Note: most areas of high NDVI (red), such as European Russia, and southern Yukon-Kukokwim River delta, occur in exceptionally warm regions with low winter near-shore sea-ice, and lack permafrost. While the areas with lowest NDVI (dark purple) are chiefly in areas of year-round sea ice.

In recognizing the limitations, intense calibrations and corrections have recently been performed to improve AVHRR data records (Tucker et al. 2005 in press). These efforts have not eliminated all possible source of errors, but the consensus among arctic ecologists and remote sensors is that major changes have occurred in the greenness of the vegetation biomass and that variations in peak biomass covary with summer temperatures. In addition, coincident MODIS data starting in February 2000 offer an invaluable asset in evaluating and assessing the accuracy of the AVHRR dataset. A long-term goal from NASA is to acquire and maintain a long-term land-surface data record from various sensors including AVHRR, MODIS and VIIRS (Vermote 2004). As a first step toward creating such an NDVI record, NASA has reprocessed 24+ years worth of AVHRR data (1981-present) using algorithms based on improvements identified in the AVHRR Pathfinder 2 project and on the knowledge gained from the MODIS surface reflectance activity. The first beta version of the dataset is scheduled to be released in summer 2006. This dataset is likely a hybrid version of AVHRR, MODIS and VIIRS, and will be the primary source of information for the circumpolar NDVI analyses in our proposed study.

NEED FOR GROUND-BASED MEASUREMENTS OF BIOMASS

There currently are no time-series of biomass data across broad vegetation categories to correlate with the changes in NDVI. The NDVI has been most carefully validated at only a few sites, all of which are outside the Arctic, such as the Kansas FIFE field area (Sellers et al. 1992) and Jasper Ridge (Gamon et al. 1995). Several recent studies in Alaska, mostly in tussock tundra vegetation, provide more information on the biotic controls (Riedel et al. 2000, Boelman et al. 2003, Stow et al. 2004, Boelman et al. 2005, Riedel et al. 2005, van Wijk and Williams 2005, Jia et al. 2006). There are many sets of biomass data collected from Arctic areas (Gilmanov and Oechel 1995, Bazilevich et al. 1997), but it is difficult to link these data to NDVI measurements because (a) very few of the data have accurate geographic coordinates, (b) the methods used to determine biomass vary widely, and (3) it is often unclear exactly what type of vegetation was involved in the study. Furthermore, the time series of NDVI varies considerably with vegetation type, and substrate (Jia et al. 2003), and circumpolar patterns of maximum NDVI vary according to bioclimate subzone, substrate pH, lake cover, and elevation (Raynolds et al. 2006 in press). *For purposes of monitoring change to circum-Arctic vegetation, it is essential to have a standard method of collecting time series of biomass data and to apply this method widely at numerous sites across the Arctic.*

THE NORTH AMERICAN ARCTIC TRANSECT (NAAT)
History and study-site locations

The NAAT was established in 2001-2005 as part of a study of the NSF-supported Biocomplexity of Patterned Ground project. The transect is approximately 1800 km long and was established to study tundra processes in all five bioclimate subzones of the Circumpolar Arctic Vegetation Map (CAVM Team et al. 2003) (Fig. 5). The zonal approach of the subdividing the Arctic follows the Russian method (Yurtsev 1994) and the Pan Arctic Flora (PAF) project (Elvebakk 1999) with some modification (See Fig. 5 for map of subzones and explanation of the zones and zonal vegetation).

The transect has eleven study locations: seven along the Dalton Highway in northern Alaska (Toolik Lake, Happy Valley, Sagwon, Franklin Bluffs, Deadhorse, West Dock, and Howe Island) and four in Canada (Inuvik, Green Cabin, Mould Bay, and Isachsen). The sites were selected using the following criteria: (1) They have representative zonal vegetation on fine grained soils (to avoid rocky soils for active layer measurements or sandy leached situaitons) and are mostly unglaciated during the last glacial maximum so that zonal vegetation and soils have had time to develop; (2) they have long-term climate records; and (3) they have good air strips that permit year-round access. Most of the subzones have at least two study locations, but there is only one location in subzones A and B (Isachsen and Mould Bay respectively). These were the only sites in these subzones within North America that satisfied the other criteria. Most of the sites along the Alaska portion of the transect are easily accessible from the Dalton Highway. Howe Island is located near Prudhoe Bay and is accessible via a 5-minute helicopter ride from Deadhorse. The Canadian sites are all accessible from Inuvik, which has excellent logistic support facilities available through the

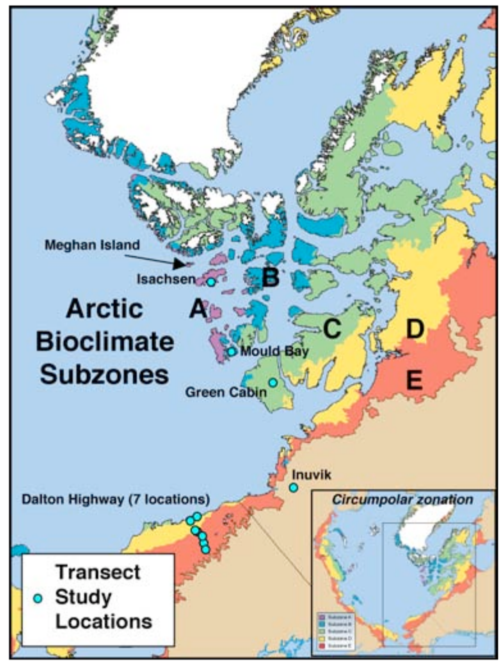

Fig. 5. The North American Arctic Transect. The transect traverses all five Arctic bioclimate subzones. The already-estabilished study locations are shown as blue dots. Meighen island (arrow) will be added in 2008. The inset maps shows the circumpolar distribution of the Arctic bioclimate subzones. Zonal vegetation and soils develop in response to the prevailing regional climate on relatively flat, mesic areas with fine-grained soils, not influenced by extremes of soil chemistry, snow or disturbance (Vysotsky 1927)There are five subzones defined mostly on the basis of mean July temperature (MJT). Subzone A is the coldest, with MJTs less than 2 ˚C, and Subzone E the warmest with MJTs between 10 and 12 ˚C. Each subzone has a characteristic suite of plant growth forms, with cushion forbs, lichens and mosses in the coldest subzone and low shrubs up to 2 m tall in the warmest subzone.

Aurora Insitute. The Inuvik site is accessible by road, and the others are accessible by Twin Otter flights from Inuvik. Long (5000 ft) runways at Isachsen and Mould Bay make these sites also accessible by larger aircraft such as DC-3s or C-130s. Parks Canada maintains a small cabin and weather station at Green Cabin; the runway there is short and accessible with small aircraft.

Data collected to date

A standard set of environmental information currently is being monitored at each location along the NAAT (Table 1). Data collected to date are in four major data reports (Munger 2004, 2005; Barreda et al. 2006, Vonlanthen et al. 2006). The trends of temperature, snow cover, active layer, frost heave, soil carbon, biomass, NDVI, invertebrate populations, patterned-ground morphology, plant diversity, plant communities were reported in several talks at the Fall AGU meetings and elsewhere (Walker et al. 2004, 2005; Epstein et al. 2005; Ping et al. 2002, 2005; Raynolds et al. 2005, Daanen et al. 2005, Kade et al. 2005; Kelley et al. 2004).

Table 1. Key data sets and models at three scales along the NAAT as part of the Biocomplexity project and the NSF Greening of the Arctic SASS project. (Source or person(s) collecting the data is listed in parentheses.)

	Macroscale (Climate gradient to circumpolar)	**Mesoscale (Toposequence to regional)**	**Microscale (Patterned-ground elements to 10-m grids)**
Climate	Trends in air and ground temperature, snow depth along the climate gradient (Romanovsky, US Weather Service, Environment Canada). Circumpolar land-surface temperature (Comiso)	Trends in soil temperatures, and snow distribution along toposequences (Romanovsky).	Soil temperatures, and snow depth on patterned-ground elements. (Romanovsky) Snow profiles on patterned-ground elements (Walker et al.) Snow depth maps (10 x 10-m grids) (Raynolds, Munger).
Permafrost	Trends in permafrost temperature, n-factor unfrozen water content, active layer depth, and frost heave along the climate gradient. (Romanovsky, Kade). Circumpolar permafrost map (Brown et al.)	Trends in n-factor, active layer depth, and frost heave along the toposequences (Romanovsky, Kade) WIT/ArcVeg model of patterned-ground formation (Daanen, Misra, Epstein)	Heave, active layer depth, soil-water content, unfrozen water, and n-factor within patterned-ground elements (Romanovsky). Active-layer and snow-depth maps (10 x 10 m grids) (Raynolds, Munger)
Geology/ geomorphology	Circumpolar patterns of landscape age, glacial geology, bedrock,and physiography. (CAVM Team, Raynolds)	Surficial geomophology along toposequences. (Walker et al.)	Elements of patterned-ground features. (Walker et al., Tarnocai) Thermo-mechanical model of differential frost heave (Nickolsky, Romanovsky) DFH model of heave initiation (Peterson, Krantz)
Soils	Circumpolar Soils Map (Tarnocai and Ping) Circumpolar Carbon Map (Tarnocai) Trends in soil C and N along the climate gradient (Ping and Michaelson)..	Soil associations along toposequences (Ping). Trends in soil chemical and physical characteristics along toposequences. (Ping and Michaelson)..	Pedon within each patterned ground element (Ping). Cryptogamic crusts in each patterned ground element. (Michaelson) Physical and chemical properties of soils in each patterned-ground element. (Ping and Michaelson).. N-cycling in each patterned-ground element (Kelley).
Soil biota	Trends in soil invertebrates, microbes, fungi/ mycorrhizae along the climate gradient. (Gonzalez, Timling)	Trends in soil invertebrates, microbes, fungi/ mycorrhizae along toposequences. (Gonzalez, Timling)	Soil invertebrates, microbes, fungi/ mycorrhizae in patterned-ground elements. (Gonzalez, Timling)
Vegetation	Circumpolar AVHRR NDVI, and vegetation(CAVM Team, Raynolds, Epstien, Jia) Trends in zonal vegetation biomass along the climate gradient (Walker et al., Epstein) Buried seed bank along the climate gradient (Kelley) ArcVeg succession models along the climate gradient (Epstein)	Plant communities along toposequences (Kade, Vonlanthen et al.). 10 x 10-m vegetation maps along toposequences (Raynolds, Munger)	Plant communities within patterned-ground elements (Kade, Vonlanthen et al., Matveyeva, Daniëls). 1 x 1-m vegetation maps (Kade) Handheld LAI and NDVI of patterned-ground elements. Biomass of plant communities (Walker et al., Epstein). Buried seed bank within patterned ground elements (Kelley)

Special significance of the Isachsen and Mould Bay sites

Bioclimate Subzone A (purple areas in Figure 5) is the coldest smallest subzone – mean July temperatures are less than 2-3 ˚C, and it occupies only about 2% of the Arctic. It is located primarily on islands surrounded by summer sea-ice and has a very small vascular-plant flora. The total floras of areas in Subzone A are usually less than 50 vascular-plant species. In subzone B, the mean July temperatures are only about 1-2 ˚C warmer than in Subzone A, but the total floras are much larger, with normally over 100 species (Young 1971, Rannie 1986). Additionally, there are unexplained major shifts in the functional composition of the plant communities between subzones A and B – there are no woody species and no sedges in the flora of Subzone A and the wetlands have no peat accumulation; whereas in Subzone B sedges and dwarf shrubs are important functional types in many habitats and wetlands often have thick peat accumulations. In Subzone C, sedges and prostrate dwarf shrubs are the dominant growth forms in zonal habitats (Yurtsev 1994, Walker et al. 2005).

Subzone A is likely to be especially sensitive to climate change because: (1) the physical boundary of the Arctic Ocean constrains a poleward shift of this Subzone A, and (2) the biological effects of temperature changes are most prounounced where maximum summer temperatures are near the freezing point (Cramer and Leemans 1993). Similar differences occur across other taxonomic groups (Chernov and Matveyeva 1997). The sites in the cold regions of Subzone A and B will likely experience major climate change if the surrounding ocean becomes ice free in summer.

These areas are remote, poorly studied, and difficult to access; there are no permanent settlements and few military or civilian installations to provide logistic access or long-term climate information from these regions. Isachsen and Mould Bay are currently the only study sites in Subzones A and B where long-term integrated studies of climate, vegetation, active layer, and permafrost are being conducted. Isachsen is near the extreme northern end of the climate gradient, with the coldest summer temperatures of any site in Arctic North America (mean July temperature: 2 ˚C). Mould Bay is only slightly warmer (mean July temperture: 3 ˚C). A similar set of sites is proposed in Russia (part of our NASA-funded GOA project) so there would be sites in Subzones A and B in North American and Asia by 2008.

Future of the NAAT

The study sites along the Dalton Highway have been permitted by the Bureau of Land Management and other US, Alaska and North Slope Borough government entities. These sites are recognized as long-term study sites and will likely be permitted in the future through annual permitting procedures. Most of the sites are easily accessed from Fairbanks and the Toolik Lake Field Station so that future work at these sites is relatively secure, although there are issues related to disturbance from seismic activities and off-road vehicles associated with the ongoing oil and gas exploration in the region.

The Canadian sites are less secure and may have to be dismantled during IPY unless new funding is secured to continue monitoring. The sites have been established with the approval of Parks Canada, Environment Canada and the local hunters and trappers at Sachs Harbor. These permits are valid through the end of our current NSF-funded Biocomplexity of Patterned Ground project (September 2006). The funds requested here would ensure that the characterization of the sites would be continued during the IPY years and that the sites would be recognized as part of the Arctic Observatory Network (AON) for several initiatives (see project coordination). The sites would also become the part of the Western Transect in the Canadian IPY effort called "Climate impacts on Canadian Arctic Tundra (CiCAT) (Henry and al. 2006).

PROJECT PARTS

Table 2. Parts of the proposed work and approaches.

Part	Activity	Approach (Responsibility)
1. North American Arctic Transect	a. Field camps. b. Helicopter support for Isachsen field work. c. Aircraft support for establishing and manning the camps.	a. Yurt camps at Isachsen and Mould Bay supported. Fly camps at Green Cabin and Meeghan Island. (VECO) b. 1 week of helicopter suppprt (VECO, Polar Shelf Program). c. Twin Otter and DC-3 support (VECO, Aklak Air).
2. Arctic biomass	d. International protocol for biomass collection.	d. Workshop and biomass manual in collaboration with the Canadian ITEX IPY and Arctic LTER projects (Walker, Shaver, Henry).

	e. Sample biomass along the NAAT in accordance with the established protocol. f. Extrapolation to broader regions.	e. Clip harvest of biomass at all 12 sites in 2008 ((Walker, Raynolds, Epstein). f. Hierarchical map analysis of biomass and NDVI patterns (10-m grids, 25-km areas surrounding the grids, circumpolar region) using geobotanical mapping methods and remote sensing (TM, MODIS, IKONOS, ASTER and AVHRR imagery) (Jia, Raynolds, Munger). Soil mapping (Ping and Michaelson)
3. Coordination with other IPY activities	g. Camp science and logistic coordination h. Project and IPY coordination i. Data management	g. Science and logistics coordinator at Isachsen and Mould Bay camps (Kuss, Raynolds, VECO).Toolik Field Station (Barnes, Abels) h. Organization workshop 2007, Synthesis Workshop 2009 (Walker). i. Data manager, data CD-ROM (Patrick Kuss).
4. Education and outreach	j. Public education and outreach k. Student involvement	j. NAAT component for AGA (Nolan, Prokein, Barbour, Maier) j. NAAT field trip for the 9th ICOP conference (Walker) k. Arctic Field Ecology course (Gould, Gonzalez)

Part 1: North American Arctic Transect (NAAT)

Field camps. We will conduct the research along a transect through northern Alaska and Canada. We request funds to support the remote Canadian portion of the transect during 2007 and 2008. All the necessary logistic needs for this can be anticipated because of experience gained during 2003-2005 Biocomplexity of Patterned Ground expeditions to the same areas with similar sized operations. The camps at Isachsen and Mould Bay will be of the same type as those used at these sites in 2004 and 2005 (Figure 7). These camps will be in place for 8 weeks each summer to accommodate 20 people each. Each camp will have two Western Shelter yurt-style tents for laboratory space, dining, and evening seminars. Student camp facilities will be separate from the main camp and will be in place for shorter periods of time, corresponding to the timing of the Arctic Field Ecology courses. VECO Polar Resources will provide a cook/camp manager for each camp. The camp at Green Cabin will be a smaller fly camp that will use personal tents for short periods during the summers of 2007 and 2008. A temporary camp will also be established on Meighen Island in the very coldest part of the Canadian Archipelago (Figure 9) to conduct vegetation and soil surveys during one week in 2008.

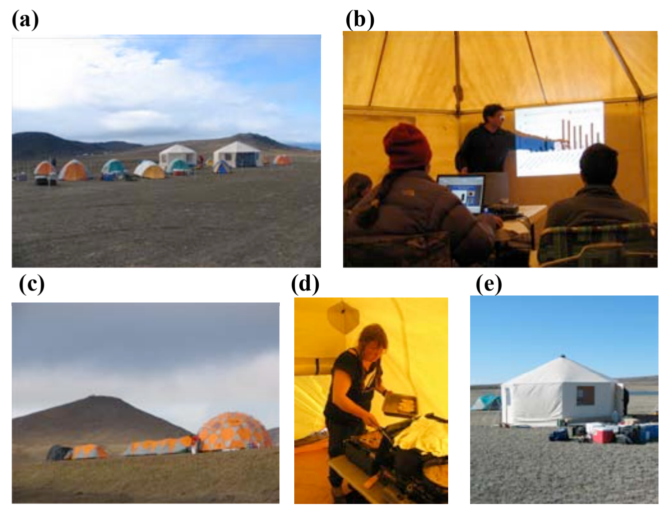

Figure 7. Camp facilities. (a) Main camp at Isachsen with two yurts for laboratory space and (b) evening seminar. (c) Arctic Field Ecology Camp at Isachsen with large dome for classes and cooking. (d) Sarah Harvey, VECO, camp cook and manager at Green Cabin 2003. (e) Western Shelter at Green Cabin.

Air support. Air support for the project will include a pre-summer flight by a DC-3 to both the Isachsen and Mould Bay camps to deliver the camp facilities and cache fuel and to conduct snow surveys. If Hajo Eicken's SIZONET project is funded, the spring camp could also support the sea-ice investigations that will occur out of Mould Bay. Transportation of researchers and students to the camps during the summer will be by Twin Otter aircraft. We have budgeted air support for 20 people during each summer. Other IPY groups may also join the camps on a space available basis for the arranged flights or can make their own flight arrangements. We have also budgeted for one week of helicopter time to visit the Meighen Island site from Isachsen.

Permitting. Permits for the research in Canada is required from Parks Canada, Nunavut, and the Hunters and Trappers Association in Sachs Harbor. The arrangements will be coordinated through Canadian Polar Continental Shelf Program and the Aurora Institute in Inuvik. The locations along the Dalton Highway and at Prudhoe Bay require permits and permissions from a variety of Federal, State, North Slope Borough, and industry agencies and are updated as needed.

Part 2: Arctic biomass

Goals and major questions

The responses of NDVI and vegetation biomass to warming are difficult to predict and are not uniform across broad arctic landscapes (Zhou and Myneni 2004). To extend the Jia et al. (2003) study to the circumpolar region, biomass measurements are needed from field locations across the complete arctic climate gradient and around the circumpolar Arctic. Because of the great difficulty of coordinating (spatially and temporally) ground-level measurements of biomass with satellite-derived NDVI values, our approach will be to monitor maximum summer biomass periodically (every 3-5 years) at numerous permanently marked plots along the NAAT and elsewhere in the Arctic using standard methods. A sampling design will be developed that will permit detection of 10-20% changes in biomass within the set of zonal permanent plots of each subzone. This will be based on samples collected previously from Toolik Lake by Gus Shaver and from 107 High Arctic Biocomplexity plots in 2005. There are particularly few simultaneous measurements of NDVI and biomass at the ends of the tundra biomass gradient, i.e., areas with either very shrubby vegetation or areas with polar desert vegetation. These "transition zones" may be most sensitive to climate change (Epstein et al. 2004), so much of our effort will focus at the ends of the bioclimate gradient.

Our primary goal in this proposal is to determine how strongly biomass and NDVI are correlated with land-surface temperatures at plot-, landscape-, regional, and circumpolar scales. Based on the literature and experience gained during making the Circumpolar Arctic Vegetation Map, we expect that zonal sites in each subzone will be dominated by different plant functional types – the biomass will be dominated by mosses, lichens, and forbs with much barren soil in subzone A; by mosses, lichens, and graminioids in Subzone B; by sedges, prostrate evergreen shrubs, and mosses in Subzone C; by prostrate evergreen and deciduous shrubs, mosses and sedges in Subzone D; and by erect deciduous and evergreen shrubs, graminoids and mosses in Subzone E.

We also expect that different factors will act to control biomass patterns in each subzone. For example, in Subzone A, micro-habitats associated with small patterned-ground features exhibit large differences in biomass and other key ecosystem properties. Preliminary data collected during the Biocomplexity studies at Isachsen indicate that ten to one-hundred-fold difference in biomass often occur between patterned-ground elements within distances of only a few centimeters (50 g m^{-2} in the centers and 500 g m^{-2} in the margins of small nonsorted polygons (Walker and Epstein 2006 unpublished data). Much higher values of biomass and soil carbon are present than previous studies suggested are common in the High Arctic (Vonlanthen et al. 2006). Similar findings have been recently shown from the High Arctic at Thule (Welker et al. personal communication). These differences have major effects on local surface temperatures, available water, and nutrients. Snow and snow melt water plays a large role in the regional distribution of biomass and soil carbon at all scales in the High Arctic.

Approach

International biomass workshop and ITEX manual.

A key aspects of these studies will be to link changes in greenness that can be detected with satellites to ground-level changes in plant communities and their biophysical properties. As discussed above, there are no long-term time-series of tundra biomass and leaf area that can be used to calibrate changes detected with space-based instruments; the biomass data that do exist cannot be used for relating NDVI to biomass because of uncertainties regarding the locations and methods used. This project will provide a legacy baseline of biomass information across the complete gradient, against which future changes can be compared. This project will, therefore, address a critical need for standardizing data collection, sorting, and reporting biomass data.

During the first year of the project, an international workshop will be held in conjunction with the International Tundra Experiment (ITEX) to develop a standardized approach for collecting biomass. Some topics that will be addressed include (1) statistically adequate sampling, (2) how to measure moss, lichen and cryptobiotic-crust biomass, (3) biomass collection in different bioclimate subzones, (4) scaling biomass from plots to landscapes to the circumpolar Arctic, (5) sorting into plant functional groups, (6) procedures for sampling above-ground and below-ground biomass, (7) hierarchical approaches for sorting biomass, (8) methods of reporting biomass data, (9) ground-level measurements of other key biophysical data (e.g., LAI, IPAR, ground-level NDVI measurements). The protocols will be published as part of the ITEX manual of standard procedures. Funds are requested to invite key investigators who are working at the flagship environmental and arctic environmental observatories, where long-term biomass studies could be conducted. Dr. Gus Shaver and Dr. Greg Henry have long experience with biomass studies in the Arctic and will help to identify the key datasets and help organize the workshop. Funds are requested to invite 20 participants to the workshop, which will be held in Fairbanks, AK.

Collection of biomass data along the NAAT

We will use the ITEX protocol to obtain a legacy dataset of biomass information from the NAAT locations during the second year of the project. Biomass samples will be collected from the 220 plots established during the Biocomplexity of Patterned Ground project. Some biomass data have already been collected from the transect (Vonlanthen et al. 2006) and will be used to help design a statistically valid sampling approach. Two basic approaches have been used so far: (1) random sampling along 50-m transects within zonal landscapes, and (2) sampling within homogeneous plant associations that are considered the zonal vegetation in each bioclimate subzone. The latter approach is being used to scale up the plot-level information to small 10-m patches of patterned ground using detailed vegetation maps of 10-m grids. Additional data will be collected from the other sites along the conceptual toposequence (ridge crests, mesic slopes, wetlands, streamside communities).

Extrapolation of biomass to broader regions

Geobotanical maps and NDVI maps of larger areas are needed to scale up to landscapes and regions surrounding the intensive study locations. The relationship of biomass to landscape variables including soil types, geology, hydrological networks and snow patterns will be studied in detail at two sites at the northern and southern ends of the NAAT. Maps of the other sites along the transect will be prepared in future years.

At Toolik Lake, a master's thesis project of Corinne Munger will examine the spatial and temporal NDVI patterns with reference to a hierarchy of geobotanical maps that have been prepared for the region (Walker et al. 2003 submitted). The purpose of this study will be to determine if we can detect a change in biomass over the past 24 years, and to determine in which vegetation types the greatest change has occurred. Two Thematic Mapper images (Aug 3 1985, and Aug 4 1998) of the region will be examined to determine how NDVI has changed over the 13-yr period, and how NDVI is related to a suite of geobotanical variables, including vegetation type, glacial history, slope, aspect, and surface geomorphology (presence of water track or patterned ground features). The relatively fine grain of the TM images (30-m) will permit analysis of maximum NDVI in relationship to terrain features mapped at similar resolution. Furthermore, the time-series of the AVHRR-derived NDVI for the region will be extracted from the Jia et al. (2003) data set to see how the time-series of NDVI has varied over the past 20+ years on different aged glacial surfaces and other course-scale (>1-km) terrain features. Finally, biomass will be collected from 60 marked study plots where biomass was sampled in 1993 (Shippert et al. 1995, Walker et al. 1995, Shippert 1997). The plots span the range of community types mapped in the region.

At Isachsen and Mould Bay, there are currently no baseline maps or biomass data against which to monitor change. To help in the scaling of biomass collected at the study locations, we are proposing to map the soils, vegetation, topography, and snow conditions at three scales: (1) *Regional scale*: To capture the majority of the variation associated with major landscape features (e.g., large hills, differences in geology, major drainages), the geobotany (vegetation, soils, geology, landforms, surficial geology, percent lakes, topography, NDVI) will be mapped within a 25-km^2 area surrounding the main intensive study areas at Isachsen and Mould Bay, primarily from high-resolution satellite imagery and available aerial photographs. Both the geobotanical map and the NDVI map will be made from high-resolution satellite imagery that will be obtained for the study area during the first year of the study (Landsat TM (30-m resolution) or ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer, 15-m resolution in the VNIR). Transects across the area will be conducted to establish the correlations between the patterns visible on the imagery and the ground conditions. (2) *Landscape scale*: To capture the variation along typical small hill slopes, three 100-m^2 grids will be mapped at dry, mesic, and wet hill-slope positions along typical toposequences representing regional meso-topographic gradients (Billings 1973). (3) *Micro-scale*: Finally, to characterize the variation within patterned-ground features, 1-m^2 plots will be mapped. Studies at all three scales will include characterization of the permafrost, microclimate, snow, soils, geomorphological and geological conditions. Vladimir Romanovsky will drill shallow boreholes (2 to 5 meters) along each transect. Each site will be equipped by four-channel U12 Hobo mini-logger to continuously (one hour time resolution) measure ground temperature at four different depths. A Hobo H8 Pro mini-logger will be installed near the borehole for continuous measurements of the ground surface temperature and the ground temperature near the permafrost table with the same time resolution. Vegetation will be characterized using the Braun-Blanquet approach (Dierschke 1994). The soils and geomorphological characteristics at each position along the toposequences will be fully characterized by Chien Lu Ping and Charles Tarnocai using the methods of the US Soil Conservation Service (Soil Survey Staff 1999). The data set will include vegetation, maximum NDVI, snow cover, soils, geomorphology, geology, water cover, and a digital elevation model. Preliminary studies of the vegetation at Isachsen have shown that the snow distribution and hydrological networks are particularly important factors influencing the distribution of biomass and soil carbon in the extreme High Arctic. Pilot studies of snow characteristics will be carried out in consultation with Dr. Matthew Sturm (US Army CRREL). Dr. Chien Lu Ping (UAF) and Dr. Charles Tarnocai (Agri. and Agri-Foods Canada) will conduct soil and geomorphological mapping studies at Isachsen and Mould Bay. Dr. Skip Walker and his graduate students will conduct detailed studies of the plant communities and biomass at all three scales in conjunction with Dr. Gus Shaver (Marine Biological Laboratory), Dr. Greg Henry (Univ.of British Columbia), and Dr. Fred Daniels (University of Muenster). Biomass will be clipped from all the study plots following the protocols developed during the first year of the project. Dr. Fred Daniëls is submitting a proposal to the German government for collaborative vegetation research, and Dr. Greg Henry is submitting a large proposal to the Government of Canada Program for IPY. These studies will build on earlier studies. Approximately one month of field time will be needed at each site to establish the NDVI/biomass/soil carbon/terrain relationships. Other projects will be invited to collaborate to characterize the fluxes of CO_2, water, and energy along the same transects. Other potential collaborators will investigate sea-ice characteristics, atmospheric contaminants, biodiversity, and soil fungi (see *Coordination with other IPY activities*, below).

The goal of these field studies is to develop a hierarchical conceptual framework of the Arctic Terrestrial System across the arctic bioclimate gradient that can be used for characterization of the state of the Arctic biome and monitoring studies at multiple scales. The framework will include the major elements of the arctic terrestrial system (vegetation, soils, permafrost, snow) and how they affect energy, water, and carbon budgets along toposequences in each of the major bioclimate subzones. This is the same basic framework used in the construction of the Circumpolar Arctic Vegetation map (Walker 2000).

Part 3: Coordination with other IPY activities.

Project and IPY coordination

The proposed work will be strongly integrated with several other international studies that are planned along the transect or that have indicated they would take advantage of the improved logistics if our proposal is funded (see letters of commitment):

1. "International Tundra Experiment" (**ITEX** as part of the "Climate Change Impacts on Canadian Arctic Tundra Ecosystems (**CiCAT**) project in the Candian IPY Program, Dr. Greg Henry, University of Alberta),
2. "Circumpolar Biodiversity Monitoring Program" (**CBMP**, Dr. Mike Gill, CBMP Secretariat, Whitehorse, NWT, Canada),
3. "**Pan-Arctic IPY Network of Carbon/Water/Energy Observatories"** (Donie Bret-Harte, Brian Barnes, Sergei Zimov, John Hobbie, Gus Shaver, Ed Rastetter, UAF, Cherskty, Russia, and the Ecosystem Center),

4. "Consortium for Coordination of Observation and Monitoring of the Arctic for Assessment and Research" and "Back to the Future" (**COMAAR** and **BTF**, Dr. Terry Callaghan, Abisko, Sweden),
5. "Circumpolar Active Layer Monitoring" (**CALM**, (Dr. Fritz Nelson, University of Deleware),
6. "Thermal State of Permafrost" (**TSP**, Dr. Vladimir Romanovsky, UAF);
7. "**Dynamics of Disturbed Tundra Ecosystem Rehabilitation**" (Dr. Anne Naeth, University of Alberta),
8. "**Classification and Analysis of Circumpolar Arctic Plant Communities**" (Dr. Fred Daniëls, University of Muenster),
9. "**Community Genomics Investigation of Fungal Adaptation to Arctic Extremes**" (Dr. Lee Taylor and Ina Timling, UAF),
10. "Atmospheric transport, deposition, and retention of bioaccumulative contaminants in the Arctic: terrestrial ecosystems and community response to change" (**ATRESP**, Dr. Jesse Ford, Oregon State University),
11. "The State of the Arctic sea ice cover: An integrated Arctic seasonal ice zone observing network" (**SIZONET**, Dr. Hajo Eicken, UAF).

These projects are seeking separate funding for IPY activities at Isachsen, Mould Bay, and Toolik Lake. The combined group of projects will help achieve an assessment of current and projected patterns of terrestrial ecosystems along the complete Arctic climate gradient. Overall project coordination will be the responsibility of the Principal Investigator (Walker). We will also work with the IPY Joint Committee, the Circumarctic Environmental Observatory Network (CEON) and COMAAR to achieve coordination of this project within the international group of IPY projects.

Camp science and logistics coordination

A post-doctoral student will be hired to act as the science and logistic coordinator at the Isachsen, Mould Bay, and Green Cabin camps in 2007 and 2008. Dr. Patrick Kuss, who has extensive experience in the Arctic and has spent two summers along the NAAT, has been identified as a potential person for this position. The coordinator would work with VECO Polar Resources to ensure that the camps run smoothly, that all necessary permits are obtained, that everyone going to the camps has all necessary equipment and paper work completed. The post-doc would also have science responsibilities of his/her own science project, to help with mapping and the characterization of the sites, to help with the data management needs for the project, and to help in the coordination of the 2008 9th International Conference on Permafrost Field Trip (see below).

Data management.

Several data reports summarize the data collected up to the present from the NAAT study sites (Munger et al. 2005, Munger et al. 2004, Barreda et al. 2006, Vonlanthen et al. 2006). A data manager will be hired for the project to produce hard-copy data reports for the GOA-IPY studies and to make the NAAT data available on a series of CD-ROMs. The data will also be archived at the Arctic Data Coordination Center (ADCC) and the Joint Office of Science Support (JOSS). Spatial data will be also archived at the Geographic Information Network of Alask (GINA) at UAF. We will also be disseminating data through the Circum-Arctic Environmental Observatory Network (CEON) and COMAAR.

Part 4: Education and outreach

The primary goal of this component is to educate the public and train students regarding arctic systems and IPY. There are three major education and outreach activities that will be conducted:

Arctic Field Ecology course (Gould, Gonzalez)

Arctic Field Ecology is an existing University of Minnesota accredited field course that has been successfully integrated in two major research efforts in the Arctic: The Canadian transect for the Circumpolar Arctic Vegetation Map (CAVM) (Gould et al. 2003) and a study of the biocomplexity of frost-boil ecosystems (Walker et al. 2004). This educational component of the NAAT will have five objectives: (1) To introduce a diverse set of University students to both the general ecology of the Arctic, and to the specific research questions associated with the greening of the Arctic proposal, *i.e.* How will changes in climate and sea ice affect the terrestrial environment, particularly vegetation composition, structure, and biomass? The field course will have a complementary focus on biodiversity patterns at the landscape and regional scale in the Arctic. (2) To introduce students to an integrated "systems science" approach to terrestrial ecology that is the framework of this study. (3) To introduce students to a variety of research scientists and technicians as well as research techniques in order to further their education. (4) To introduce students to the concept of Traditional Ecological Knowledge and to native elders. (5) To involve two college age Inuit students in the summer field activities along the transect. The field course has facilitated the involvement of twenty formally enrolled university students as well as a number of graduate assistants and local Inuit over the course of the previous biocomplexity study. Fifty-seven participants in all were introduced to the biocomplexity study through the integration of the *Arctic Field Ecology* component. We include native elders and youth as participants in the course in order to foster local participation and to introduce traditional ecological knowledge as a component of the curriculum. We propose to offer a four week summer field course as an integrated component of the NAAT work during IPY. We will offer one section of 6-10 students each field season during 2007 and 2008. We will establish field camps at the NAAT sites in Green Cabin, Mould Bay, and Isachsen during the summer field season and coordinate teaching with research activities associated with the study. These objectives will be accomplished by making the course available internationally, recruiting Canadian Inuit students, selecting a set of non Inuit students from applications, planning and scheduling course activities in conjunction with NAAT logistics and research objectives, recruiting a graduate student to assist in the course and to develop independent research on the effectiveness of educational and research goals of the effort, conducting the course and reporting on activities. Course activities include daily seminars, readings and discussion, field activities, data collection and analysis, reporting and discussion of findings. The class will help organize and participate in evening seminars as a component of the NAAT field camps.

Arctic Geobotanical Atlas (Barbour, Meier, Prokien)

The NAAT will become a major section of the Arctic Geobotanical Atlas, which is funded separately as part of the GOA project. The AGA web-page designer, Edie Barbour, would receive partial funding from this proposal to develop an NAAT component for the atlas. The site will include maps of the sites along the transects, explanations of the research and regional geobotany at each site, and access to key maps and data sets via internet map server software. The web-site will use EarthSLOT visualization software to "fly" along the transect and stop at each of the research sites to educate the public about the nature of the climate gradient, greening of the Arctic and potential impacts. This product would also be used for the NICOP field trip.

NAAT field trip for the 9th ICOP conference (Walker)

If this project is funded, a field trip along the NAAT will be part of the 9th International Conference on Permafrost. For the NICOP field trip, we are requesting funds for VECO to partially support one Twin-Otter flight along the Canadian portion of the NAAT. Participants of the field trip would be expected to pay half of the air support and their camp costs.

SCHEDULE OF TASKS

Project	Activity	Year 1	Year 2	Year 3
1. N. Amer. Arc. Transect	Field Camps (Walker, Kuss, Raynolds)	X	X	
2. Arctic Biomass	Workshop to develop protocols (Walker, Epstein, Shaver, Henry)	X		
	Sampling along the NAAT (Epstein, Munger, Raynolds)		X	
	Remote Sensing and GIS for extrapolation (Munger, Raynolds)	X	X	X
	Geobotanical mapping (Walker, Ping, Tarnocai)	Isachsen	Mould Bay	
3. Coordination with other IPY activities	Camp science and logistic coordination (Kuss)	X	X	
	Project workshops (Walker	X		X
	Project coordination and data management (Walker, Romanovsky, Epstein) Kuss, Maier, Barbour)	X	X	X
4. Education/Outreach	Arctic Field Ecology Course (Gould)	X	X	
	NAAT website development (Barbour)	X		
	NICOP field trip (Kuss)		X	

D. RESULTS OF PRIOR NSF SUPPORT

1. Arctic Climate Change, Substrate, and Vegetation, OPP-9908829, $1,828,990, 7/1/99 – 9/31/04, D.A. Walker, PI, W.A. Gould and H. Epstein, Co-PIs. This project is part of the Land-Atmosphere-Ice Interactions (LAII) Arctic Transitions in the Land-Atmosphere System (ATLAS) study. The primary goal of the overall project was characterization of the fluxes of energy, water, and trace gases in the Arctic. One component of our studies produced maps at several scales including the Circumpolar Arctic Vegetation Map (CAVM) (Muller et al. 1998, Muller et al. 1999, Walker 2000, Walker et al. 2002, CAVM Team 2003, Gould et al. 2003b, Gould et al. 2003c, Walker et al. 2005, Raynolds et al. 2005a, b, c). The project also characterized the vegetation, soil, and spectral reflectance patterns in relationship to zonal vegetation boundaries in the Arctic (Copass et al. 2000, Jia et al. 2002, 2003, 2004, 2006, Raynolds 2006 in press, Riedel et al. 2005a, b, Epstein et al. 2004., Riedel et al. 2005a,b). *This work was highly relevant to the proposed synthesis because (1) The CAVM is the framework for the proposed research, and (2) the greenness studies of Jia et al. in Alaska were our main impetus for further NDVI research.*

2. Biocomplexity associated with biogeochemical cycles in frost boil ecosystems. OPP-0120736, $2,750,421, 10/1/01-9/30/06, D.A. Walker, PI, H.E. Epstein, W.A. Gould, W.B. Krantz, R. Peterson, C.L. Ping, V.E. Romanovsky, Co-PIs. This project is in the final year of funding. This project established the sites along the 1800-km North American Arctic Transect. Frost-heave features play an important role in Arctic-ecosystem functions, including the flux of trace gases to the atmosphere, flux of water and nutrients to streams, and the recycling of important nutrients to wildlife populations. The response of these systems to climate change is different in each bioclimate subzone. An interdisciplinary team of vegetation and ecosystems scientists, climate and permafrost specialists, soil scientists, and modelers is examining the climate, permafrost, geomorphology, soils, vegetation, and invertebrates associated with patterned ground features. Publications to date have included an overview of the project and a conceptual model of how vegetation affects the morphology of patterned ground forms with results from the Low Arctic potion of the gradient (Walker et al. 2003b, Walker et al. 2004, 2005), descriptions of the differential frost heave model, a physically based model of self-organization of frost boils and earth mounds (Peterson and Krantz 2003, Peterson et al. 2003, Daanen et al. 2005), description of a numerical model of frost-boil dynamics (Nikolsky et al. 2004), characterization of the vegetation (Epstein et al. 2005, Kade et al. 2005), descriptions of the soil processes in frost boils (Michaelson et al. 2002, Ping et al. 2002, Ping et al. 2003, 2005a, b), the active layer (Kelley et al. 2004), and the educational component (Gould et al. 2003a). Synthesis activities include a Biocomplexity of Patterned Ground session at the Fall 2006 AGU meeting with papers to be published in the *Journal of Geophysical Research,* and a book is planned that will synthesize the result of the five-year project. *This study is relevant to the proposed work because the NAAT was established during this work, and a great deal of baseline climate, soil, vegetation, and geomorphological information has been collected. This is the only such transect across the full Arctic bioclimate gradient. It has used consistent sampling protocols for a suite of biological and geophysical parameters, and the information from this study will be a key legacy dataset to be combined with the information collected during IPY. Furthermore, the logistics for the transect were worked out during the Bicomplexity project, so we know the transect is feasible. The project also has a strong educational component that will be continued during IPY*

3. Towards an arctic geographic information network: a web-based plant-to-planet-scale geobotanical atlas centered on the Toolik Lake Field Station, Alaska. ARC-0425517, $819,460, 12/15/04-11/30/07. D.A. Walker, PI.

4. Greening of the Arctic: Synthesis and models to examine the effects of climate, sea-ice, and terrain on circumpolar vegetation change. NSF ARC-0531180, $481,765 to UAF and $406,603 to University of Virginia, 2005-2007. 1/1/06-12/31/08. D.A. Walker and H.E. Epstein, Co-PIs.

Projects 3 and 4 have been recently funded by NSF and are part of the GOA initiative along with another project funded by NASA. See p. 1-2 for brief descriptions of these projects.

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*Walker, D. A., H. E. Epstein, W. A. Gould, A. M. Kelley, A. N. Kade, J. A. Knudson, W. B. Krantz, G. Michaleson, R. A. Peterson, C. L. Ping, M. A. Raynolds, V. E. Romanovsky, and Y. Shur. 2004. Frost-boil ecosystems: complex interactions between landforms, soils, vegetation, and climate. Permafrost and Periglacial Processes 15:171-188.
*Walker, D. A., H. E. Epstein, J. G. Jia, C. Copass, E. J. Edwards, W. A. Gould, J. Hollingsworth, J. Knudson, H. Maier, A. Moody, and M. A. Raynolds. 2003a. Phytomass, LAI, and NDVI in northern Alaska: relationships to summer warmth, soil pH, plant functional types and extrapolation to the circumpolar Arctic. Journal of Geophysical Research - Atmospheres 108:8169, doi:8110.1029/2001d00986.
*Walker, D.A., Epstein, H.E., Kuss, P., Michaelson, G.J., Ping, C.L., Raynolds, M.K., Romanovsky, V.E. & Tarnocai, C.T. 2004. Interactions of multiple factors in creating small patterned-ground features across the Arctic bioclimate gradient. *Eos Transactions, AGU* 85, fall supplement: F424.
*Walker, D. A., W. A. Gould, H. A. Maier, and M. K. Raynolds. 2002. The Circumpolar Arctic Vegetation Map: AVHRR-derived base maps, environmental controls, and integrated mapping procedures. Int. J. Remote Sensing 23:25521-22571.
*Walker, D. A., T. D. Hamilton, M. D. Walker, A. Balsar, H. Maier, C. Munder, and N. A. Auerbach. 2003 submitted. Vegetation of the Toolik Lake region in relationship to glacial geology. *in* J. Hobbie, editor. Toolik Lake LTER Book.
*Walker, D. A., A. N. Kade, G. J. Michaelson, C. L. Ping, M. K. Raynolds, V. E. Romanovsky, H. E. Epstein, A. M. Kelley, W. A. Gould, G. Gonzalez, W. B. Krantz, and C. T. Tarnocai. 2003b. Biocomplexity of frost-boil ecosystems: models for analyzing self-organization across the Arctic bioclimate gradient. Biocomplexity in the Environment Awardees Meeting, Arlington, VA, 15-17 Sep 2003.
*Walker, D. A., M. K. Raynolds, F. J. A. Daniels, E. Einarsson, A. Elvebakk, W. A. Gould, A. E. Katenin, S. S. Kholod, C. J. Markon, E. S. Melnikov, N. G. Moskalenko, S. S. Talbot, B. A. Yurtsev, and CAVM Team. 2005. The Circumpolar Arctic Vegetation Map. Journal of Vegetation Science 16:267-282 + appendices.
Williams, M., W. Eugster, E. B. Rastetter, J. P. McFadden, and F. S. Chapin. 2000. The controls on net ecosystem productivity along an arctic transect: A model comparison with flux measurements. Global change Biology 6(S1):116-126.
Young, S. B. 1971. The vascular flora of St. Lawrence Island with special reference to floristic zonation in the arctic regions. Contributions from the Gray Herbarium 201:11-115.
Yurtsev, B. A. 1994. Floristic division of the Arctic. Journal of Vegetation Science 5:765-776.
Zhou, L., and R. B. Myneni. 2004. Satellite-inferred increased activity of arctic tundra between 1982 and 1999 (Case study in Stow, D.A. et al. Remote sensing of vegetation and land-cover change in Arctic tundra ecosystems). Remote Sensing of Environment 89:302-304.
Zhou, L., C. J. Tucker, R. K. Kaufmann, D. Slayback, N. V. Shabanov, and R. B. Myneni. 2001. Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999. Journal of Geophysical Research - Atmospheres 106:20,069-020,083.

F. BIOGRAPHICAL SKETCHES

DONALD A. (SKIP) WALKER
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Professional Preparation:

1964-1967		Mechanical Engineering, Astronautics, U.S. Air Force Academy
1972	B.A.	Environmental Biology, University of Colorado, Boulder
1977	M.A.	Environmental Biology, University of Colorado, Boulder
1981	Ph.D.	Environmental Biology, University of Colorado, Boulder

Appointments:

Professor, Department of Biology and Wildlife, University of Alaska Fairbanks 1999-present
Director, Alaska Geobotany Center, 1999-present
Fellow, Institute of Arctic and Alpine Research, University of Colorado 1986-1999
Co-Director, Tundra Ecosystem Analysis and Mapping Laboratory 1986-1999
Assistant Professor Attendant-Rank (1986-1994), Associate Professor Attendant-Rank (1994-1998), and Professor Attendant-Rank (1998-1999), Department of Environmental Population and Organismic Biology, University of Colorado

Publications, five most relevant:

Jia, G.J., Epstein, H.E. & Walker, D.A. 2003. Greening of arctic Alaska, 1981-2001. *Geophysical Research Letters* 30, 2067, doi: 10.1029/2003GL1018268.

Walker, D.A. 2000. Hierarchical subdivision of arctic tundra based on vegetation response to climate, parent material, and topography. *Global Change Biology* 6: 19-34.

Walker, D.A., Gould, W.A., Maier, H.A. & Raynolds, M.K. 2002. The Circumpolar Arctic Vegetation Map: AVHRR-derived base maps, environmental controls, and integrated mapping procedures. *Int. J. Remote Sensing* 23: 25521-2571.

Walker, D.A., Epstein, H.E., Jia, J.G., Copass, C., Edwards, E.J., Gould, W.A., Hollingsworth, J., Knudson, J., Maier, H., Moody, A. & Raynolds, M.A. 2003. Phytomass, LAI, and NDVI in northern Alaska: relationships to summer warmth, soil pH, plant functional types and extrapolation to the circumpolar Arctic. *Journal of Geophysical Research - Atmospheres* 108: 8169, doi:10.1029/2001d00986.

Walker, D.A., Raynolds, M.K., Daniels, F.J.A., Einarsson, E., Elvebakk, A., Gould, W.A., Katenin, A.E., Kholod, S.S., Markon, C.J., Melnikov, E.S., Moskalenko, N.G., Talbot, S.S., Yurtsev, B.A. & CAVM Team. 2005. The Circumpolar Arctic Vegetation Map. *Journal of Vegetation Science* 16:267-282 + appendices.

Five other significant publications:

Walker, D.A., Auerbach, N.A., Bockheim, J.G., Chapin, F.S.I., Eugster, W., King, J.Y., McFadden, J.P., Michaelson, G.J., Nelson, F.E., Oechel, W.C., Ping, C.L., Reeburg, W.S., Regli, S., Shiklomanov, N.I. & Vourlitis, G.L. 1998. Energy and trace-gas fluxes across a soil pH boundary in the Arctic. *Nature* 394: 469-472.

Walker, D.A., Auerbach, N.A. & Shippert, M.M. 1995. NDVI, biomass, and landscape evolution of glaciated terrain in northern Alaska. *Polar Record* 31: 169-178.

Walker, D.A., Billings, W.D. & Molenaar, J.G.d. 2001. Snow-vegetation interactions in tundra environments. In: H. G. Jones, R. W. Hoham, J. W. Pomeroy and D. A. Walker (Eds.), *Snow Ecology*. Cambridge University Press, Cambridge.

Walker, D.A., Bockheim, J.G., Chapin, F.S.I., Eugster, W., Nelson, F.E. & Ping, C.L. 2001. Calcium-rich tundra, wildlife, and the "Mammoth Steppe". *Quaternary Science Reviews* 20: 149-163.

Walker, D.A., Jia, G.J., Epstein, H.E., Raynolds, M.A., Chapin , F.S., III, Copass, C.D., Hinzman, L., Knudson, J.A., Maier, H., Michaelson, G.J., Nelson, F., Ping, C.L., Romanovsky, V.E. & Shiklomanov, N. 2003. Vegetation-soil-thaw-depth relationships along a low-arctic bioclimate gradient, Alaska: Synthesis of Information from the ATLAS Studies. *Permafrost and Periglacial Processes* 14: 103-123.

Synergistic activities:

Currently PI on a grant to create a web-based hierarchical Arctic Geobotanical Atlas.

Major synthesis of information in chapters and articles on snow ecology (Walker et al. 2001), Arctic vegetation (Walker et al. 2005 in press), and active layer-vegetation interactions (Walker et al. 2003).

Service on the National Research Council Committee on Cumulative Environmental Effects of Alaskan North Slope Oil and Gas Activities (2000-2003) and resulting book: NRC, N.R.C. 2003. *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope*. National Academies Press, Washington, D.C., 288 pp.

Co-editor of book Jones, H.G., Pomeroy, J.W., Walker, D.A. & Hoham, R.W. 2001. *Snow Ecology*. Cambridge University Press, Cambridge, 378 pp.

Directed the creation and publication of the Circumpolar Arctic Vegetation Map (CAVM Team 2003), an 11-year effort involving 35 vegetation scientists from all Arctic countries.

Major collaborators and affiliations:

Nancy Bigelow, *UAF;* Jim Bockheim, *University of Wisconsin; Linda Brubaker, University of Washington;* Terry Chapin, *UAF, Berkeley;* Fred Daniëls, *Institute of Plant Ecology, University of Muenster;* Arve Elvebakk, *University of Tromso, Norway;* Howard E. Epstein, *University of Virginia;* William A. Gould, *International Institute of Tropical Forestry USDA, San Juan, PR;* Larry Hinzman, *UAF;* Allan Hope, *San Diego State University;* Jiong Jia, *University of Virginia;* Jed Kaplan, *Max Plank Institute for Biogeochemisty, Jena, Germany;* Alexia M. Kelley, *Ph.D. student, University of Virginia;* Julie Knudson, *Colorado State University;* William B. Krantz, *University of Cincinnati;* Carl Markon, *USGS, Anchorage, AK;* Nadya Matveyeva, *Komarov Botanical Institute, St. Petersburg, Russia;* Gary Michaelson, *Palmer Research Center, UAF;* Natalia Moskalenko, *Earth Cryosphere Institute, Moscow, Russia;* Fritz Nelson, *New York University, Albany;* Rorik Peterson, *UAF,* Chien-Lu Ping, *Palmer Research Center, UAF;* Martha Raynolds, *UAF;* Valodya Razzhivin, *Komarov Botanical Institute, St. Petersburg, Russia;* Buck Sharpton, *UAF;* Yuri Shur, *UAF;* Stephen Talbot, *USFWS, Anchorage, AK.*

Graduate and Post doctoral advisors:

Dr. Patrick Webber, Michigan State University, M.A. and Ph.D. advisor

Graduate students and post docs:

Anja N. Kade, UAF, Ph.D. major advisor; Corrine Munger, UAF, MS, major advisor: Martha K. Raynolds, UAF, Ph.D. committee member; Andrew Borner, UAF, MS committee member, Carl Markon UAA MS committee member: Amy Carroll, UAF, Ph.D. committee member; Corinne Vonlanthan, UAF, Post-doc; Ina Timling, UAF, Ph.D. committee member; Martin Wilmking, UAF, Ph.D. committee member; Jim Walton UAF, Ph.D. committee member.

VLADIMIR ROMANOVSKY

Academic Preparation:

M.S. - 1975; Geophysics (Honor Diploma), Moscow State University

M.S. - 1985; Mathematics (Honor Diploma), Moscow State University

Ph.D. - 1992; Geology, Moscow State University

Ph.D. - 1996; Geophysics, University of Alaska, Fairbanks

Appointments:

Associate Professor of Geophysics, University of Alaska Fairbanks, Alaska, 1999-present.Research Associate Professor, Geophysical Institute, University of Alaska Fairbanks, Alaska, 1998-1999.

Research Associate, Geophysical Institute, University of Alaska Fairbanks, Alaska, 1996-1998.

Research Assistant, Geophysical Institute, University of Alaska Fairbanks, Alaska, 1992-1996.

Associate Professor of Geophysics and Geocryology, Moscow State University, 1985-1992.

Science Researcher, Department of Geocryology, Moscow State University, Russia, 1980-1985.

Geophysicist, Faculty of Geology, Moscow State University, Russia, 1975-1980.

Publications: five most closely related to the proposed project

Sazonova, TS, Romanovsky, VE, Walsh, JE, and DO Segueev, 2004. Permafrost dynamics in 20th and 21st centuries along the East-Siberian transect, *Journal of Geophysical Research*, V. 109, DO1108.

Sazonova, TS and VE Romanovsky, 2003. A Model for Regional-Scale Estimation of Temporal and Spatial Variability of the Active Layer Thickness and Mean Annual Ground Temperatures. *Permafrost and Periglacial Processes*, 14, pp.125 - 139.

Romanovsky, V, Burgess, M, Smith, S, Yoshikawa, K, and Brown, J, 2002. Permafrost temperature records: Indicators of climate change, *EOS*, *AGU Transactions*, *83*, 50, 589-594, December 10.

Romanovsky, VE and Osterkamp, TE, 2001. Permafrost: Changes and impacts. *In:* Paepe, R and Melnikov, V (Eds.), Permafrost Response on Economic Development, Environmental Security and Natural Resources, Kluwer Academic Publishers, 297-315.

Romanovsky, VE and TE Osterkamp, 2000. Effects of unfrozen water on heat and mass transport processes in the active layer and permafrost, *Permafrost and Periglacial Processes*, *11*, 219-239.

Five other significant publications:

Zhuang, Q, Romanovsky, VE, and AD McGuire, 2001. Incorporation of a permafrost model into a large-scale ecosystem model: Evaluation of temporal and spatial scaling issues in simulating soil thermal dynamics, *Journal of Geophysical Research – Atmospheres*, *106*, D24, 33,649-33,670.

Osterkamp, TE and VE Romanovsky, 1999. Evidence for warming and thawing of discontinuous permafrost in Alaska, *Permafrost and Periglacial Processes, 10*(1), 17-37.

Romanovsky, VE, Osterkamp, TE, and Duxbury, N, 1997. An evaluation of three numerical models used in simulations of the active layer and permafrost temperature regimes, *Cold Regions Science and Technology, 26,* 3, 195-203.

Romanovsky, VE and Osterkamp, TE, 1997. Thawing of the active layer on the coastal plain of the Alaskan Arctic, *Permafrost and Periglacial Processes, 8*(1), 1-22.

Romanovsky, VE and Osterkamp, TE, 1995. Interannual variations of the thermal regime of the active layer and near-surface permafrost in Northern Alaska. *Permafrost and Periglacial Processes, 6*(4), 313-335.

Synergistic Activities:

1. Service to the scientific community as a President of the US Permafrost Association, 2004-2006.
2. Service to the scientific community as a Director of the RAISE (Russian-American Initiative on Shelf-Land Environments in the Arctic) Science Management Office, OPP NSF, 1999-2002.
3. Service on the "Task Force on Climate Change, Permafrost and Civil Infrastructure" of the Arctic Research Commission, 2001-2004.
4. Member of the Arctic Climate System Study (ACSYS)/Climate and Cryosphere (CliC) Numerical Experimentation Group (NEG) of the World Climate Research Programme (WCRP), 2001- present.
5. Member of the NASA NEESPI Science Plan Writing Working Group, 2002- present.
6. Service to the scientific community as a Chair of "Modeling of Permafrost" Subgroup of the International Permafrost Association (IPA), 2003-present.
7. Service to the scientific community as a member of the National Academies "Designing an Arctic Observing Network" Committee of the Polar Research Board, 2004-2006.

Collaborators:

Prof. L.D. Hinzman, Dr. A.D. McGuire, Prof. T.E. Osterkamp, Dr. T.S. Sazonova, Dr. T. Zhang (U of Colorado, Boulder), (U of Alaska, Fairbanks), Prof. K.M. Hinkel (U of Cincinnati, OH), Prof. F.E. Nelson (U of Delaware, DE), Prof. N.N. Romanovskiy (Moscow State University).

Graduate and Postdoctoral Advisors: Prof. S.A. Ushakov, Moscow State University, Prof. B.N. Dostovalov, MSU, Prof. N.N. Romanovskiy, MSU, Prof. V.A. Zakharov, MSU, Prof. T.E. Osterkamp, UAF, Fairbanks.

Thesis Advisor and Postgraduate-Scholar Sponsor the Last 5 Years (Total of 19 students):

Q. Zhuang - PhD 2001 Member of Advisory Committee
Jin Huijun M.S. - 2001 Member of Advisory Committee
A. Bucki M.S. - 2002 Member of Advisory Committee

J. Lovick M.S. - 2003 Member of Advisory Committee
T. Sazonova PhD - 2003 Chairman of Advisory Committee
D. Nicolsky M.S. - 2003 Member of Advisory Committee
S. Pokrovsky M.S. - 2003 Chairman of Advisory Committee
G. Yershova M.S. - 2003 Chairman of Advisory Committee
Ken Tape - M.S. - 2004 Member of Advisory Committee
P. P. Overduin PhD - 2005 Member of Advisory Committee
Fred Calef III PhD - in progress Member of Advisory Committee
Margaret Darrow PhD - in progress Member of Advisory Committee
Lars Backstrom PhD - in progress Member of Advisory Committee
D. Nicolsky PhD - in progress Chairman of Advisory Committee
A. Kade - PhD - in progress, Member of Advisory Committee
L. Oliver – PhD – in progress, Chairman of Advisory Committee

Post Doctoral and Visiting Research Fellows Supported:

R. A. Peterson 2000 – 2001
G. S. Tipenko 2000 – 2005
D. O. Sergueev 2001 – 2003
T. S. Sazonova 2003 – 2004
S. S. Marchenko 2003 – present
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HOWIE EPSTEIN

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Academic Training:

B.A.	1986	Cornell University, Computer Science
M.S.	1995	Colorado State Universit, Rangeland Ecosystem Science
Ph.D.	1997	Colorado State University, Ecology

Professional Experience:

2004-present	*Associate Professor*, Department of Environmental Sciences, University of Virginia, Charlottesville, VA
1998-2004	*Assistant Professor*, Department of Environmental Sciences, University of Virginia, Charlottesville, VA
1997-1998	*Post-Doctoral Research Associate*, Institute of Arctic and Alpine Research, University of Colorado, Boulder, Colorado.
1992-1997	*Graduate Research Assistant*, Departments of Rangeland Ecosystem Science and Forest

Areas of Expertise:

Ecosystem and plant community ecology; climate-plant-soil interactions; grassland, savanna, and tundra ecosystems; field studies, remote sensing and simulation modeling

Five Relevant Publications (total of 47 peer-reviewed articles and chapters):

Jia, G.J., H.E. Epstein and D.A. Walker. 2006. Spatial heterogeneity of tundra vegetation in response to recent temperature changes. *Global Change Biology* 12:42-55.

Walker, M., H. Wahren, L. Ahlquist, J. Alatolo, S. Bret-Harte, M. Calef, T. Callaghan, A. Carroll, C. Copass, H. Epstein, G. Henry, R. Hollister, I.S. Jonsdottír, J. Klein, B. Magnusson, U. Molau, S. Oberbauer, S. Rewa, C. Robinson, G. Shaver, K. Suding, A. Tolvanen, Ø. Totland, P.L. Turner, C. Tweedie, P. Webber, P. Wookey. 2006. Plant community response to experimental warming across the tundra biome. *Proceedings of the National Academy of Sciences* 103:1342-1346.

Chapin III, F.S., M. Sturm, M.C. Serreze, J.P. McFadden, J.R. Key, A.H. Lloyd, A.D. McGuire, T.S. Rupp, A.H. Lynch, J.P. Schimel, J. Beringer, W.L. Chapman, H.E. Epstein, E.S. Euskirchen, L.D.

Hinzman, G. Jia, C.-L. Ping, K.D. Tape, C.D.C. Thompson, D.A. Walker, and J.M. Welker. 2005. Role of terrestrial ecosystem changes in arctic summer warming. *Science* 310:657-660.

Riedel, S.M. H.E Epstein and D.A. Walker. 2005. Biotic controls over spectral indices of arctic tundra vegetation. *International Journal of Remote Sensing* 26:2391-2405.

Epstein, H.E., J. Beringer, C. Copass, W. Gould, A. Lloyd, F.S. Chapin III, C.L. Ping, G. Michaelson, S. Rupp and D.A. Walker. 2004. The nature of spatial transitions in arctic ecosystems. *Journal of Biogeography* 31:1917-1933.

Five Additional Publications:

Riedel, S.M., H.E. Epstein, D.A. Walker, D.L. Richardson, M.P. Calef, E.J. Edwards, and A. Moody. 2005. Spatial and temporal heterogeneity of LAI, NDVI and aboveground net primary production for four tundra types in northern Alaska. *Arctic, Antarctic and Alpine Research* 37:35-42.

Calef, M.P., H.E. Epstein, A.D. McGuire, T.S. Rupp and H.H. Shugart. 2005. Analysis of vegetation distribution in Interior Alaska and sensitivity to climate change using a logistic regression approach. *Journal of Biogeography* 32:863-878.

Epstein, H.E., M.P. Calef, M.D. Walker, F.S. Chapin III, A.M. Starfield. 2004. Detecting changes in arctic plant communities in response to warming over decadal time scales. *Global Change Biology* 10:1325-1334.

Jia, G.J., H.E. Epstein and D.A. Walker. 2004. Controls over intraseasonal patterns of AVHRR-NDVI for the arctic tundra in northern Alaska. *International Journal of Remote Sensing* 25:1547-1564.

Kelley, A.M., H.E. Epstein and D.A. Walker. 2004. Role of vegetation and climate in permafrost active layer depth in arctic tundra of northern Alaska and Canada. *Journal of Glaciology and Geocryology* 26(Suppl.):269-274.

Synergistic Activities:

Council of International Program Directors and Advisors – University of Virginia, 2006

Co-Director of the Program for Environmental and Biological Conservation, Departments of Environmental Science and Biology, University of Virginia – co-developer of a joint undergraduate program in conservation across two science department.

Lower Division Advising Fellow, College of Arts and Sciences, University of Virginia – selected as a University Fellow for advising first and second year undergraduate students; fellowship includes a research award.

Mead Endowment Honored Faculty, College of Arts and Sciences, University of Virginia – received 2004-2005 award for excellence in teaching and faculty-student interactions.

Workshop Participant - participant in the National Center for Ecological Synthesis and Analysis (NCEAS) workshop on "the fate of nitrogen inputs to terrestrial ecosystems."

Review Panel Member: NSF Office of Polar Programs Committee of Visitors – 2003; NASA Earth Science Enterprise (ESE) Interdisciplinary Science (IDS) – 2003

Recent collaborators in addition to all co-authors listed above:

Uma Bhatt, Joey Comiso, Jed Kaplan, Greg Okin, Brian McGlynn, Daniel Welsch

Graduate Advisors and Supervisors:

William K. Lauenroth, Colorado State University (M.S.)

Ingrid C. Burke, Colorado State University (Ph.D.)

Marilyn D. Walker and F.S. (Terry) Chapin, University of Alaska Fairbanks (Post-Doctoral Supervisors)

Graduate and Postdoctoral Advisees:

Mei Yu, postdoctoral research associate (2002-2004); Gensuo Jiong Jia, postodoctoral research associate (1999-2003); Monika Calef (co-advised), Ph.D. 2003; Anne Hochsprung M.S. 2005; Sebastian Riedel, M.S. 2001; Ben Cook, Ph.D candidate; Ryan Emanuel, Ph.D. candidate; Christie Feral, Ph.D. candidate; Lorelei Hartman, Ph.D. candidate; Alexia Kelley, Ph.D. candidate; Junran Li, Ph.D. candidate; Daniel Muth, Ph.D. candidate; Qin Yu, Ph.D. candidate; Jin Wang, Ph.D. candidate

PATRICK KUSS

Personal Data:

Date of Birth:	23 January 1975 in Ludwigshafen, Germany
Citizenship:	German
Work address:	Institute of Botany, University of Basel, Schönbeinstr. 6 CH-4057 Basel, Switzerland, Phone: 0041 61 267 2976, patrick.kuss@unibas.ch
Languages:	German, English, Spanish, Norwegian, French, (rudimentary Russian)

Education

1993	US High School Diploma, Little Miami High School, Morrow, OH exchange student scholarship from Dr. Helmut Kohl, ex-Chancellor of Germany
1995	German Abitur (High School Diploma), Ludwigshafen, Germany
1995-1996	Civil Service with Associación ANAI and Museo Nacional de Costa Rica, Costa Rica
1996-2003	Biology, Soil Science and Scandinavian Language studies, University of Freiburg, Germany
1999	Arctic biology and geophysics studies, University Studies on Svalbard, Norway
2003	German University Diplom (M.Sc.) in Biology, University of Freiburg, Germany Examinations in Geobotany, Plant Physiology, Microbiology and Soil Science
2003	Arctic Field Ecology Course, Banks Island, Canada, course of the University of Minnesota
2003-2006	PhD, Institute of Botany, University of Basel, Switzerland
July 2006	PhD dissertation defence, Institute of Botany, University of Basel, Switzerland

Areas of Specialization

Arctic and Alpine Vegetation Ecology, Molecular Ecology, Phytosociology, Plant Population Demography

Professional Experience

i.	Biocomplexity research expedition, Prince Patrick and Banks Island, Canada
2003	Biocomplexity research expedition, Banks Island, Canada, and Alaskan North Slope, USA
2001	Mycological field assistant, Podocarpus National Park, Loja, Ecuador
2001	Botanical and zoological expedition, Popigai River, Siberia, Russia
2000	Botanical and zoological expedition, Karupelv Valley Project, Trail Ø, Greenland
1999	Botanical and zoological field assistant, Norwegian Polar Institute, Svalbard, Norway
1995-96	Botanical field assistant, Museo Nacional de Costa Rica, Costa Rica

Publications (peer-reviewed):

Kuss P, Pluess AR, Ægisdottir HH, Stöcklin J (2006) *Natural fragmentation and genetic differentiation of three Alpine plants*. American Journal of Botany. (under revision).

Ægisdottir HH, Kuss P, Stöcklin J (2006) *No inbreeding depression in populations of the monocarpic* Campanula thyrsoides *in the Swiss Alps*. Submitted to Flora.

Fischer M, Kuss P, Stöcklin J (2006) *Impact of invasive* Opuntia *species on the native succulent vegetation of Tenerif*e. Submitted to Bauhinia. (in German)

Kuss P, Æegisdottir HH, Stöcklin J (2006) Big bang in the mountains – *the demography of* Campanula thyrsoides *and its implications for long-term persistence*. In preparation for Oecologia.

Kuss P, Ægisdottir HH, Stöcklin J (2006) *Campanula thyrsoides*. In preparation for Perspectives in Plant Ecology, Evolution and Systematics (as part of the Biological Flora of Central Europe).

Kuss P, Raidl S, Beenken L et al. (2004) *Cortinarius huronensis* Ammirat & Smith var. *huronensis* + *Pinus rotundata* Link. Descriptions of Ectomycorrhizae 7/8:21-27.

Kuss P, Metzler B (2006) *Qualitative and functional diversity of ectomycorrhizae fungi associated with Pinus rotundata in raised peat bogs in the Southern Black Forest, Germany.* In preparation for Mycological Progress.

Raidl S, Kuss P (2006) *Cortinarius huronensis* Ammirat & Smith var. *huronensis* + *Pinus rotundata* Link. In preparation for Color Atlas of Ectomycorrhizae.

Kuss P (2006) *The ecology of fire*. Submitted to Schweizer Beiträge zur Dendrologie. (in German)

Kuss P (2005) *Fascination Mountain Biota*. Bauhinia 19:70-71. (book review, in German)

Walker DA, Epstein HE, Kuss P, Michaelson GJ, Ping CL, Raynolds MK, Romanovsky VE & Tarnocai CT (2004). *Interactions of multiple factors in creating small patterned-ground features across the Arctic bioclimate gradient*. Eos Transactions, AGU 85, fall supplement: F424.

MARTHA K. RAYNOLDS (PH.D. STUDENT, EXCEPTIONAL QUALIFICATIONS THAT MERIT CONSIDERATION IN THE EVALUATION OF THIS PROPOSAL)

Professional Preparation

Dartmouth College, Geography-Environmental Studies, B.A. 1978
Virginia Polytechnic Institute and State University, M.S. Botany, 1980
University of Alaska Fairbanks, Vegetation mapping, current Ph.D. student

Appointments

Research Associate, University of Alaska Fairbanks, 2001-present
Research Assistant, University of Alaska Fairbanks, 1999-2001
Consulting Ecologist, ABR, Inc., Fairbanks, 1995-1999
Botanist, Arctic National Wildlife Refuge, USF&WS, 1987-1992

Publications (Five most closely related):

Raynolds, M.K., D. A. Walker and H. A. Maier. (in press 2006). NDVI patterns and phytomass distribution in the circumpolar Arctic. *Remote Sensing of Environment*.

Walker, D.A., M.K. Raynolds, F.J.A. Daniels, E. Einarsson, A. Elvebakk, W.A. Gould, A.E. Katenin,S.S. Kholod, C.J. Markon, E.S. Melnikov, N.G. Moskalenko. S.S. Talbot, B.A. Yurtsev, and the CAVM Team. 2005. The Circumpolar Arctic Vegetation Map. *Journal of Vegetation Science* 16:267-282.

Raynolds, M.K., D. A. Walker and H. A. Maier. 2005. Plant community-level mapping of arctic Alaska based on the Circumpolar Arctic Vegetation Map. *Phytocoenologia* 35(4): 821-848.

CAVM Team (D.A. Walker (project director), W.A. Gould, L.C. Blliss, S.A. Edlund, M.K. Raynolds, S.C. Zoltai, F.J.A. Daniëls, C. Bay, M. Wilhelm, E. Einarsson, G. Gundjonsson, A. Elvebakk, B.E. Johansen, F.V. Ananjeva, D.S. Drozedov, A.E. Katenin, S.S. Kholod, L.A. Konchenko, Y.V. Korostelev, E.S. Melnikov, N.G. Moskalenko, A.N. Polezhaev, O.E. Ponomareva, E.B. Pospelova, I.N. Safronova, R.P. Shelkunova, B.A. Yurtsev, M.D. Fleming, C.J. Markon, D.F. Murray, and S.S. Talbot). 2003. *Circumpolar Arctic Vegetation Map*. Scale 1:7,500,000. Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Walker, D. A., H. E. Epstein, G. J. Jia, A. Balsar, C. Copass, E. J. Edwards, W. A. Gould, J. Hollingsworth, J. Knudson, H. Maier, A. Moody, and M. K. Raynolds, 2003. Phytomass, LAI, and NDVI in northern Alaska: relationships to summer warmth, soil pH, plant functional types and extrapolation to the circumpolar Arctic. *Journal of Geophysical Research* Vol. 108, No. D2, 8169, doi:10.1029/2001JD000986.

Five other relevant papers:

Walker DA, H.E. Epstein, W.A. Gould, A.M. Kelley, A.N. Kade, J.A. Knudson, W. B. Krantz, G. Michaelson, R.A. Peterson, C.L. Ping, M.K. Raynolds, V.E. Romanovsky, Y.Shur. 2004. Frost-boil ecosystems: complex interactions between landforms, soils, vegetation, and climate. Permafrost and Periglacial Processes 15: 171-188.

Gould, W.A., M. K. Raynolds and D.A. Walker. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. *Journal of Geophysical Research*, 108 (D2):8167, doi:10.1029/2001JD000948.

Gould, W.A., M.K. Raynolds, D.A. Walker, H.A. Maier, S. Edlund, and S. Zoltai. 2002. Canadian arctic vegetation mapping. *International Journal of Remote Sensing* 23:4597-4609.

Walker, D.A., W.A. Gould, M.K. Raynolds, H.A. Maier. 2002. The Circumpolar Arctic Vegetation Map: Environmental controls, AVHRR-derived base maps, and integrated mapping procedures. *International Journal of Remote Sensing*, 23: 2551-2570.

Raynolds, M.K. and N.A. Felix. 1989. Airphoto analysis of winter seismic trails in northeastern Alaska. *Arctic* 42(4):362-367.

WILLIAM A. GOULD

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Expertise and interests:

Research and teaching in ecology with a focus on vegetation and plant community ecology, fire ecology, biodiversity patterns and ecosystem consequences, vegetation change, remote sensing analysis, hierarchical GIS spatial analyses, and mapping vegetation and ecosystem properties.

Education:

Ph.D. EPO Biology, University of Colorado–Boulder 1998
M.S. Plant Biology, University of Minnesota 1992
B.S. Biology, University of Minnesota 1988

Current positions:

Research Ecologist, International Institute of Tropical Forestry, USDA Forest Service, Río Piedras, Puerto Rico. 2001-2006
Research Associate, University of Alaska Fairbanks, Institute of Arctic Biology 1999-2006
Instructor, University of Minnesota, Dept. of Ecology, Evolution and Behavior, Lake Itasca Forestry and Biological Station. 1998-2006

Grants:

USGS Biological Resource Division ($120k) *Modeling GAP habitats (PRGAP).* 2006-2008
USGS Biological Resource Division ($270k) *PR-USVI Gap Analysis Project.* 2006-2008
USFS ($20k) *The ecology and distribution of shade coffee in Puerto Rico* 2005-2006
USGS Biological Resource Division ($390k) *Puerto Rico Gap Analysis Project (PR-GAP)* 2002-2006
NSF Biocomplexity proposal ($275k subaward) *Biocomplexity of frost -boil ecosystems* 2002-2006

Five most relevant publications:

1) **Gould, W.A.**, D.A. Walker, and D. Biesboer. 2003. Combining research and education: Bioclimatic zonation along a Canadian Arctic transect. *Arctic*. Volume 56 No. 1. pp 45-54.
2) **Gould, W.A.**, D.A. Walker, M. Raynolds, and H. Maier. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. *Journal of Geophysical Research-Atmospheres*, VOL. 108, NO. D2, 8167, doi:10.1029/2001JD000948, 2003.
3) **Gould, W.A.,** D.A. Walker, M. Raynolds, H. Maier, S. Edlund, and S. Zoltai. 2002. Canadian Arctic Vegetation Mapping. *International Journal of Remote Sensing.* 23:4597-4609.
4) **Gould, W.A**. 2000. Remote sensing of vegetation, plant species richness, and regional diversity hotspots. *Ecological Applications.* 10:1861-1870.
5) Walker, D.A., F. Daniels, A. Elvebakk, **W. Gould**, A. Katenin, C. Markon, M. Raynolds, S. Talbot. 2005. The Circumpolar Arctic vegetation map. *JVS* 16:267-282.

Additional recent publications:

6) Epstein, H.E., J. Beringer, **W.A. Gould**, A.H. Lloyd, C.D. Thompson, F.S. Chapin III, G.J. Michaelson, C.L. Ping, T.S. Rupp, D.A. Walker. 2004. The Nature of Spatial Transitions in the Arctic. *Journal of Biogeography.* 31:12 1917.
7) Walker DA, Epstein HE, **Gould, WA**, Kelley AM, Kade AN, Knudson JA, Krantz W, Michaelson G, Peterson RA, Ping CL, Raynolds MK, Romanovsky VE, Shur Y. 2004. Frost-boil ecosystems: complex interactions between landforms, soils, vegetation, and climate. *Permafrost and Periglacial Processes*. 15: 171-188.
8) Martinuzzi, S., **Gould, W.A.**, & Ramos González, O. 2006. Land development, land use, and urban sprawl in Puerto Rico integrating remote sensing and population census data. *Landscape and Urban Planning.* In press.
9) Martinuzzi, S., **W.A. Gould**, O. M. Ramos, and B. Edwards. 2006. Development of a landform model for Puerto Rico. *Caribbean Journal of Sciences*. In press.

10) **Gould, W.**, G. González, and G. Carrero Rivera. Structure and composition of vegetation along an elevational gradient in Puerto Rico. *J. Veg. Sci.* In review.

GAIUS R. SHAVER

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Birthdate: 19 August 1949
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Education:

B.S. with departmental honors in Biological Sciences, Stanford University, 1972
A.M. in Biological Sciences, Stanford University, 1972 (B.S. and A.M. awarded coterminally)
Ph.D. in Botany, Duke University, 1976

Appointments:

The Ecosystems Center, Marine Biological Laboratory, Woods Hole, Massachusetts:Asst Scientist, 1979 – 198; Assoc Scientist, 1984 – 1990; Senior Scientist, 1990 - present

Brown University, Providence, Rhode Island: Professor (MBL), Department of Ecology and Evolutionary Biology, 2004-present

National Science Foundation, Washington, DC (on leave from The Ecosystems Center) Program Director, Ecosystem Studies, 1996-1998

University of Alaska, Fairbanks: Research Associate, 1976 – 1986; Principal Research Associate, 1986 - present

San Diego State University, San Diego, California: Instructor and Research Associate, 1976 - 1979

Selected Publications:

Shaver, G.R., L.C. Johnson, D.H. Cades, G. Murray, J.A. Laundre, E.B. Rastetter, K.J. Nadelhoffer, and A.E. Giblin. 1998. Biomass accumulation and CO_2 flux in three Alaskan wet sedge tundras: Responses to nutrients, temperature, and light. Ecological Monographs 68:75-99.

Shaver, G.R., J. Canadell, F.S. Chapin, III, J. Gurevitch, J. Harte, G. Henry, P. Ineson, S. Jonasson, J. Melillo, L. Pitelka, and L. Rustad. 2000. Global Warming and Terrestrial Ecosystems: A Conceptual Framework for Analysis. BioScience 50: 871-882.

Shaver, G.R., M.S. Bret-Harte, M.H. Jones, J. Johnstone, L. Gough, J. Laundre, and F.S. Chapin, III. 2001. Species Composition Interacts With Fertilizer To Control Long Term Change In Tundra Productivity. Ecology 82: 3163-3181.

Rastetter, E.B., P.M. Vitousek, C. Field, G.R. Shaver, D. Herbert, and G.I. Ǻgren. 2001. Resource Optimization and Symbiotic N Fixation. Ecosystems 4: 369-388.

Schmidt, I.K., S. Jonasson, G. Shaver, A. Michelsen, and A. Nordin. 2002. Mineralization and allocation of nutrients by plants and microbes in four arctic ecosystems: responses to warming. Plant and Soil 242: 93-106.

McKane, R.B., L.C. Johnson, G.R. Shaver, K.J. Nadelhoffer, E.B. Rastetter, B. Fry, A. E. Giblin, K. Kielland, B.L. Kwiatkowski, J. A. Laundre, and G. Murray. 2002. Resource-based niches provide a basis for plant species diversity & dominance in arctic tundra. Nature 415:68-71

van Wijk, M.T., K. Clemmensen, G.R. Shaver, M. Williams, T.V. Callaghan, F.S. Chapin III, J.H.C. Cornelissen, L. Gough, S.E. Hobbie, S. Jonasson, J.A. Lee, A. Michelsen, M.C. Press, S.J. Richardson, H. Rueth. 2003. Long-term ecosystem level experiments in Toolik Lake, Alaska, and Abisko, Northern Sweden: generalizations and differences in ecosystem and plant type responses to global change. Global Change Biology 10: 105-123.

Mack, M.C., E.A.G. Schuur, M.S. Bret-Harte, G.R. Shaver, and F.S. Chapin, III. 2004. Ecosystem carbon storage in arctic tundra reduced by long-term nutrient fertilization. Nature 431: 440-443

Callaghan, T.V., L.O. Björn, F. S. Chapin III, Y. Chernov, T.R. Christensen, B. Huntley, R. Ims, M. Johansson, D.J. Riedlinger, S. Jonasson, N. Matveyeva, W.C. Oechel, N. Panikov, G. Shaver. 2005. Chapter 7: Arctic Tundra and Polar Desert Ecosystems In: ACIA, 2005. Arctic Climate Impact Assessment. Cambridge University Press. pp. 243-352.

Walker, Marilyn D., C. Henrik Wahren, Robert D. Hollister, Greg H. R. Henry, Lorraine E. Ahlquist, Juha M. Alatalo, M. Syndonia Bret-Harte, Monika P. Calef, Terry V. Callaghan, Amy B. Carroll, Howard E. Epstein, Ingibjörg S. Jónsdóttir, Julia A. Klein, Borgþór Magnússon, Ulf Molau, Steven F. Oberbauer, Steven P. Rewa, Clare H. Robinson, Gaius R. Shaver, Katharine N. Suding, Catharine C. Thompson, Anne Tolvanen, Ørjan Totland, P. Lee Turner, Craig E. Tweedie, Patrick J. Webber, Philip A. Wookey. 2006. Plant Community Responses to Experimental Warming Across the Tundra Biome. Proceedings National Academy of Sciences 103:1342-1346.

"Synergistic" activities

Ecological Society of America: Vice President for Science (2004-2007)

MBL Semester in Environmental Science: course developer, lecturer, lab instructor, and student advisor 1998-2004

SEARCH (Study of Environmental Arctic Change) steering committee 2002-2006

Arctic Climate Impacts Assesment (ACIA); Terrestrial Ecosystems Review Panel, 2001-2005

Editorial Boards: Ecology (1992-1995); Arctic, Antarctic, and Alpine Research (1995-present); Ecosystems (1999-present); Plant and Soil (2000-2002)

Recent Collaborators:

R. Aerts	L. Johnson	W. J. O'Brien
G. Ågren	S. Jonasson	W. C. Oechel
W. B. Bowden	G. W. Kling	S. Perakis
T.V. Callaghan	J. A. Laundre	B. J. Peterson
J. Canadell	R. Julkunnen-Titto	L. Pitelka
F. S. Chapin	J.A. Lee	E. B. Rastetter
J.H.C. Cornelissen	S. McIntyre	L. Rustad
L. A. Deegan	R.B. McKane	M. Sommerkorn
C. Field	J. M. Melillo	M. Steiglitz
A. E. Giblin	A. Michelsen	B. Sveinbjörnsson
D. Herbert	U. Molau	J. Welker
S.E. Hobbie	K. J. Nadelhoffer	M. Williams
J. E. Hobbie	C. Neill	P. Wookey
C.S. Hopkinson	S. Oberbauer	P. Vitousek

Graduate or Postgraduate Advisors:

H.A. Mooney, W.D. Billings

Graduate students and postdoctoral fellows:

Mary Booth	Loretta Johnson	Inger Kappel Schmidt
M.S. Bret-Harte	Annika Nordin	Mark van Wijk
Laura Broughton	Heather Rueth	Yuriko Yano
L. Gough		

GREGORY H. R. HENRY

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Education

McGill University, Plant-insect relations, NSERC postdoctoral scientist, 1987.
University of Toronto, Arctic Plant Ecology, Ph.D., 1987.
Dalhousie University, Environmental Studies, M.E.S., 1981.
Dalhousie University, Biology, B.Sc. (Hon.) Biology, 1978.

Academic Appointments

Research Associate, University of British Columbia, Centre for Biodiversity Research, 2001 - present
Associate Professor, University of British Columbia, 1996-present
Assistant Professor, University of British Columbia, 1992-1996
Adjunct Professor, University of Alberta, Department of Botany, 1989-1992

Adjunct Professor, University of Alberta, Canadian Circumpolar Institute, 1988-1992
Assistant Professor, University of Alberta, 1987-1992

Relevant Research Experience

1. *Response of tundra ecosystems to climate variability and experimental warming*. Warming experiments established in seven tundra plant communities at Alexandra Fiord, Ellesmere Island in 1992, as part of the International Tundra Experiment (ITEX). Warming combined with snow addition and removal, and warming combined with fertilization in two tundra types. Measurements include growth and reproductive responses of plants, soil carbon and nutrient dynamics, and net ecosystem exchange of CO_2 (NEE).

2. *Canadian Tundra Ecosystem Carbon Study (CTECS)*. We established the first study of carbon fluxes in Canadian tundra systems using a combination of eddy covariance and static chamber techniques at the Tundra Ecology Research Station at Daring Lake, NWT in 2004. This is collaborative project with Peter Lafleur at Trent University and Paul Grogan at Queen's University. Studies include experimental manipulations of temperature, nutrients, and snow cover in low shrub tundra, and the influence of caribou grazing is assessed through defoliation experiments and the establishment of large exclosures. Vegetation change and NEE are measured in each of the experimental plots.

3. *ArcticNet – Theme 2: Food, Water and Resources in the Shifting N-S Thermal Gradient of the Terrestrial Eastern Canadian Arctic*. ArcticNet is a Networks Centres of Excellence established in 2003 with over 90 scientists and managers in the natural, human health and social sciences and their partners in Inuit organizations, northern communities, federal and provincial agencies and the private sector to study the impacts of climate change in the coastal Canadian Arctic. The main research platform is the Canadian research icebreaker, the *Amundsen*. I lead project 2.6 "Warming the Tundra: Health, Biodiversity, and Greenhouse Gas Implications" which includes research on responses of tundra systems to climate variability and experimental warming and snow depth manipulations, contaminants, and CO_2 fluxes from both tundra and freshwater surfaces. Community level research links perceptions of vegetation change to studies of permanent plots established near the communities.

4. *Long-term Change in Arctic Tundra Systems*. Changes in tundra vegetation are assessed by re-visiting plots used in previous studies. In 2005, we re-measured plots in wet sedge meadow communities used in my PhD research between 1980 and 1984 and found a significant increase in both aboveground and belowground biomass. This research will be expanded to include sites at Truelove Lowland on Devon Island, the site of the International Biological Program Tundra project from 1969-1972.

5. *Succession after recent deglaciation in the Canadian High Arctic*. The terminus of the Twin Glacier at Alexandra Fiord on eastern Ellesmere Island has retreated nearly 300 m since 1959, with 200 m occurring since 1981, when I began measuring the loss of ice. The precisely dated surfaces has allowed accurate measurements of vegetation development and to test ecological models of succession.

6. *Reconstruction of arctic climate using dendroecological methods on* Cassiope tetragona. I helped to develop a method to retrospectively measure the annual growth and reproduction along branches of the wide spread arctic shrub, *Cassiope tetragona*. Using dendrochronological statistics, we have been able to reconstruct summer climate over the past 100 years in the eastern Canadian High Arctic. Future research will involve reconstructing circumpolar climate from samples collected from throughout the range of the plant.

Relevant Recent Publications

Rayback, S.A. and **Henry, G.H.R**. 2006. Reconstruction of summer temperature for a Canadian High Arctic site from retrospective analysis of the dwarf shrub, *Cassiope tetragona*. Arctic, Antarctic and Alpine Research (in press).

Walker, M.D., Wahren, H., Hollister, R.D., **Henry, G.H.R.**, Ahlquist, L., Alatalo, J.M., Bret-Harte, S., Calef, M., Callaghan, T.V., Carroll, A, Epstein, H., Jónsdóttir, I., Klein, J., Magnússon, B., Molau, U., Oberbauer, S.F., Rewa, S., Robinson, C., Shaver, G.R., Suding, K., Thompson, C., Tolvanen, A., Totland, Ø., Turner, L., Tweedie, C., Webber, P.J., Wookey, P.A. 2006. Plant community responses to experimental warming across the tundra biome. Proceedings of The National Academy of Sciences USA 103: 1342-1346.

Rayback, S.A. and **Henry, G.H.R**. 2005. Dendrochronological potential of the arctic/alpine dwarf shrub, *Cassiope tetragona*. Tree-Ring Research 61: 43-53.

Deslippe, J., Egger, K., & **Henry, G.H.R**. 2005. Impacts of warming and fertilization on nitrogen fixing microbial communities in the Canadian High Arctic. FEMS Microbiology Ecology 53: 41-50.

Welker, J.M., Rayback, S.A. and **Henry, G.H.R**. 2005. Arctic and North Atlantic Oscillation phase changes are recorded in the isotopes ($\delta^{18}O$ and $\delta^{13}C$) of *Cassiope tetragona* plants. Global Change Biology 11: 997-1002.

Tolvanen, A, Alatalo, J.M. and **Henry, G.H.R.** 2004. Resource allocation patterns in a forb and a sedge in two arctic environments-short-term response to herbivory. Nordic Journal of Botany 22: 741-747.

Welker, J.M., Fahnestock, J.T., **Henry, G.H.R.**, O'Dea, K.W. and Chimners, R.A. 2004. CO_2 exchange in three Canadian high arctic ecosystems: response to long-term experimental warming. Global Change Biology 10: 1981-1995.

Jones, G.A. and **Henry, G.H.R**. 2003. Primary plant succession on recently deglaciated terrain in the Canadian High Arctic. Journal of Biogeography 30: 277-296.

Welker, J.M., Fahnestock, J.T., **Henry, G.H.R**., O'Dea, K.W. and Piper, R.E. 2002. Microbial activity discovered in previously ice-entombed arctic ecosystems. EOS, Transactions, American Geophysical Union 83: 281 & 284.

Tolvanen, A., Schroderus, J. and **Henry, G.H.R**. 2002. Age- and stage-based bud demography of *Salix arctica* under contrasting muskox grazing pressure in the High Arctic. Evolutionary Ecology 15: 443–462.

Tolvanen, A. and **Henry, G.H.R**. 2001. Responses of carbon and nitrogen concentrations in high arctic plants to experimental warming. Canadian Journal of Botany 79: 711-718.

Tolvanen, A., Schroderus, J. and **Henry, G.H.R**. 2001. Demography of three dominant sedges under contrasting grazing regimes in the high Arctic. Journal of Vegetation Science 12: 695-670.

Shaver, G.R., Canadell, J., Chapin, F.S., III, Gurevitch, J., Harte, J., Henry, G., Ineson, P., Jonasson, S., Melillo, J., Pitelka, L., Rustad, L. 2000. Global warming and terrestrial ecosystems: a framework for analysis. BioScience 50: 871-882.

Tolvanen, A. and **Henry, G.H.R.** 2000. Population structure of three dominant sedges under muskox herbivory in the High Arctic. Arctic, Antarctic and Alpine Research 32: 449-455.

Arft, A.M., Walker, M.D., Gurevitch, J., Alatalo, J.M., Bret-Harte, M.S., Dale,M., Diemer, M., Gugerli, F., **Henry, G.H.R**., Jones, M.H., Hollister, R.D., Jonsdottir, I.S., Laine, K., Levesque, E., Marion, G.M., Molau, U., Mølgaard, P., Nordenhaus, U., Raszhivin, V., Robinson, C.H., Starr, G., Stenstrom, A., Stenstrom,¨M., Totland, Ø., Turner, P.L., Walker, L.J., Webber, P.J., Welker, J.M., and Wookey, P.A. 1999. Responses of tundra plants to experimental warming: meta-analysis of the International Tundra Experiment. Ecological Monographs 69: 491-511.

Manuscripts submitted

Zalatan, R., Gunn, A., and **Henry, G.H.R**. 2005. Long-term abundance patterns of barren-ground caribou using dendroecology. Submitted to *Arctic, Antarctic and Alpine Research*, July 2005, 21 manuscript pages.

Hill, G.B. and **Henry, G.H.R**. 2006. Long-term sedge meadow response to high arctic climate warming. Submitted to Global Change Biology, May 2006. 17 manuscript pages.

Oberbauer, S.F., Tweedie, C.E., Welker, J.E., Fahnestock, J.T., **Henry, G.H.R.**, Webber, P.J., Hollister, R.D., Walker, M.D., Kuchy, A., and Starr, G. Carbon dioxide exchange responses of arctic tundra ecosystems to experimental warming along moisture and latitudinal gradients. Submitted to *Ecological Monographs* April 2006. 53 ms pages.

Other Publications

Bean, D, and Henry, G.H.R. 2003. *CANTTEX Field Manual Part A: Setting Up a Basic Monitoring Site*. CANTTEX Field Manual. Environment Canada. www.emannorth.ca/canttex. 31 pages.

Bean, D. and Henry, G.H.R. and Rolph, S. 2003. *CANTTEX Field Manual Part B: Additional Methods and Experimental Manipulations*. CANTTEX Field Manual. Environment Canada. www.emannorth.ca/canttex. 59 pages.

Other Evidence of Northern Expertise

Chair, International Tundra Experiment (ITEX), 2003- present.
Chair, Canadian Tundra & Taiga Experiment (CANTTEX), 1999 – present.
Associate editor, Arctic, Antarctic and Alpine Research, 2006 – present.
Editorial associate for the journal Arctic, 1996 – present.
Member, Steering Committee, Ecological Monitoring and Assessment Network –North, 2000-present.
Fellow of the Arctic Institute of North America, 1996 – present.

CHIEN-LU PING

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Education: Chung-Hsing University, Taiwan 1965 B.S. Agriculture Chemistry
Washington State University 1972 M.S. Soils
Washington State University 1976 Ph.D. Soils

Experience:

1993-present Professor of Soil Science, Agricultural and Forestry Experiment Station,
University of Alaska Fairbanks

1989-93 Associate Professor of Soil Science, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks
1982-1989 Assistant Professor of Agronomy, Agricultural and Forestry Experiment Station, University of Alaska Fairbanks
1977-1982 Natural Resource Scientist II, Washington State Department of Natural Resources
1976-1977 Forest Soil Specialist, Washington State Department of Natural Resources

Selected Activities:

Land Grant University representative to the National Cooperative Soil Survey Program in Alaska
Executive Secretary, International Permafrost Association Cryosol Working Group, 1993-1998
Coordinator, Joint US-Russia Seminar on Cryopedology and Global Change, Moscow, 1992
Coordinator, US-Russian exchange in Cryosol study, NE Russia-Alaska, 1992; 1994
Coordinator, Joint international Cryosol study in the Qinghai-Tibet Plateau, 1999
Visiting Professor to National Chung-Hsing University, Taiwan, Feb.-June, 2000
Visiting Senior Scholar to the Cold and Arid Regions Environment and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China, June- Sept. 2000

Recent and Relevant Publications:

Ping, C.L., G.J. Michaelson, E.C. Packee, C.A. Stiles, D.K. Swanson, and K. Yoshikawa. 2005. Characterization and formation of soils in the Caribou-Poker Creek Research Watershed, Alaska. Soil Science Society of America Journal 69:1761-1772.

Ping, C.L., G.J. Michaelson, J.M. Kimble and D.A. Walker. 2005. Soil acidity and exchange properties of cryogenic soils in Arctic Alaska. Soil Science and Plant Nutrition 51 (5): 649-653.

Ping, C.L., R. Boone, M.H. Clark, E.C Packee and D.K. Swanson. 2005. State Factor Control of Soils Formation in Interior Alaska. p.21-38. In Chapin, F.S., III, M. Oswood, K. Van Cleve, L. Viereck, and D. Verbyla.. Alaska's Changing Boreal Forest. Oxford University Press, New York.

Ping, C.L. 2004: Pedology, Soil Classification and Survey: Cold region soils. p.268-276. *In* D. Hillel et al. (eds.) *Encyclopedia of Soils in the Environment*. Elsevier Science Ltd. London.

Ping, C.L., Michaelson, G.J., Overduin, P.P. and Stiles, C.A. 2003. Morphogenesis of frostboils in the Galbraith Lake area, Arctic Alaska. Proceedings of the Eighth International p. 897-90. *In* M. Phillips, S. M. Springman and L.U. Arenson (eds.) Proceedings of the Eighth Inernational Conference on Permafrost, Zürich, Switzerland.

Ping, C.L., G.J. Michaelson, J.M. Kimble, Y.L. Shur and D.A. Walker. 2002. Morphogenesis of soils associated with frost boils. Supplement, Eos Transactions, American Geophysical Union. 83(47):F259.

Michaelson, G.J., C.L. Ping. 2003. Soil organic carbon and CO_2 respiration at subzero temperature in soils of Arctic Alaska. Journal of Geophysical Research. 108 (D2): 8164 (ALT 5-1 – 5-10).

Dai, X.Y., C.L. Ping and G.J. Michaelson. 2002. Characterization of soil organic matter in Arctic tundra soils by different analytical approaches. Organic Geochem. 33(4):407-419.

Ping, C.L., J.G. Bockheim, J.M. Kimble, G.J. Michaelson, and D.A. Walker. 1998 Characteristics of cryogenic soils along a latitudinal transect in arctic Alaska. J. Geophy. Res. 103:28,917-28,928.

Ping, C.L., G.J. Michaelson, and J.M. Kimble. 1997. Carbon storage along a latitudinal Transact in Alaska. Nutrient Cycling in Agroecosystems, 49:235-242.

Graduate Student Advisors:

Patrick **Borden**, Marcus **Clark**, Xiaoyan **Dai**, Claudi **Hoefle**, Anja **Kade**, Evan **Kane** Wendy **Loya**, Lorene **Lynn**, Tom **Malone**, Paul **Overduin**, Lisa **Popovics**, John **Shaw**, Caroline **Sheehy**, Michelle **Weston**, Chunhao **Xu**, Noreen **Zaman**, Lijie **Zhu**.

Recent US Collaborators Other than Co-authors Above and PIs Here:

James M. Bockheim, Univ. Wisconsin
Laodong Guo, University of S. Mississipi
Ron. Sletten, Univ. Washington
T.J. Zhang, Univ. Colorado
John Hobbie, MSL, Woods Hole
Dave McQuire, Univ. Alaska
Josha P. Schimel, UC Santa Barbara

G. SUMMARY PROPOSAL BUDGET

H. BUDGET JUSTIFICATION

Salaries and benefits. The project PI, Dr. D.A. Walker, will lead the project. He has 36 years of experience in the Arctic, including research in geobotanical mapping, remote sensing, and arctic plant ecology, has led five expeditions to the Canadian High Arctic, and coordinated several international efforts including the Circumpolar Arctic Vegetation Map and the Biocomplexity of Patterned Ground project. He is on a 75% FTE. His summer salary is funded by other GOA projects for 3 months in 2007 and 2008. He is requesting 3 mo summer salary support for 2009 plus 3 months in 2008 to cover a sabbatical that he will fully devote to GOA and IPY-related activities.

Dr. Vlad Romanovsky is a co-PI on the project and has 30 years of experience in Russia and other parts of the Arctic. He has established the climate and permafrost monitoring program along the NAAT and will coordinate activities related to climate, active layer, and permafrost along the NAAT. He will establish bore-holes for monitoring permafrost temperatures at Isachsen, Mould Bay, and Green Cabin and will maintain the climate, active layer, and heave monitoring at all the sites. He is requesting 1 month of summer salary support per year.

Dr. Patrick Kuss will be a post-doctoral research associate on the project (listed with "other personnel" in Year 1 and with "senior personnel" in Years 2 and 3.) He has many years experience in the Arctic including participating in two expeditions along the NAAT and expeditions to Greenland, Siberia, and Svalbard. He has just completed his Ph.D., which investigated the genetic differentiation in of plants in the alpine. He will have many roles in the project including coordinate the science activities at Isachsen, Mould Bay and Green Cabin, coordinate the data management activities, organize the 2008 NICOP NAAT Field Trip, and develop a science project related to the GOA objectives. His salary is fully covered for the project.

The project will have one Ph.D. student, Martha Raynolds, who is examining the NDVI spatial relationships for the circumpolar region. She has organized all the previous expeditions of the Alaska Geobotany Center to the Canadian High Arctic. She has over 20 years of Arctic experience and was the principal mapper of Circumpolar Arctic Vegetation Map and first author of the Alaska Arctic Tundra Vegetation Map. She will assist Dr. Kuss in organizing the expeditions in 2007 and 2008. She will also organize the biomass field campaign in 2008. Her academic year salary is covered by a UAF Fellowship in Year 1, and 50% by the GOA Synthesis project in Year 2. She is requesting 6 mo salary in Years 2 and 3.

Corinne Munger is a Masters student who is analyzing the spatial and temporal patterns of NDVI at Toolik Lake. She has worked at the Alaska Geobotany Center for four years and has participated in the 2005 expedition to Isachsen. Her salary is covered by a TASK Fellowship in 2007, and she is requesting full funding for years 2 and 3. She will conduct field research in conjunction with her thesis at Toolik in 2007, and assist with the biomass field campaign in 2008.

The technical staff at UAF include Hilmar Maier and Edie Barbour. Mr. Maier's salary is fully covered in Year 1 by the GOA Synthesis project and the Arctic Geobotanical Atlas (AGA) Project. We are requesting 3 mo support for him in Years 2 and 3. Ms. Barbour's salary is covered in Year 1 by the AGA project. She is requesting 3 mo support in years 2 and 3.

We are also requesting support for two undergraduate students to assist with biomass sampling and sorting, and data management.

All personnel have a 3% inflation rate added to salaries. All graduate students work 50% during the academic year and full time during the summer.

Permanent equipment. No permanent equipment is requested.

Travel. Travel funds are requested for 10 US and 10 foreign participants to attend a workshop to develop the international protocols for sampling and reporting biomass data. $2000 is budgeted for each domestic trip, and $2500 is budgeted for each international trip to include airfare, per diem, and hotel.

Travel funds are requested for 20 participants to get to Inuvik for the summer field seasons in Years 1 and 2. These costs are budgeted at $2000 per participant to include air fare, per diem and hotel enroute.

Travel funds are requested for 20 RT to Inuvik to participate in the 2007 and 2008 field seasons at Isachsen and Mould Bay. These are for people involved in the project from US institutions. The costs are budgeted at $2000 per RT to cover plane fares, per diem and hotel costs at Dawson enroute to Invuvik.

Participant support costs. There are no participant support costs in the budget.

Other direct costs.

Materials and supplies. $2500 per year is budgeted for high-resolution remote sensing imagery (ASTER, IKONOS) of the Isachsen, Mould Bay, and Green Cabin sites.

$10,000 is budgeted in Year 1 to cover the cost of materials and supplies for drilling the shallow permafrost bore holes at Isachsen, Mould Bay, and Green Cabin. At each location, five shallow boreholes (2-5 m deep) will be drilled along a topographical and soil moisture gradient. Each hole will be equipped by four-channel U12 Hobo mini-logger to continuously (one hour time resolution) measure ground temperature at four different depths. A Hobo H8 Pro mini-logger will be also installed near the borehole for continuous measurements of the ground surface temperature and the ground temperature near the permafrost table with the same time resolution. The cost of one full set of equipment for one borehole (including PVC pipe) is $600.00. We will need $9,000.00 to equip all planned sites. $1,000.00 will be necessary for the drilling accessories.

Computer. $2000 per year is budgeted to cover anticipated GIS and remote sensing support, including plotter and copier supplies and computer maintenance charges. These costs are based on annual costs of about $6000 for maintaining the GIS facility at the Alaska Geobotany Center (AGC). We estimate that about 1/3 of the yearly AGC activity will be devoted to NAAT related issues including development of the NAAT web site, and maps and GIS products for the remote-sensing and geobotanical mapping at the Canadian sites.

Publication and communication. $5000 is budgeted in Year 2 to cover the production and publication of the biomass protocols that will be part of the ITEX sampling manual.

Services: $10,000 per year is budgeted for soils and landform maps of Isachsen and Mould Bay in Years 1 and 2. Dr. Chien Lu Ping and Dr. Charles Tarnocai to will make the maps at 1:5000-scale for 25 km^2 areas at both sites and will conduct soil surveys along toposequences.

$8,000 per year in Years 1 and 2 is budgeted for the services of Dr. Misha Zhurbenko, Dr. Olga Afonin, and Dr. Alexei Potemkin to identify the lichens, mosses, and liverworts that will be collected during phytosociological and mapping studies at Isachsen and Mould Bay. This cost is based on their current rate of $4/specimen and collection of 2000 specimens per year.

Subcontracts. $50,000 per year is budgeted to International Institute of Tropical Forestry in Puerto Rico for the services of Dr. William Gould, who will be a co-PI and in charge of the Arctic Field Ecology course.

$17,500 per year is budgeted for a subcontract to the University of Virginia for the services of Dr. Howard Epstein. He is a co-PI on the project and is directing much of the NDVI and biomass related work. He will help in organizing the 2007 biomass workshop and help in the remote-sensing aspects of the NDVI maps of Isachsen and Mould Bay. He is requesting 0.5 month of summer salary support per year plus $10,000 to help in the analysis and production of the the NDVI maps at Isachsen and Mould Bay.

Other. In-state-tuition fees are requested for the M.S. thesis of Corinne Munger.

Indirect costs. An agreed **modified total direct cost (F&A)** rate is set at 47.5% by the University of Alaska Fairbanks. All professional and technician salaries are increased 3% annually. All materials and service costs are estimates based on current information available at the time of the writing.

VECO Polar Resources (VPR): The cost of supporting the 2007 and 2008 field camps at Isachsen and Mould Bay are included in an attached letter and budget from VPR. Their preliminary estimate of $693,730 covers the cost of establishing two 20-person camps for two months in 2007 and 2008 at Isachsen and Mould Bay. The cost includes Twin Otter and DC-3 air support for the camps. It also includes 40 hours of helicopter support in 2008 at Isachsen, support for small fly camps at Green Cabin in 2007 and 2008 and at Meighen Island in 2008. The budget also includes $44,166 for four days of Twin-

Otter support for the NICOP NAAT Field Trip in 2008. This includes $28,000 for DC-3 support to position the fuel for the field trip and $16,166 for the Twin Otter.

The VPR estimate does not include any cost-sharing with other researchers. Considerable cost sharing may be possible with Canadians involved with the ITEX-CiCAT project if that project is funded. The items where cost sharing with ITEX are possible are identified as "ITEX collab." Other projects identified as collaborators are submitting budgets that cover their own logistic costs.

I. CURRENT AND PENDING SUPPORT

J. FACILITIES, EQUIPMENT, AND OTHER RESOURCES

ALASKA GEOBOTANY CENTER

The mission of AGC is to explore and understand global tundra ecosystems and to foster responsible land use and conservation of these systems. The Center is dedicated to excellence in field research, teaching and making our teaching and research relevant to societal issues and concerns. Interdisciplinary geobotanical research involves the cooperation among vegetation scientists, soil scientists, hydrologists, geologists, geographers, permafrost specialists, and other involved in Earth system research. Our primary areas of interest are climate change, paleoecology, vegetation classification and analysis, geobotanical mapping, snow ecology, and disturbance ecology in northern regions. AGC is located in the Institute of Arctic Biology (IAB) at the University of Alaska Fairbanks. The facilities of the Institute include a well-staffed administrative office, and a library specializing in northern topics.

AGC's lab facilities include equipment to support vegetation and soil field research and computer equipment to support GIS and remote-sensing work. AGC's current computing resources include a total of 14 GIS workstations, personal workstations, portable notebook computers, file servers and web servers. The AGC maintains a full complement of high-end software and peripheral devices to support our GIS and remote-sensing environment, allowing us to perform advanced GIS analysis, image processing and graphic layout on the Unix, Macintosh and Intel platforms. The major software packages currently used at AGC include ARC/Info Workstation, ArcView and ArcGIS (Environmental Research Systems, Inc.) for geographic information system analysis and cartographic design, ENVI (Research Systems, Inc.) and Land Analysis System (USGS) for manipulation and analysis of multi-spectral remote sensing data, Photoshop (Adobe Systems, Inc.) for editing graphic images and Studio MX (Macromedia, Inc.) for website development and graphic production. We will also utilize TerraExplorer, a 3-D "full motion flight" simulator developed by Skyline Software, which is being developed as a user interface for the web site for the Arctic Atlas.

THE GEOPHYSICAL INSTITUTE

The Geophysical Institute has an extensive collection of high latitude climate library resources. Some of the arctic specific information is available nowhere else. Additionally, what is not available locally, such as more exotic interdisciplinary materials, can be obtained efficiently using the elctronic document delivery services covering both stocked and unstocked journals.

A sufficient amount of computer resources, including Macintosh and LINUX workstations, are available for the climate analysis. These machines are used for running the numerical codes and analysis of the data and presentation preparation. Additionally, and very importantly, the group access to significant super-computer resources in the form a Cray X1 and several IBM SP and Regatta systems at the Arctic Region Supercomputing Center (ARSC) located at UAF. The supercomputer facility is already used extensively by Uma Bhatt in running the GCMs and doing data analysis and can provide resource to facilitate the use of high-resolution remote sensing data. A high-end visualization facility (including a CAVE) is available to the group at ARSC.

K. LETTERS OF COMMITMENT

30 November 2005

Dear Prof Donald (Skip) Walker

On behalf of the ICSU/WMO Joint Committee for the International Polar Year 2007-2008 we wish to thank you for submitting a proposal entitled 'GREENING OF THE ARCTIC: CIRCUMPOLAR BIOMASS:' for consideration as an IPY activity. Success of the IPY depends fundamentally on excellent research and support and on a high level of international coordination, derived from the talents and energy of groups such as yours.

At its November meeting in Geneva the Joint Committee completed evaluations of all proposals received up to 30 September 2005 for scientific or educational significance, for consistency with the IPY themes, regions and time frames, for evidence of international collaboration, and for development of effective management plans covering communications, operations, data, and education and outreach. In addition, the Joint Committee examined each proposal for evidence of involvement by scientists from non-polar nations, for indications of interdisciplinarity within the proposal and of linkages to other IPY activities, and for evidence that activities proposed would contribute to an IPY legacy. The Joint Committee evaluated more than 200 coordination proposals and expects to evaluate one additional set of coordination proposals submitted by 31 January 2006.

The Joint Committee considers that your proposal as submitted includes very strong scientific, education and outreach components and demonstrates a high level of adherence to IPY themes and goals. The Joint Committee therefore endorses your proposal as a prominent and valued part of the IPY program. The Joint Committee intends that these endorsements will provide assistance as IPY participants seek funding for the work proposed.

The IPY International Programme Office will shortly provide additional guidance for project coordinators and steering groups, including description of initial IPY information management processes. As part of that information exchange, we will expect project coordinators to keep the IPO informed about funding status of their projects and about substantial changes from the projects as proposed. In all cases, we wish you enormous success with your component of the IPY.

Yours sincerely

Co-chairs of Joint Committee

Ian Allison Michel Béland

Conservation of Arctic Flora and Fauna

5 January 2006

Donald A. Walker, Ph.D
Professor, Institute of Arctic Biology
Director, Alaska Geobotany Center
University of Alaska Fairbanks
PO Box 757000
Fairbanks, Alaska 99775-7000

Dear Skip,
It was a pleasure meeting you again at ICARP II.

As a follow-up to all our verbal discussions and emails to date, this letter may serve as CAFF's formal endorsement for your Greening of the Arctic IPY project. In addition, CAFF fully endorses all efforts toward the boreal forest mapping project.

This letter reaffirms CAFF's formal endorsement which you received when you originally presented your project to the CAFF Management Board in Helsinki, February 2005. All eight Arctic countries were present at this meeting.

Though CAFF cannot commit funds at this time, we will offer whatever other support is applicable and possible. We are very interested in following the progress, and will help facilitate contacts and coordination with other ongoing Arctic initiatives as best as possible - especially as they relate to the CAFF Flora Group which is now the IUCN SSC Arctic Plant Specialist Group; and the projects under the Circumpolar Biodiversity Monitoring Program (CBMP).

Please contact me if anything additional is required.

Sincerely,

Maria V Gunnarsd

Maria Victoria Gunnarsdottir
Executive Secretary
CAFF International Secretariat

MARINE BIOLOGICAL LABORATORY

WOODS HOLE, MASSACHUSETTS 02543 (508) 548-3705 FAX: (508) 457-1548

THE ECOSYSTEMS CENTER

19 April 2006

Donald A. (Skip) Walker, Ph.D
Professor, Institute of Arctic Biology
Director, Alaska Geobotany Center
PI-GOA IPY initiative
University of Alaska Fairbanks
PO Box 757000
Fairbanks, Alaska 99775-7000

Dear Skip,

The Arctic LTER project strongly supports your efforts to establish a string of terrestrial observatories along the North American Arctic Transect, with Toolik Field Station as a southern "anchor." Establishment of the NAAT will greatly facilitate our ability to scale up from the diverse, intensive, long-term research that has been carried out at Toolik since 1975. Establishment of the NAAT also presents significant opportunities for interaction with the developing Flagship Observatory we are trying to build at Toolik Lake, including our current proposal for a PanArctic IPY Network of Carbon/Water/Energy observatories.

I personally also look forward to interacting with you on the NAAT research, including the development of standard biomass sampling protocols and other protocols for PanArctic comparison of vegetation properties and processes. As part of my own research on C fluxes, I hope to be able to visit all the NAAT sites within the next 3-5 years. Research of this type is always enhanced by a strong established data base for each site, allowing a much richer interpretation and application of any new results.

Please let me know if there is anything else I can do to help.

Cheers,

G. R. Shaver

Gaius R. Shaver

Jerry Brown
P.O. Box 7
Woods Hole, MA 024543

April 18, 2006

Dr. Donald A. Walker
Professor, Institute of Arctic Biology
Director, Alaska Geobotany Center
University of Alaska Fairbanks
PO Box 757000
Fairbanks, Alaska 99775-7000

Dear Skip:

I understand you are submitting an IPY proposal entitled “Greening of the Arctic (GOA): North American Arctic Transect (NAAT)”. The proposal is most timely and will provide an outstanding legacy for the IPY. I endorse the proposal for a number of reasons.

Many aspects of the proposal directly compliment and supplement the objectives of the three of the four coordinated permafrost programs that have been approved by the IPY Joint Committee: (Thermal – TSP #50; Coastal-ACCO-Net #90; Carbon CAPP #373). Several of these investigators are involved in your current and proposed GOA projects. We plan to include the GOA as a cooperating project in the IPY-IPA permafrost program.

Your proposal will provide additional sites for the permafrost observatory network that includes active layer measurements (CALM) and permafrost temperatures (TSP); including the High Arctic sites at Isachsen, Mould Bay, and Green Cabin. In addition, the Ninth International Conference on Permafrost to be held in Alaska includes the field excursion along the NAAT. This will offer an excellent opportunity for some participants to visit the field sites and to present related information at the Conference.

Finally, your results will help explain recent trends in active layer thickness and permafrost temperatures for Northwestern North America and serve as a long-term baseline against which to interpret future changes.

Sincerely,

Jerry Brown, President
International Permafrost Association

PS: I am in the field and do not access to my IPA letterhead or my signature.

UNIVERSITY OF DELAWARE

DEPARTMENT OF GEOGRAPHY

University of Delaware
Newark, Delaware 19716-2541
Ph: 302/831-2294/2295
Fax: 302/831-6654

January 24, 2006,

Dr. D. A. Walker, Director
Alaska Geobotany Center
University of Alaska—Fairbanks
BO Box 757000
Fairbanks, AK 99775-7000

Dear Skip:

I write to express my enthusiastic support for your proposed "North American Arctic Transect" project. The work you describe in the proposal will provide a unified scientific basis for evaluating changes in the Arctic region over a long period. Its international character, use of standardized methods, and geographic scope are in the spirit of the International Polar Year and guarantee the project's success and influence.

I was very glad to learn that you will include the collection of data pertaining to the active layer and upper permafrost in your protocol. This is an important aspect of the proposed project. The Circumpolar Active Layer Monitoring (CALM II) project will be glad to assist in any capacity it can, including development of observation strategies, cross-linking your data with those in the CALM archive, and collaborating in data synthesis and publication. We are particularly pleased that you will consider designating your sites as part of the CALM network, as this will help to insure that observations continue at them after the conclusion of your project.

I extend my best wishes to you for this important project. Please let me know how CALM can assist with its development.

Yours sincerely,

Frederick E. Nelson
Professor
Principal Investigator, CALM II

2006 April 19

Donald A. Walker, Ph.D
Professor, Institute of Arctic Biology
Director, Alaska Geobotany Center
University of Alaska Fairbanks
PO Box 757000
Fairbanks, Alaska 99775-7000

Dear Skip:

I have read your proposal entitled "IPY: Greening of the Arctic (GOA): North American Arctic Transect (NAAT)." I am happy to be a collaborator on the project because there are many areas of potential collaboration with our Canadian IPY proposal "Climate Change Impacts on Canadian Arctic Tundra Ecosystems (CiCAT): Interdisciplinary and Multi-scale Assessments". CiCAT will provide the first comprehensive assessment of the state of Canadian arctic tundra ecosystems and their vulnerabilities in response to climate change. The proposal involves 50 scientists from across Canada, and will serve as the Canadian contribution to the IPY core project "International Tundra Experiment (ITEX): impacts of long-term experimental warming and climate variability on tundra ecosystems" (led by Greg Henry) and will link to many other IPY projects within Canada and internationally.

The Canadian portion of your NAAT coincides with the "Western Transect" in our CiCAT proposal. We will help to coordinate both the science and logistics along this transect. We can also help in the coordination with other Canadian researchers who will be interested in using the climate gradient for a variety research activities. We would be interested in using the databases you have developed at the Issachsen, Mould Bay, and Green Cabin sites. In addition, we will work with you to further develop these data bases and to make them compatible with those from the other CiCAT sites.

Your proposed workshop to establish protocols for collecting and reporting circumpolar tundra biomass data is also central to the goals of CiCAT, and I will work with you to help organize this workshop and incorporate the results into the revised ITEX Manual.

Your proposal is truly in the spirit of the International Polar Year and will greatly help us understand the issues related to the rapidly changing terrestrial system.

Very best regards,

Dr Greg Henry
Principal Investigator, CiCAT IPY initiative and Chair, International Tundra Experiment (ITEX)
Department of Geography
University of British Columbia
Vancouver, BC V6T 1Z2, Canada

www.geog.ubc.ca/itex
cc: IPY Joint Committee ipyipo@bas.ac.uk

April 22, 2006

Dr. Skip Walker
Institute of Arctic Biology
University of Alaska Fairbanks
Fairbanks, AK 99775

Dear Skip:

We strongly support your Greening of the Arctic (GOA) North American Arctic Transect (NAAT) proposal and your plan to make the NAAT part of the Arctic Observatory Network. Satellite observatories will be an important complement to the main group of Flagship Observatories with whom we propose to work. The Toolik Field Station agrees to act as the southern anchor point for the NAAT to help with logistics and science where needed. This would be a synergistic activity because the NAAT will enhance the Toolik Lake research capabilities. Researchers from Toolik would be encouraged to take advantage of the climate, permafrost, active layer, soil, invertebrate, and vegetation information that you are collecting from the NAAT sites and to participate in field research at these sites. The transect will also offer a variety of educational opportunities that could be centered at Toolik.

The string of satellite observatories that you are proposing will also enhance our own IPY proposal to develop a PanArctic IPY Network of Carbon/Water/Energy observatories. Your plan to focus on the spatial and temporal variation in circumpolar biomass will greatly enhance efforts to synthesize and scale observations of carbon, water, and energy fluxes to the pan-Arctic.

They are also complementary to our on-going process-level studies of shrub dynamics in northern Alaska. The spatial and temporal analysis of NDVI proposed by Corinne Munger at Toolik Lake should give us insight as to the changes that have occurred in the Toolik Lake region during the past two decades. We will also by interested in the biomass protocol workshop you have proposed and would like to participate in this effort.

Both Brian Barnes and I hope that both your project and ours are funded!

Sincerely,

Dr. Syndonia Bret-Harte
Associate Science Director, Toolik Field Station
Research Assistant Professor
Institute of Arctic Biology
University of Alaska
Fairbanks, AK 99775

DEPARTMENT OF
FISHERIES AND WILDLIFE

OREGON
STATE
UNIVERSITY

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April 20, 2006

Dr. Skip Walker
Director, Alaska Geobotany Center
University of Alaska – Fairbanks
PO Box 75700
Fairbanks, Alaska 99775-7000

Dear Skip:

I have read your proposal entitled "IPY: Greening of the Arctic (GOA): North American Arctic Transect (NAAT)". Your proposal focuses on completing the fourth of four legs of the larger GOA project. One objective is to stabilize field operations at high Arctic (Subzones A and B) stations in the North American Arctic, so that these data-rich sites can serve as "magnet" locations for collaborative work during IPY. A second goal is to determine the strength of relationships between biomass and NDVI at four spatial scales, ranging from individual GOA plots to landscape, regional, and circumpolar scales. The third and fourth goals involve coordination with other SEARCH, IPY, and LTER activities as well as providing selected educational opportunities.

We are extremely interested in the implications of GOA for helping to elucidate likely future trajectories of change related to partitioning of atmospheric contaminants from the atmosphere to terrestrial landscapes and thence into terrestrial foodwebs. Because of the extensive datasets for GOA sites regarding climate, soils, and vegetation there is high potential for deep collaboration with our IPY project ("IPY: Atmospheric transport, deposition, and retention of bioaccumulative contaminants in the Arctic: Terrestrial ecosystems and community response to change (ATRESP)"). If funded we are planning to include many of the GOA sites (specifically including Isachsen and Mould Bay) in our studies.

Contaminant studies are often limited by the paucity of critical multi-scale data on key climate and other variables, which hampers modeling. Paul Bartlett, who is handling the atmospheric modeling part of our project, will certainly be able to make good use of the rich data sets from GOA sites in both North America and Asia to inform his transport models. Further and reciprocally, our project may be able to provide scenario-based outputs that may be of use to GOA and GOA-related projects.

We think the opportunity to combine our studies on one set of climate response variables of significant interest to Arctic residents (contaminants)

ABISKO
NATURVETENSKAPLIGA
STATION
KUNGL. VETENSKAPSAKADEMIEN
ABISKO SCIENTIFIC RESEARCH STATION
THE ROYAL SWEDISH ACADEMY OF SCIENCES

22[nd] April 2006

To Whom it May Concern,

Re: IPY Proposal GOA *"Greening of the Arctic"* proposal by Dr. D. Walker, University of Ala

I hereby confirm that I am enthusiastic to collaborate with Dr. Donald Walker in the above proposal Royal Swedish Academy of Sciences' Abisko Scientific Research Station is committed to undertakir ecological research and monitoring within its own research and long-term monitoring mandates, and within research projects that the Station operates or participates in. The Station is also committed to hosting such projects operated by researchers using the Station's facilities.

The Director's experience within the Arctic Climate Impact Assessment, the planning of the Arctic Observatories Network (AON) and the International Conference for Arctic Research Planning (ICA has highlighted the necessity for basic ecological measurements to be made at Flagship Observatorie satellite field stations and particularly in remote locations that are infrequently visited yet potentially represent important aspects of ecological variability. The concept of GOA that combines fundament ecological measurements with remote sensing is compelling and the Abisko Station and I would be enthusiastic to contribute to the project. Collaboration between GOA and planned IPY proposals, particularly BTF ("Back to the Future") that aims to revisit old, often isolated sites, to record basic ecological information would generate significant synergy.

The Abisko Station coordinates SCANNET (a network of 16 Scandinavian and North European Fie bases) and is the European coordinator of CEON (Circumarctic Environmental Observatories Netw within which the GOA proposal is highly relevant. The Station would be willing to disseminate rele GOA information or requests for data etc. within these networks. I am also eager to seek legacy, a n goal of IPY, by adopting any new measurements at the Abisko Station that could be relevant for lon term monitoring. Further, the Station co-ordinates the IPY project COMAAR "Consortium for coordination of observation and monitoring of the Arctic for assessment and research" that is under auspices of the Arctic Council of Ministers, and I would be happy to collaborate with Dr. Walker to establish an interface between GOA and COMAAR.

Please do not hesitate to contact me should you require further information,

T. V. Callag

Prof. Dr. *h.c.* Terry V. Callaghan

Director

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April 24, 2006

Prof. Donald "Skip" Walker
Director, Alaska Geobotany Center
Institute of Arctic Biology
University of Alaska Fairbanks

Subj: Letter of support for proposal to NSF "IPY: Greening of the Arctic (GOA): North American Arctic Transect (NAAT)"

Dear Skip,

This letter is to acknowledge my role as Major Collaborator and confirm my full support of your proposal "IPY: Greening of the Arctic (GOA): North American Arctic Transect (NAAT)" to the National Science Foundation. I am delighted to be associated with this work as I believe that your proposal hits on a major, much neglected aspect of Arctic ecosystem change, specifically the linkage between a declining sea ice cover and associated atmospheric and terrestrial change in the coastal regions. Given that much of our knowledge and long-term observations of the Arctic system derive from sites within less than <10 km of the coast, your approach to consider this problem from a broader, integrated perspective matches our interests well.

In support of your work I am planning to make available to you detailed analyses of coastal sea ice data (onset of freeze-up, first ice, break-up, ice-free coasts, distribution of recurring lead systems as source of heat etc.) that we have collected for the time period 1996-2004 along the Alaska coastline at spatial resolutions compatible with your project goals. As part of our pending proposal "IPY: Collaborative research on the state of the Arctic sea ice cover: An integrated seasonal ice zone observing network (SIZONET)" we are planning to continue and expand this work and are aiming to closely coordinate our field measurements and remote sensing activities with your group. Specifically, we are looking forward to joint field campaigns along key sites of your Arctic transect and have requested synthetic aperture radar (SAR) coverage as part of our project plans for the coastal areas of your study region. As I have data credits for at least one more year of such Radarsat SAR data in this region, I would be happy to work with corresponding imagery covering your study area independent of the success of our proposal.

With best wishes,

Hajo

Hajo Eicken
Associate Professor of Geophysics
e-mail: hajo.eicken@gi.alaska.edu, phone: 907-474-7280
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April 25, 2006

Donald A. Walker, Ph.D
Professor, Institute of Arctic Biology
Director, Alaska Geobotany Center
University of Alaska Fairbanks
PO Box 757000
Fairbanks, Alaska 99775-7000

Re: GOA NAAT proposal

Dear Dr. Walker:

By this letter I like to express my willingness to collaborate on the Isachsen and Mould Bay mapping and toposequence studies as part of the Greening of the Arctic proposal.

As I am always interested in the relationship between vegetation communities and geospatial distribution of soils in the arctic tundra, the toposequence study of soils and vegetation in Isachsen and Mould Bay would be the first for the High Arctic. The information gained form this study would contribute to our understanding of the effect of shrub expansion on soil properties.

I look forward to working with you on this exciting project.

Sincerely,

Chien-Lu Ping, Ph.D.
Professor of Soil Science
Palmer Research Center
School of Natural Resources and Agricultural Sciences
University of Alaska Fairbanks
533 E. Fireweed Ave.
Palmer, AK 99645
Tel: 907-746-0462
Fax: 907-746-2677
e-mail: pfclp@uaa.alaska.edu

26 April 2006

Dear Skip,

I am writing to convey my strongest support for your “IPY: Greening of the Arctic” proposal. The work your team has carried out characterizing vegetation and soil processes along a transect spanning the five bioclimatic zones you have identified is fundamental to improving our understandings of arctic ecosystem function. The diverse data collected at each site along your transect provides a critical baseline against which to evaluate future changes in the arctic.

In my view, the next steps you propose should be given high priority for funding. Firstly, formal establishment of your sites as a North American Arctic Transect (NAAT) associated with IPY, with attendant strengthening of the base camp infrastructure, will dramatically increase the value of these cornerstone sites and your team’s data to the international community. Secondly, carrying out focused studies to parameterize models relating remote-sensing NDVI data to on-the-ground biomass will be key to accurately measuring changes in vegetation cover and the expected continuing greening of the arctic.

I am also hopeful that your proposal will be funded as I am eager to continue our collaboration to study microbial diversity in soils along the NAAT. I would propose that our student, Ina Timling, participate in your proposed expeditions to collect the necessary soils. Pending funding of my parallel proposal, IPY: A Community Genomics Investigation of Fungal Adaptation to Cold, I would be very pleased to share our data on fungal community composition along the transect. We are proposing to carry out the most thorough study of microbial diversity in the arctic yet undertaken. Our approach is to extract total genomic DNAs from the soil samples, then PCR-amplify diagnostic fungal gene regions, construct clone-libraries, and carry out high-throughput sequencing via collaboration with a genome center. A tremendous synergy will result from integrated analyses of your soil and vegetation data together with our fungal community data.

Sincerely,

D. Lee Taylor

D. Lee Taylor

Assistant Professor

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April 20, 2006

Dr. Skip Walker
Director, Alaska Geobotany Center
University of Alaska – Fairbanks
PO Box 75700
Fairbanks, Alaska 99775-7000

Dear Skip:

I have read your proposal entitled "IPY: Greening of the Arctic (GOA): North American Arctic Transect (NAAT)". Your proposal focuses on completing the fourth of four legs of the larger GOA project. One objective is to stabilize field operations at high Arctic (Subzones A and B) stations in the North American Arctic, so that these data-rich sites can serve as "magnet" locations for collaborative work during IPY. A second goal is to determine the strength of relationships between biomass and NDVI at four spatial scales, ranging from individual GOA plots to landscape, regional, and circumpolar scales. The third and fourth goals involve coordination with other SEARCH, IPY, and LTER activities as well as providing selected educational opportunities.

We are extremely interested in the implications of GOA for helping to elucidate likely future trajectories of change related to partitioning of atmospheric contaminants from the atmosphere to terrestrial landscapes and thence into terrestrial foodwebs. Because of the extensive datasets for GOA sites regarding climate, soils, and vegetation there is high potential for deep collaboration with our IPY project ("IPY: Atmospheric transport, deposition, and retention of bioaccumulative contaminants in the Arctic: Terrestrial ecosystems and community response to change (ATRESP)"). If funded we are planning to include many of the GOA sites (specifically including Isachsen and Mould Bay) in our studies.

Contaminant studies are often limited by the paucity of critical multi-scale data on key climate and other variables, which hampers modeling. Paul Bartlett, who is handling the atmospheric modeling part of our project, will certainly be able to make good use of the rich data sets from GOA sites in both North America and Asia to inform his transport models. Further and reciprocally, our project may be able to provide scenario-based outputs that may be of use to GOA and GOA-related projects.

We think the opportunity to combine our studies on one set of climate response variables of significant interest to Arctic residents (contaminants) with the deep datasets and collaborations of the GOA network is a rich one, and wish you the best of luck in this proposal.

Sincerely,

Jesse Ford

Jesse Ford
Research Associate Professor

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