Greening of the Arctic: An IPY initiative

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Abstract: One of the key goals of IPY will be 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. Changes in the biomass of terrestrial ecosystems will likely affect the permafrost, active layer, carbon reserves, trace-gas fluxes, hydrological systems, biodiversity, wildlife populations and the habitability of the Arctic. Changes in green biomass can be expected across the entire bioclimate gradient from treeline to the coldest parts of the Arctic. The Greening of the Arctic (GOA) initiative consists of a group of scientists who are part of three major components that will examine the spatial and temporal trends of greening in the Arctic, how these trends are affecting the indigenous people of the Arctic, and develop a web-based Arctic Geobotanical Atlas to help communicate the results of the study to students, scientists, government agencies, and the general public.

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Component I: Sea Ice – Land-surface-temperature – Greening relationships. This component will examine in detail 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). The study will examine historical trends in NDVI and document areas of major increases or decreases in the NDVI and link these trends to 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 past trends in NDVI to predict future distribution of arctic vegetation using the BIOME4 model. Transient dynamics of the vegetation will be examined using the ArcVeg model. This component is already funded as an ARCSS Synthesis project.

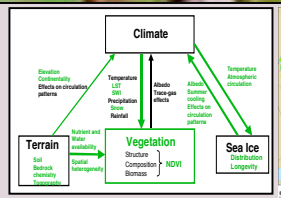

Fig. 1. The climate–sea-ice–terrain–vegetation system. Topics and linkages highlighted in green are the main foci of Component I of the GOA initiative.

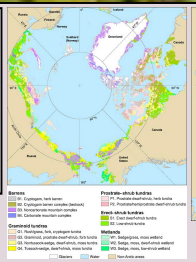

Fig. 2. The Arctic tundra biome. Note the close proximity of all parts of the biome to perennially or seasonally frozen seawaters. 61% of the tundra is within 50 km of sea ice, 80% is within 100 km, and 100% is within 350 km. This strong linkage between the Arctic Ocean and the tundra makes the biome particularly sensitive to changes to the summer sea-ice distribution. The southern boundary of the biome is tree line. (Walker et al. 2005).

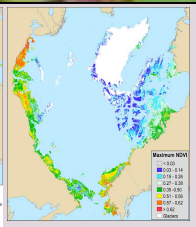

Fig. 3. Maximum NDVI of the Arctic. The GOA project will examine the spatial patterns of NDVI with respect to land-surface temperature, elevations, presence and type of permafrost, soil type, vegetation type, glacial history, and bioclimate subzones. From Walker et al. (2003).

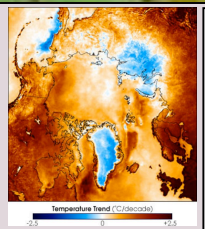

Fig. 4. Land surface temperatures will be derived from AVHRR satellite data. These data show the circumpolar annual temperature anomalies in the Arctic from 1981 to 2003, based on AVHRR thermal infrared data. Blue areas show areas of cooling and red areas have warmed. (Adapted from Comiso 2004).

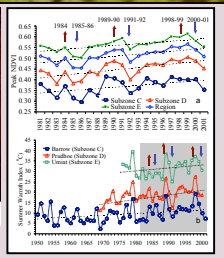

Fig. 5 The GOA project will also examine the temporal NDVI patterns for the whole Arctic. These data from northern AK show the trend in temperatures (lower diagram) and maximum (peak) summer NDVI (upper diagram) for the three bioclimate subzones in northern AK. The shaded area in (b) highlights the period of SWI covered by the NDVI data in (a). The arrows show years of corresponding increases (red) and decreases (blue) in NDVI and SWI. Regional NDVI increased by 17% between 1980 and 2000. From Jia et al. (2003).

Component II: Arctic transects in North America and Eurasia. This component will examine NDVI-ecosystem relationships along transects through all 5 arctic bioclimate subzones. The North American Arctic Transect (NAAT) has been established as part of a NSF-funded Biocomplexity in the Environment (BE) project. The Russian part of the study is linked to the Circumpolar Arctic *Rangifer* Monitoring and Assessment (CARMA) project, and will examine the linkages between greening trends, the range and forage for the reindeers of the Nenets people, and the regional sea-ice conditions. The Russian component has been proposed to the NASA/USDA Land Cover Land-Use Change initiative. An additional proposal to the SEARCH program will address logistics for establishing camps, helicopter support, and field studies along the North America Arctic Transect during the IPY 2007-2008 time period, and developing protocols and field manual for biomass collection, and data management that can be used at other sites across the Arctic.

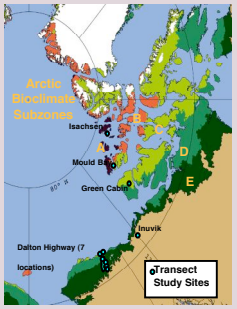

Fig. 6. The North American Arctic Transect. The transects will traverse all five Arctic bioclimate subzones and examine the spatial and temporal patterns of NDVI in relationship to sea-ice, land-surface temperatures and a host of terrain variables (CAVM Team 2003).

Fig. 7. Nenets woman drives her sled across an eroding road in the gas field at Bovonenkova on the Yamal Peninsula. Component II will focus on how changes in greening and land-use patterns are affecting traditional herding by the indigenous people of the Yamal region, which has undergone extensive transformation of vegetation cover in the past 20 years (Forbes 1999).

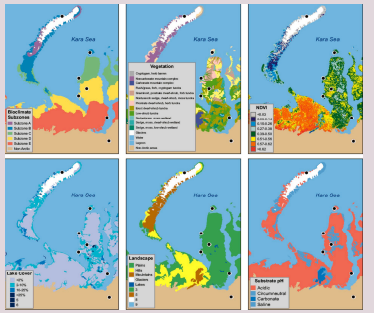

Fig. 8. The Eurasian Arctic Transect. Black dots are proposed study locations in each of the bioclimate subzones along the Yamal Peninsula and Novaya Zemlya.

Component III: Arctic Geobotanical Atlas. An outreach/education component of the project will 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 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. This component is funded by an NSF grant. Educational application of the AGA in the classroom will be proposed at a later date. Linkage of the project to the University of the Arctic and Integrative Graduate Education and Research Traineeship (IGERT) will also occur in relationship to the human dimensions aspects of the project.

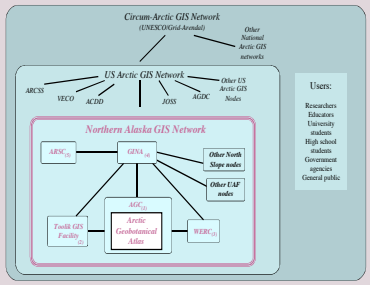

Figure 9. The AGA would be linked to a variety of networks through the worldwide web. The information in the AGA would be accessible with a variety of visualization tools including the Swathviewer, ArcIMS, Chameleon, and EarthSLOT. The red box shows the Northern Alaska network. The red numbered nodes are part of the support team developing the AGA (AGC, Alaska Geobotany Center; GINA, Geographic Information Network of Alaska; ARSC, Alaska Regional Supercomputer Center; WERC, Water and Environmental Research Center).

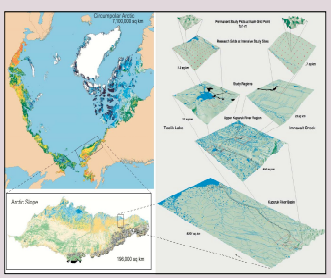

Figure 10. Hierarchy of map scales in the AGA. Maps in the atlas could be accessed by map scale, theme, region, or year.

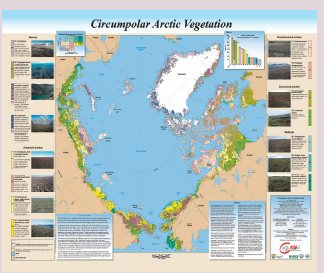

Figure 11. The GIS database behind the Circumpolar Arctic Vegetation Map would be the top level in the hierarchy of databases. Nine other themes are in the circumpolar database at 1: 7.5 million scale.

Literature cited:

CAVM Team. 2003. Circumpolar Arctic Vegetation Map (Scale 1:7,500,000). *in.* Conservation of Arctic Flora and Fauna (CAFF) Map No. 1, U.S. Fish and Wildlife Service, Anchorage, AK.

Comiso, J. C. 2003. Warming trends in the Arctic from clear sky satellite observations. Journal of Climate 16:3498-3510.

Forbes, B. C. 1999. Reindeer herding and petroleum development on Poluostrov Yamal: sustainable or mutually incompatible uses? Polar Record 35:317-322.

Jia, G. J., H. E. Epstein, and D. A. Walker. 2003. Greening of arctic Alaska, 1981-2001. Geophysical Research Letters 30.

Walker, D. A., H. E. Epstein, J. G. Jia, A. Balser, C. Copass, E. J. Edwards, W. A. Gould, J. Hollingsworth, J. Knudson, H. A. 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 - Atmospheres 108:8169.

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.