Organization Proposals
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Cover Page Elements
- Proposal Summary
- Business Data
- Budget
- Program Specific Data
- Proposal Team

Current Organization: UNIVERSITY OF ALASKA SYSTEMS

Submitted Proposal

Proposal Title: Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects

This proposal has been successfully submitted to NSPIRES. Please print this page for your records before continuing.

Proposal Number: **08-LCLUC08-2-0026**

Submittal Requirements: This proposal and its attachments are to be submitted electronically. You can print a copy of the proposal for your records.

Print

Cover Page for Proposal Submitted to the National Aeronautics and Space Administration

NASA Proposal Number

08-LCLUC08-2-0026

****LATE PROPOSAL** (Due Date: 10 / 01 / 2008)**

NASA PROCEDURE FOR HANDLING PROPOSALS

This proposal shall be used and disclosed for evaluation purposes only, and a copy of this Government notice shall be applied to any reproduction or abstract thereof. Any authorized restrictive notices that the submitter places on this proposal shall also be strictly complied with. Disclosure of this proposal for any reason outside the Government evaluation purposes shall be made only to the extent authorized by the Government.

SECTION I - Proposal Information

Principal Investigator	E-mail Address	Phone Number
Skip Walker	**ffdaw@uaf.edu**	**907-474-2460**

Street Address (1)	Street Address (2)
Irving Building	**Room 311**

City	State / Province	Postal Code	Country Code
Fairbanks	**AK**	**99775**	**US**

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

Proposed Start Date	Proposed End Date	Total Budget	Year 1 Budget	Year 2 Budget	Year 3 Budget	Year 4 Budget
06 / 01 / 2009	**05 / 31 / 2013**	**1117847.00**	**311275.00**	**339600.00**	**299032.00**	**167940.00**

SECTION II - Application Information

NASA Program Announcement Number	NASA Program Announcement Title
NNH08ZDA001N-LCLUC	**Land Cover/Land Use Change**

For Consideration By NASA Organization *(the soliciting organization, or the organization to which an unsolicited proposal is submitted)*

NASA , Headquarters , Science Mission Directorate , Earth Science

Date Submitted	Submission Method	Grants.gov Application Identifier	Applicant Proposal Identifier
10 / 07 / 2008	**Electronic Submission Only**		

Type of Application	Predecessor Award Number	Other Federal Agencies to Which Proposal Has Been Submitted
New	**NNG06GE00A**	

International Participation	Type of International Participation
Yes	**Equipment Facility Other**

SECTION III - Submitting Organization Information

DUNS Number	CAGE Code	Employer Identification Number (EIN or TIN)	Organization Type
615245164	**3R2B4**	**926000147**	**2A**

Organization Name (Legal Name)	Company Division
UNIVERSITY OF ALASKA SYSTEMS	**GRANTS AND CONTRACTS ADMINISTRATION**

Organization DBA Name	Division Number
UNIVERSITY OF ALASKA FAIRBANKS	

Street Address (1)	Street Address (2)
ADMINISTRATIVE SERVICES CTR RM 109	

City	State / Province	Postal Code	Country Code
FAIRBANKS	**AK**	**997750000**	**USA**

SECTION IV - Proposal Point of Contact Information

Name	Email Address	Phone Number
Skip Walker	**ffdaw@uaf.edu**	**907-474-2460**

SECTION V - Certification and Authorization

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in the Cover Sheet/Proposal Summary in response to this Research Announcement, the Authorizing Official of the proposing organization (or the individual proposer if there is no proposing organization) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in the two Certifications and one Assurance contained in this NRA (namely, (i) the Assurance of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs, and (ii) Certifications, Disclosures, and Assurances Regarding Lobbying and Debarment and Suspension.

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Authorized Organizational Representative (AOR) Name	AOR E-mail Address	Phone Number
Andrew Parkerson-Gray	**fnamg@uaf.edu**	**907-474-1851**

AOR Signature *(Must have AOR's original signature. Do not sign "for" AOR.)* **Date**

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION VI - Team Members

Team Member Name	E-mail Address	Phone Number
Skip Walker	**ffdaw@uaf.edu**	**907-474-2460**

Organization Name	Team Member Role	International Participation
University of Alaska Fairbanks	**PI**	**No**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

Team Member Name	E-mail Address	Phone Number
Josefino Comiso	**josefino.c.comiso@nasa.gov**	**301-614-5708**

Organization Name	Team Member Role	International Participation
NASA Goddard Space Flight Center	**Co-I**	**No**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
Yes	**NASA Goddard Space Flight Center**	**40000.00**

Team Member Name	E-mail Address	Phone Number
Vladimir Romanovsky	**ffver@uaf.edu**	**907-474-7459**

Organization Name	Team Member Role	International Participation
University of Alaska Fairbanks	**Co-I**	**No**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

Team Member Name	E-mail Address	Phone Number
Howard Epstein	**hee2b@virginia.edu**	**434-924-4308**

Organization Name	Team Member Role	International Participation
University of Virginia	**Co-I**	**No**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

Team Member Name	E-mail Address	Phone Number
Gary Kofinas	**gary.kofinas@uaf.edu**	**907-474-7078**

Organization Name	Team Member Role	International Participation
University of Alaska Fairbanks	**Co-I**	**No**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

Team Member Name	E-mail Address	Phone Number
Uma Bhatt	**bhatt@gi.alaska.edu**	**907-474-2662**

Organization Name	Team Member Role	International Participation
University of Alaska Fairbanks, Geophysical Institute	**Co-I**	**No**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

Team Member Name	E-mail Address	Phone Number
Pavel Orekhov	**orekhov.eci@gmail.com**	**7-917-5186680**

Organization Name	Team Member Role	International Participation
Earth Cryosphere Institute SB RAS	**Collaborator**	**Yes**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

Team Member Name	E-mail Address	Phone Number
Bruce Forbes	**bforbes@ulapland.fi**	**358-16-341-2710**

Organization Name	Team Member Role	International Participation
University of Lapland	**Collaborator**	**Yes**

U.S. Government Agency Participation	U.S. Government Agency	Total Funds Requested
No		**0.00**

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION VII - Project Summary

We propose to develop predictive remote-sensing tools and models that can be used to help stakeholders plan for and adapt to the multiple forces of change that are affecting the Arctic. We focus on the Yamal region in northwest Siberia where a combination of gas development, reindeer herding, climate change, and extraordinarily sensitive permafrost landscapes are affecting the land and people. Our proposal has two components that analyze changes to the biophysical and social-ecological systems and several subcomponents: Component 1. Biophysical studies: climate/ sea-ice/ vegetation interactions. (a) Ground based observations will be conducted in the coldest northern part of the peninsula at Belyy Island and will complete a 700-km bioclimatic transect across the Yamal Peninsula. (b) Studies using remote sensing will analyze the spatial and temporal patterns of and sea-ice, land-surface temperatures, and vegetation greenness as indicated by the NDVI. (c) We will refine an arctic tundra vegetation change model (ArcVeg) to simultaneously examine the effects of climate change, reindeer foraging, and denudation by industrial development along the Arctic bioclimate gradient. Component 2. Social-ecological studies. (a) We will use determine the extent of the infrastructure and related disturbances using Quickbird imagery and the mid-decadal global land survey (GLS-2000). (b) We will conduct interviews with the nomadic Nentsy to provide a detailed picture of how the reindeer are using the rangelands. (c) An international workshop will address the topic of Arctic cumulative effects.

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION VIII - Other Project Information

Proprietary Information

Is proprietary/privileged information included in this application?

Yes

International Collaboration

Does this project involve activities outside the U.S. or partnership with International Collaborators?

Yes

Principal Investigator	Co-Investigator	Collaborator	Equipment	Facilities
No	**No**	**Yes**	**Yes**	**Yes**

Explanation :

Scientists from the Earth Cryosphere Institute SB RAS, Moscow Department, will be primarily responsible for the ground measurements along the transect on the Yamal Peninsula and for coordination of the field activities in part two of the proposal. Bruce Forbes at the Arctic Centre, Rovaneimi Finland, will coordinate the activities involving the Nenets participation in the project.

NASA Civil Servant Project Personnel

Are NASA civil servant personnel participating as team members on this project (include funded and unfunded)?

Yes

Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year	Fiscal Year
2010	**2011**			
Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs	Number of FTEs
3	**3**			

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION VIII - Other Project Information

Environmental Impact

Does this project have an actual or potential impact on the environment?	Has an exemption been authorized or an environmental assessment (EA) or an environmental impact statement (EIS) been performed?
No	**No**

Environmental Impact Explanation:

Exemption/EA/EIS Explanation:

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION VIII - Other Project Information

Historical Site/Object Impact

Does this project have the potential to affect historic, archeological, or traditional cultural sites (such as Native American burial or ceremonial grounds) or historic objects (such as an historic aircraft or spacecraft)?

No

Explanation:

SECTION IX - Program Specific Data

Question 1 : Short Title:

Answer: Yamal Cumulative Effects

Question 2 : Type of institution:

Answer: Educational institution

Question 3 : Will any funding be provided to a federal government organization including NASA Centers, JPL, other Federal agencies, government laboratories, or Federally Funded Research and Development Centers (FFRDCs)?

Answer: Yes

Question 4 : Is this Federal government organization a different organization from the proposing (PI) organization?

Answer: Yes

Question 5 : Does this proposal include the use of NASA-provided high end computing?

Answer: No

Question 6 : Research Category:

Answer: 2) Data analysis/data assimilation/Earth System modeling (including Guest Observer Activities)

Question 7 : Team Members Missing From Cover Page:

Answer:

Martha Raynolds - Post doc at UAF
Natalya Moskakenko - Russian botanist at ECI
Edie Barbour - Web page designer at UAF
Hilmar Maier - GIS/remote sensing tech manager at UAF
Qin Yu - Graduate student UV
Marina Leibman - ECI permafrost specialist

Question 8 : This proposal contains information and/or data that are subject to U.S. export control laws and regulations including Export Administration Regulations (EAR) and International Traffic in Arms Regulations (ITAR).

Answer: No

Question 9 : I have identified the export-controlled material in this proposal.

Answer: N/A

Question 10 : I acknowledge that the inclusion of such material in this proposal may complicate the government's ability to evaluate the proposal.

Answer: N/A

Question 11 : Please select a group

Answer: Climate impacts and Adaptation- (If you select this answer, proceed to Question 12)

Question 12 : Climate impacts and Adaptation

Answer: Ecosystems and Biodiversity

Question 13 : International Program Contributions (Small Proposals)

Answer: NEESPI

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Cumulative Budget

Budget Cost Category	Funds Requested ($)				
	Year 1 ($)	Year 2 ($)	Year 3 ($)	Year 4 ($)	Total Project ($)
A. Direct Labor - Key Personnel	**34029.00**	**35560.00**	**37159.00**	**38832.00**	**145580.00**
B. Direct Labor - Other Personnel	**38565.00**	**45741.00**	**47618.00**	**49571.00**	**181495.00**
Total Number Other Personnel	**2**	**3**	**3**	**3**	**11**
Total Direct Labor Costs (A+B)	**72594.00**	**81301.00**	**84777.00**	**88403.00**	**327075.00**
C. Direct Costs - Equipment	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
D. Direct Costs - Travel	**24000.00**	**30000.00**	**30000.00**	**12000.00**	**96000.00**
Domestic Travel	**6000.00**	**6000.00**	**6000.00**	**6000.00**	**24000.00**
Foreign Travel	**18000.00**	**24000.00**	**24000.00**	**6000.00**	**72000.00**
E. Direct Costs - Participant/Trainee Support Costs	**35000.00**	**0.00**	**50000.00**	**0.00**	**85000.00**
Tuition/Fees/Health Insurance	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Stipends	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Travel	**35000.00**	**0.00**	**50000.00**	**0.00**	**85000.00**
Subsistence	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Number of Participants/Trainees	**10**		**15**		**25**
F. Other Direct Costs	**101390.00**	**171112.00**	**75500.00**	**20000.00**	**368002.00**
Materials and Supplies	**1000.00**	**11500.00**	**11500.00**	**1000.00**	**25000.00**
Publication Costs	**0.00**	**3000.00**	**3000.00**	**3000.00**	**9000.00**
Consultant Services	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
ADP/Computer Services	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**4000.00**
Subawards/Consortium/Contractual Costs	**99390.00**	**155612.00**	**60000.00**	**15000.00**	**330002.00**
Equipment or Facility Rental/User Fees	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Alterations and Renovations	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Other	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
G. Total Direct Costs (A+B+C+D+E+F)	**232984.00**	**282413.00**	**240277.00**	**120403.00**	**876077.00**
H. Indirect Costs	**78291.00**	**57187.00**	**58755.00**	**47537.00**	**241770.00**
I. Total Direct and Indirect Costs (G+H)	**311275.00**	**339600.00**	**299032.00**	**167940.00**	**1117847.00**
J. Fee	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
K. Total Cost (I+J)	**311275.00**	**339600.00**	**299032.00**	**167940.00**	**1117847.00**
Total Cumulative Budget					**1117847.00**

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2009	**05 / 31 / 2010**	**Project**	**1**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Walker, Skip	PI	0.00	.75			7250.00	2327.00	9577.00
Bhatt, Uma	CO-I	0.00	.75			5265.00	1690.00	6955.00
Romanovsky, Vladimir	CO-I	0.00	.75			6916.00	2220.00	9136.00
Kofinas, Gary	CO-I	0.00	.75			6329.00	2032.00	8361.00
						Total Key Personnel Costs		34029.00

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	Post Doctoral Associates	6			24351.00	7938.00	32289.00
1	Web Designer	1			3855.00	2421.00	6276.00
2	Total Number Other Personnel				Total Other Personnel Costs		38565.00
							72594.00

Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2009	**05 / 31 / 2010**	**Project**	**1**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**6000.00**
2. Foreign Travel	**18000.00**
Total Travel Costs	**24000.00**

E. Direct Costs - Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	**0.00**
2. Stipends	**0.00**
3. Travel	**35000.00**
4. Subsistence	**0.00**
Number of Participants/Trainees: 10 — **Total Participant/Trainee Support Costs**	**35000.00**

PI Name : **Skip Walker**	NASA Proposal Number
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2009	**05 / 31 / 2010**	**Project**	**1**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**1000.00**
2. Publication Costs	**0.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**1000.00**
5. Subawards/Consortium/Contractual Costs	**99390.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
Total Other Direct Costs	**101390.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**232984.00**

H. Indirect Costs

	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Modified Total Direct Costs (MTDC)	**45.10**	**173594.00**	**78291.00**
Cognizant Federal Agency: Office of Naval Research, Mr. Brian Kehoe, (703) 696-7742	**Total Indirect Costs**		**78291.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**311275.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**311275.00**

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2010	**05 / 31 / 2011**	**Project**	**2**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Walker, Skip	**PI**	**0.00**	**.75**			**7576.00**	**2432.00**	**10008.00**
Romanovsky, Vladimir	**CO-I**	**0.00**	**.75**			**7227.00**	**2320.00**	**9547.00**
Bhatt, Uma	**CO-I**	**0.00**	**.75**			**5502.00**	**1766.00**	**7268.00**
Kofinas, Gary	**CO-I**	**0.00**	**.75**			**6614.00**	**2123.00**	**8737.00**
							Total Key Personnel Costs	**35560.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Post Doctoral Associates**	**6**			**25371.00**	**8144.00**	**33515.00**
1	**Research Technician**	**1**			**3971.00**	**2494.00**	**6465.00**
1	**Hilmar Maier**	**.25**			**3874.00**	**1887.00**	**5761.00**
3	**Total Number Other Personnel**					**Total Other Personnel Costs**	**45741.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**81301.00**

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2010	**05 / 31 / 2011**	**Project**	**2**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**6000.00**
2. Foreign Travel	**24000.00**
Total Travel Costs	**30000.00**

E. Direct Costs - Participant/Trainee Support Costs

		Funds Requested ($)
1. Tuition/Fees/Health Insurance		**0.00**
2. Stipends		**0.00**
3. Travel		**0.00**
4. Subsistence		**0.00**
Number of Participants/Trainees:	**Total Participant/Trainee Support Costs**	**0.00**

PI Name : **Skip Walker**	NASA Proposal Number
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2010	**05 / 31 / 2011**	**Project**	**2**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**11500.00**
2. Publication Costs	**3000.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**1000.00**
5. Subawards/Consortium/Contractual Costs	**155612.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
Total Other Direct Costs	**171112.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**282413.00**

H. Indirect Costs

	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Modified Total Direct Costs (MTDC)	**45.10**	**279801.00**	**57187.00**
Cognizant Federal Agency: Office of Naval Research, Mr. Brian Kehoe, (703) 696-7742	**Total Indirect Costs**		**57187.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**339600.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**339600.00**

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2011	**05 / 31 / 2012**	**Project**	**3**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Walker, Skip	**PI**	**0.00**	**.75**			**7917.00**	**2541.00**	**10458.00**
Bhatt, Uma	**CO-I**	**0.00**	**.75**			**5750.00**	**1846.00**	**7596.00**
Romanovsky, Vladimir	**CO-I**	**0.00**	**.75**			**7552.00**	**2424.00**	**9976.00**
Kofinas, Gary	**CO-I**	**0.00**	**.75**			**6911.00**	**2218.00**	**9129.00**
							Total Key Personnel Costs	**37159.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Post Doctoral Associate**	**6**			**26513.00**	**8511.00**	**35024.00**
1	**Research Technician**	**1**			**4090.00**	**2569.00**	**6659.00**
1	**Hilmar Maier**	**.25**			**3991.00**	**1944.00**	**5935.00**
3	**Total Number Other Personnel**					**Total Other Personnel Costs**	**47618.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**84777.00**

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2011	**05 / 31 / 2012**	**Project**	**3**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**6000.00**
2. Foreign Travel	**24000.00**
Total Travel Costs	**30000.00**

E. Direct Costs - Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	**0.00**
2. Stipends	**0.00**
3. Travel	**50000.00**
4. Subsistence	**0.00**
Number of Participants/Trainees: 15 — **Total Participant/Trainee Support Costs**	**50000.00**

PI Name : **Skip Walker**	NASA Proposal Number
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2011	**05 / 31 / 2012**	**Project**	**3**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**11500.00**
2. Publication Costs	**3000.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**1000.00**
5. Subawards/Consortium/Contractual Costs	**60000.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
Total Other Direct Costs	**75500.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**240277.00**

H. Indirect Costs

	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Modified Total Direct Costs (MTDC)	**45.10**	**218277.00**	**58755.00**
Cognizant Federal Agency: Office of Naval Research, Mr. Brian Kehoe, (703) 696-7742		**Total Indirect Costs**	**58755.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**299032.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**299032.00**

PI Name : **Skip Walker**

Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**

NASA Proposal Number

08-LCLUC08-2-0026

NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2012	**05 / 31 / 2013**	**Project**	**4**

A. Direct Labor - Key Personnel

Name	Project Role	Base Salary ($)	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
Walker, Skip	**PI**	**0.00**	**.75**			**8273.00**	**2656.00**	**10929.00**
Bhatt, Uma	**CO-I**	**0.00**	**.75**			**6009.00**	**1929.00**	**7938.00**
Romanovsky, Vladimir	**CO-I**	**0.00**	**.75**			**7892.00**	**2533.00**	**10425.00**
Kofinas, Gary	**CO-I**	**0.00**	**.75**			**7222.00**	**2318.00**	**9540.00**
							Total Key Personnel Costs	**38832.00**

B. Direct Labor - Other Personnel

Number of Personnel	Project Role	Cal. Months	Acad. Months	Summ. Months	Requested Salary ($)	Fringe Benefits ($)	Funds Requested ($)
1	**Post Doctoral Associates**	**6**			**27706.00**	**8894.00**	**36600.00**
1	**Research Technician**				**4213.00**	**2646.00**	**6859.00**
1	**Hilmar Maier**				**4110.00**	**2002.00**	**6112.00**
3	**Total Number Other Personnel**					**Total Other Personnel Costs**	**49571.00**
						Total Direct Labor Costs (Salary, Wages, Fringe Benefits) (A+B)	**88403.00**

PI Name : **Skip Walker**	**NASA Proposal Number**
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2012	**05 / 31 / 2013**	**Project**	**4**

C. Direct Costs - Equipment

Item No.	Equipment Item Description	Funds Requested ($)
	Total Equipment Costs	**0.00**

D. Direct Costs - Travel

	Funds Requested ($)
1. Domestic Travel (Including Canada, Mexico, and U.S. Possessions)	**6000.00**
2. Foreign Travel	**6000.00**
Total Travel Costs	**12000.00**

E. Direct Costs - Participant/Trainee Support Costs

	Funds Requested ($)
1. Tuition/Fees/Health Insurance	**0.00**
2. Stipends	**0.00**
3. Travel	**0.00**
4. Subsistence	**0.00**
Number of Participants/Trainees: **Total Participant/Trainee Support Costs**	**0.00**

PI Name : **Skip Walker**	NASA Proposal Number
Organization Name : **UNIVERSITY OF ALASKA SYSTEMS**	**08-LCLUC08-2-0026**
	NASA Proposal Number

Proposal Title : **Adaptation to Rapid Land-Use and Climate Changes on the Yamal Peninsula, Russia: Remote Sensing and Models for Analyzing Cumulative Effects**

SECTION X - Budget

Start Date :	End Date :	Budget Type :	Budget Period :
06 / 01 / 2012	**05 / 31 / 2013**	**Project**	**4**

F. Other Direct Costs

	Funds Requested ($)
1. Materials and Supplies	**1000.00**
2. Publication Costs	**3000.00**
3. Consultant Services	**0.00**
4. ADP/Computer Services	**1000.00**
5. Subawards/Consortium/Contractual Costs	**15000.00**
6. Equipment or Facility Rental/User Fees	**0.00**
7. Alterations and Renovations	**0.00**
Total Other Direct Costs	**20000.00**

G. Total Direct Costs

	Funds Requested ($)
Total Direct Costs (A+B+C+D+E+F)	**120403.00**

H. Indirect Costs

	Indirect Cost Rate (%)	Indirect Cost Base ($)	Funds Requested ($)
Modified Total Direct Costs (MTDC)	**45.10**	**148403.00**	**47537.00**
Cognizant Federal Agency: Office of Naval Research, Mr. Brian Kehoe, (703) 696-7742		**Total Indirect Costs**	**47537.00**

I. Direct and Indirect Costs

	Funds Requested ($)
Total Direct and Indirect Costs (G+H)	**167940.00**

J. Fee

	Funds Requested ($)
Fee	**0.00**

K. Total Cost

	Funds Requested ($)
Total Cost with Fee (I+J)	**167940.00**

DONALD A. (SKIP) WALKER
Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, 99775, (907) 474-2460; Email: ffdaw@uaf.edu; Web site: Alaska Geobotany Center: http://www.geobotany.uaf.edu/

Education: U.S. Air Force Academy (1964-1967) - Mechanical Engineering, Astronautics; University of Colorado Boulder, Environmental Biology, B.A. (1972); M.A. (1977); Ph.D. (1981).
Areas of Specialization: Tundra Ecology, Vegetation Mapping, Landscape Ecology, Quantitative Ecology Methods, Vegetation of Northern Alaska and the Arctic, Snow-Ecosystem Interactions, Landscape Response to Climate Change, Geographic Information Systems and Remote Sensing, Disturbance and Recovery of Arctic Ecosystems.
Statement of relevant background: I have worked in the Arctic for 35 years and written extensively on the topics of cumulative impacts of oil field development and disturbance and recovery in arctic ecosystems. I served on the National Research Council Committee on Cumulative Environmental Effects of Alaskan North Slope Oil and Gas Activities (2000-2003). I have directed several large interdisciplinary and international projects, including the recent Circumpolar Arctic Vegetation Map project (http://www.geobotany.uaf.edu/cavm/abstract.shtml), the production of a web-based Arctic geobotanical atlas, a large Biocomplexity in the Environment project (http://www.geobotany.uaf.edu/cryoturbation/), and the Yamal land-cover land-use change project **(**http://www.geobotany.uaf.edu/yamal/). I've written numerous papers regarding tundra and landscape ecology; application of remote sensing for vegetation classification; and the use of NDVI to examine landscape change, greening in Alaska, and estimating circumpolar biomass. Finally, I have worked on the Yamal Peninsula and the Kolyma River area in Siberia, and collaborated extensively with the researchers at the Earth Cryosphere Institute in Moscow and the Arctic Centre, in Rovaniemi.
Professional Experience:
University of Alaska Fairbanks
Director Alaska Geobotany Center, 1999 to present; Professor, Department of Biology and Wildlife, 1999 to present.
University of Colorado Boulder
Assistant Professor Attendant Rank 1989-93; Associate Professor Attendant Rank 1996-1998; Professor Attendant Rank 1998-1999, University of Colorado Boulder; Fellow, 1985-1999; Institute of Arctic and Alpine Research (INSTAAR, University of Colorado;
Senior Research Associate, 1998-1999, INSTAAR; Co-Director, Tundra Ecosystem Analysis and Mapping Laboratory, 1989-1999; INSTAAR Research Associate, University of Colorado: Herbarium, 1990-1999
Publications: 147 refereed publications: 9 major publications (large maps, atlases, and major edited works), 10 book chapters, 105 refereed articles, 54 refereed government publications and maps and published abstracts. Plus 188 un-refereed works, including: 9 book reviews, 121 unpublished conference papers and lectures (16 invited), 55 other data reports and reports and maps to government agencies and consulting firms, and 2 theses.
Most recent and relevant publications:
Walker, D.A., U.S. Bhatt, M.K. Raynolds, V.E. Romanovsky, G.P. Kofinas, J.P. Kuss, B.C. Forbes, F. Stammler, T. Kumpula, E. Kaarlejärvi, M.O. Leibman, N.G. Moskalenko, A.A. Gubarkov, A.V. Khomutov, D.S. Drozdov, H.E. Epstein, Q. Yu, G.J. Jia, J.O. Kaplan, J.C. Comiso. 2008 (submitted). Cumulative effects of rapid land-cover and land-use changes on the Yamal Peninsula, Russia**.** *In:* Gutman, G. and P. Groisman, and Reissell. (ed.) *Eurasian Arctic Land Cover and Land Use in a Changing Climate.*
Walker, D.A., H.E. Epstein, V.E. Romanovsky, C.L. Ping, G.J. Michaelson, R.P. Daanen, Y. Shur, R.A. Peterson, W.B. Krantz, M.K. Raynolds, W.A. Gould, G. Gonzalez, D.J. Nicolsky, C.M. Vonlanthen, A.N. Kade, P. Kuss, A.M. Kelley, C.A. Munger, C.T. Tarnocai, N.V. Matveyeva, F.J.A. Daniëls (2008), Arctic patterned-ground ecosystems: A synthesis of field

studies and models along a North American Arctic Transect, *J. Geophys. Res*., 113, G03S01, doi:10.1029/2007JG000504.
Raynolds, M.K., J.C. Comiso, **D.A. Walker,** D. Verbyla. 2008. Relationship between satellite-derived temperatures, arctic vegetation types, and NDVI. *Remote Sensing of the Environment,* 112 1884-1894.
Munger, C.A., **D.A. Walker**, H.A. Maier, T.D. Hamilton. 2008. Spatial analysis of glacial geology, surficial geomorphology, and vegetation in the Toolik Lake region: relevance to past and future land-cover changes. 1255-1260 *in:* Kane, D.L. and K.M. Hinkle. *Ninth International Conference on Permafrost*, Institute of Northern Engineering, University of Alaska Fairbanks.
Walker, D.A., H.A. Maier, E.M. Barbour. 2008. A web-based arctic geobotanical atlas and a new hierarchy of maps of the Toolik Lake Region, Alaska, 1893-1898. I*n:* Kane, D.L. and K.M. Hinkle. *Ninth International Conference on Permafrost*, Institute of Northern Engineering, University of Alaska Fairbanks.
Richter-Menge, J., J. Overland, A. Proshutinsky, V. Romanovsky, L. Bengtsson, L. Brigham, M. Dyurgerov, J.C. Gascard, S. Gerland, R. Graversen, C. Hass, M. Karcher, P. Kuhry, J. Maslanik, H. Melling, W. Maslowski, J. Morison, D. Perovich, R. Przybylak, V. Rachold, I. Rigor, A. Shiklomanov, J. Stoeve, **D. Walker,** J. Walsh, 2006. *State of the Arctic Report*, 36 pp, NOAA/OAR/PMEL, Seattle, WA.
Raynolds, M.K., **D.A. Walker,** H.A. Maier. 2006. NDVI patterns and phytomass distribution in the circumpolar Arctic. *Remote Sensing of the Environment*, 102: 271-281.
Kade, A., V.E. Romanovsky, **D.A. Walker.** 2006. The n-factor of nonsorted circles along a climate gradient in Arctic Alaska. *Permafrost and Periglacial Processes*, 17: 1-11.
Jia, G.J., H.E. Epstein, **D.A. Walker**. 2006. Spatial heterogeneity of tundra vegetation response to recent temperature changes. *Global Change Biology* 12:42-55.
Daniels, F.J.A., A. Elvebakk, S.S. Talbot, **D.A. Walker**. 2005. Classification and Mapping of Arctic Vegetation: A Tribute to Boris Yurtsev. A selection of contributions, presented at the Second International Workshop on Circumpolar Vegetation Classification and Mapping, Tromsø, Sommarøya, Norway, 2-6 June 2004. *Phytocoenologia*, 35 (4): 715-1079.
Riedel, S.M. H.E. Epstein, **D.A. Walker**, D.L. Richardson, M.P Calef, E.J. Edwards, 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: 25-33.
National Research Council, Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope (Orians, G., T. Albert,, G. Brown, R. Cameron,, P. Cochran, S.C. Gerlach, G. Gryc, D. Hite, M. Kennicott, A. Lachenbruch, L. Lowry, J. Sedinger, L. Speer, **D. Walker**). 2003. *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope.* National Academies Press, Washington, D.C. 288 pp.
Walker, D.A. 1997. Arctic Alaskan vegetation disturbance and recovery: a hierarchical approach to the issue of cumulative impacts. *In:* Crawford, R.M.M. (ed.) *Disturbance and recovery in Arctic lands: an ecological perspective.* Dordrecht, the Netherlands: Kluwer Academic Publishers, pp 457-480.
Walker, D.A. 1996. Disturbance and recovery arctic Alaskan vegetation. *In:* J.F. Reynolds and J.D. Tenhunen (eds.) *Landscape function and disturbance in arctic tundra*. Ecological Studies, Vol. 120. Berlin Heidelberg: Springer-Verlag, pp. 35-71.
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 + appendices.
Epstein, H.E., J. Beringer, W.A. Gould, A.H. Lloyd, C.D. Thompson, F.S. Chapin III, G.J. Michaleson, C.L. Ping, T.S. Rupp, **D.A. Walker.** 2004. The nature of spatial transitions in the Arctic. *Journal of Biogeography* 31: 1917-1933.
Jia, G.J., H.E. Epstein, **D.A. Walker**. 2003. Greening of Arctic Alaska, 1981-2001. *Geophysical Research Letters*, 30: 2067, doi: 10:1029/2003G:O18268,2003.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Donald Walker	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Application of space-based technologies and models to address land-cover/land-use change problems on the Yamal Peninsula, Russia

Source of Support: NASA
Total Award Amount: $ 755,534 Total Award Period Covered: 06/01/06 - 05/31/09
Location of Project:
Person-Months Per Year Committed to the Project. Cal: 0.50 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Towards an arctic geographic network: a web based plant-to-planet scale geobotanical atlas centered on the Toolik Lake Field Station, Alaska

Source of Support: NSF
Total Award Amount: $ 819,460 Total Award Period Covered: 12/15/04 - 11/30/08
Location of Project: Alaska
Person-Months Per Year Committed to the Project. Cal: 3.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Adaptation to multiple rapid changes on the Yamal Peninsula, Russia: Analysis and models for predicting cumulative effects

Source of Support: NASA
Total Award Amount: $ 1,107,845 Total Award Period Covered: 06/01/09 - 05/31/13
Location of Project: Russia
Person-Months Per Year Committed to the Project. Cal: 1.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Remote Very High Arctic Terrestrial Observatory Stations: A Reconnaissance Expedition to Isachsen, Mould Bay and Green Cabin

Source of Support: NSF - This Proposal
Total Award Amount: $ 213,758 Total Award Period Covered: 06/01/09 - 05/31/11
Location of Project:
Person-Months Per Year Committed to the Project. Cal: 1.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Investigating the relationships between changing seasonality of marine shelf ice/ocean conditions and tundra vegetation, and their effects on

Source of Support: NSF
Total Award Amount: $ 0 Total Award Period Covered: 06/01/09 - 05/31/12
Location of Project:
Person-Months Per Year Committed to the Project. Cal: 0.00 Acad: 0.00 Summ: 0.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

TABLE OF CONTENTS

SCIENTIFIC/TECHNICAL/MANAGEMENT SECTION

INTRODUCTION

Study objectives and significance

The complex interactions between a rapidly changing climate, expanding resource development, and constantly evolving social, economic and political environments make it clear that more sophisticated models and approaches are needed to help in planning for the future in the Arctic and to help the indigenous people adapt to the impending changes. Current tools used in the analysis of land-cover and land-use change tend to focus on the effects of single factors such as industrial, agricultural, or climate-change impacts. Although we will examine the effects of each of these factors separately, our primary interest is in the combined *cumulative effect* of these factors. Our ultimate goal is to combine the techniques we are developing on the Yamal with tools being developed in other parts of the Arctic to move toward a synthesis of approaches. *Our principal goal is to develop better, more far-looking tools to predict the cumulative effects of resource development, climate-change, and traditional land use. To accomplish this we will employ a combination of analyses and models of climate/ vegetation change with social-ecological analyses.*

The impending changes to the Yamal Peninsula and the Nentsy

Our study takes place on the Yamal Peninsula, Russia (Fig. 1) where there are large questions regarding the future of the nomadic Nentsy and their reindeer. The effects of petroleum development are of great concern to the Nentsy, and indigenous groups in other remote areas of the Arctic with oil and gas resources have similar concerns. We focus on the changing vegetation because the plants are the foundation for the Nenets life style, providing forage for reindeer and protecting the landscape from major degradation due to wind and thermal erosion of the permafrost.

Yamal is a Nenets term for the "end of the land", which is fitting for this long tundra-covered peninsula that stretches roughly 700 km from the Arctic Circle (66° 33.5′ N) to Belyy Island (White Island, 73˚ 20' N) at the northern tip of the peninsula (Fig. 1). The peninsula is about 150 km wide with an area of 122,000 km^2 (somewhat larger than Pennsylvania or North Korea). It is one of the most remote regions on the planet with few roads, no major cities, largely intact natural ecosystems, and indigenous people who still live a nomadic lifestyle. It is, however, poised for dramatic changes (Fig. 2). Four major forces are combining to make the Yamal a "hot spot" of rapid change: the impending gas-development boom, rapid climate

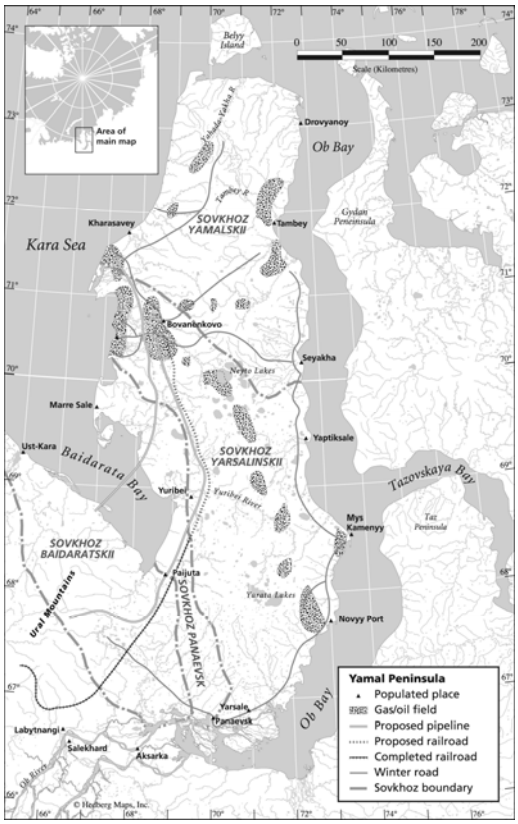

Figure 1. Yamal Peninsula and associated gas and oil fields, with existing planned transportation corridors. The main existing gas field is at Bovanenkovo (adapted from Forbes, 1999).

change, an unusually sensitive permafrost environment, and the rapid growth of the indigenous native population and their reindeer herds (Vilchek and Bykova 1992, Forbes 1995, Forbes 1997, Forbes 1999a, Vilchek 1997).

About 5000 Nentsy and over 150,000 domestic reindeer currently migrate across the peninsula and adjacent lands (Stammler 2005). Their activities strongly affect the ecology of the region, and they in turn are strongly affected by resource development and the rapidly changing economic climate (Pika and Bogoyavlensky 1995).

Figure 2. Nenets reindeer herder passing an oil derrick in the Bovanenkovo gas field, Yamal Peninsula, Russia. The presence of the gas field provides both economic opportunities for the Nentsy and a source of conflict because of competition for land and barriers created by roads and pipelines during the annual migrations. Climate change will likely enhance the growth of shrubs, also shown in the figure, and change the character of the reindeer pasture lands. Photo copyright: Brian and Cherry Alexander.

There are 200 identified gas fields and an estimated 1.8 quadrillion cubic feet (58 trillion cubic meters) of proven gas reserves on the Yamal Peninsula. So far, most of the infrastructure is concentrated at Bovanenkovo, Kharasavey and other exploratory gas fields, but full-scale development will proceed when pipelines are built to get the gas to market (Figure 1). A major new road and railroad linking Bovanenkovo to the rest of Russia is scheduled for completion in 2010 and will greatly speed up development of Bovanenkovo and the other gas fields.

Gas development is causing large-scale changes to vegetation and landscapes in some areas. These changes are exacerbated by massive ground ice that lies at shallow depths. This ice is subject to thaw that results in thermokarst, erosion and landslides. A major concern is how climate change could further affect the Yamal landscapes and the rangelands of the Nenets reindeer herds.

Summary of previous results

This proposal is a successor proposal to a current project funded by the NASA Land-Cover Land-Use Change (LCLUC) program in Mar 2006-Feb 2009 entitled "Application of space-based technologies to examine land-cover/land-use change along a transect on the Yamal Peninsula and Novaya Zemlya, Russia". Results from the current round of funding can be found in the 2008 annual report to NASA: http://www.geobotany.uaf.edu/yamal/documents/Walker2008AnnualReport2.pdf.

The major findings to date from the current studies are as follows: (1) Direct (planned) impacts of industrial activities on the Yamal Peninsula are currently local and limited in extent, but this is changing rapidly as extensive gas fields are developed and land and sea transportation corridors are developed to get the gas to market. Indirect impacts of the development at Bovanenkovo exceed the direct impacts by a factor of three, and the total area of influence of the development on the reindeer pasturelands (e.g., the area where migration routes and access to pasturelands is affected) exceeds the direct impacts by a factor of about 40 (Kumpula et al. 2006). (2) Herders generally view the threats from industrial development to be much greater

than threats from climate change, but they currently favor gas development because of increased economic and social advantages. Land withdrawals by industry, increasing Nenets population, and larger reindeer herds are increasing pressure on the rangelands (Stammler 2005, Stammler and Wilson 2006). (3) The climate and vegetation changes on the Yamal have not been as dramatic as in other parts of the Arctic. Nonetheless, change is ongoing. The trend in land-surface temperatures co-varies with the trend in sea-ice — low sea-ice in the preceding December-March period is correlated to warmer land temperature the following summer. The sea-ice trends in the Kara Sea-Yamal region are tied to variation in the North Atlantic Oscillation index (Bhatt et al. 2008 in prep.). (4) The summer sea-ice concentrations (Jul 2-22) during the past 25 years have declined 25%. The summer warming has been slight (4% increase), and the greening of the tundra as measured with Normalized Difference Vegetation Index (NDVI) has also been small (3% increase in maximum NDVI) in comparison with some other areas in the Arctic, such as the Beaufort region where the NDVI has increased 24% (Epstein et al. 2007, Raynolds et al. 2008b, Bhatt et al. 2008 in prep.). Natural disturbance, primarily from extensive landslides, has a strong effect on the local patterns of vegetation greenness. (5) There is high potential for extensive landscape effects triggered by a changing climate and expanding reindeer herds due to unstable sandy soils, and extremely ice-rich permafrost near the surface on slopes (Leibman and Kizyakov 2007). If disturbed, the ice-rich permafrost is susceptible to catastrophic failures. Over large areas of the Yamal, landslides have transformed the zonal sedge, dwarf-shrub tundra to the low-shrub tundra that is typically found on disturbed sites in this subzone. Present evidence indicates that the landslides are triggered most abundantly in wet years, as in 1989, and in warm years, as in the recent years since 2005 (Ukraintseva and Leibman 2007). (6) Models of Arctic vegetation response to climate change have followed two primary approaches. At the global scale, the BIOME model projects that the boreal forest extent will increase by 55 percent and that the arctic tundra extent will decrease by 42 percent, with a 60 percent loss of prostrate dwarf-shrub tundra (Kaplan and New 2006). The ArcVeg model predicts the variation in arctic plant growth forms across five Arctic bioclimate subzones under altered climate and disturbance regimes (Epstein et al. 2007, Yu and Epstein 2008). With a 2 ˚C increase in the mean July temperature over a 200-year period, ArcVeg projects that total biomass will increase by up to 100% in both the Low and High Arctic. The largest responses will be to the woody plants, but these follow the more rapid response of other plant growth forms (graminods, forbs, mosses, and lichens). The major accomplishments of the group of researchers involved in the project were summarized in talks given at the 2008 Yamal LCLUC Workshop in Moscow, 28-30 Jan 2008. http://www.geobotany.uaf.edu/yamal/ppt and the 2008 NASA LCLUC Workshop.

RELEVANCE TO NASA, LCLUC, IPY AND NEESPI

This research addresses NASA's Strategic Subgoal 3A (Study of Earth from space to advance scientific understanding and meet societal needs). It specifically addresses NASA's Science questions related to how the Earth system is changing and how the Earth system is responding to natural and human-induced changes. It will focus on NASA's research objective 3A.3 (quantify global land cover change and terrestrial productivity, and improve carbon cycle and ecosystem models). It addresses four of the five research goals of the LCLUC program, and all five of the key LCLUC science questions. The project will combine the long-term record available through NASA's Landsat satellites with NOAA's AVHRR sensors and more recent sensors that provide very detailed spatial and spectral information regarding land-cover/land-use change in the Arctic. Furthermore, this proposal addresses the objectives of the Northern Eurasia Earth Science

Partnership Initiative (NEESPI) — it most directly addresses the NEESPI science questions regarding the local and hemispheric effects of anthropogenic changes to land use and climate.

Perceived impact of the proposed work

We are building on the previous projects that have been involved in examining vegetation change (Greening of the Arctic) along long bioclimate transects in North America (Fig. 3) (Epstein et al. 2008, Walker et al. 2008b) and Eurasia (Epstein et al. 2007, Walker et al. 2008 submitted). A primary focus of the research along these transects is predictive models of vegetation response to climate change on both natural (zonal, undisturbed) and disturbed patches of land. Research along both transects is analyzing the relationship of reductions in sea-ice concentrations to changes in land-surface temperature, timing of snowmelt, and NDVI.

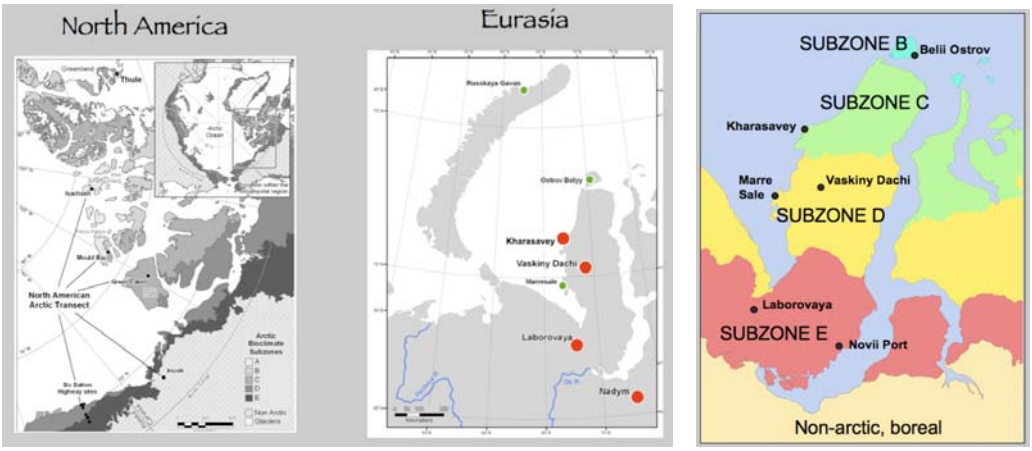

Figure 3. (Left) *North American and Eurasian Arctic Transects.* ***(Right)*** *Bioclimate subzones on the Yamal Peninsula according to the Circumpolar Arctic Vegetation Map (CAVM Team 2003).*

The project is also contributing substantially to the existing body of knowledge regarding the cumulative-effects of oil and gas development in the Arctic (Walker et al. 1987, NRC 2003, Forbes 2008) by expanding the concept to include the social and climate-change effects. One piece of the project will bring together a larger group from other countries with similar issues (Russia, Finland, Canada, Norway, and the US) to first describe state-of-the-art methods of integrated, comprehensive assessments of cumulative effects and then move toward new solutions that draw on the combined experiences from all the participating countries.

Value added of international collaborative research

The research program proposed here is achievable because it integrates the efforts of several institutions. Our colleagues in Russia and Finland have a long-term investments in climate-change and land-use-change research on the Yamal Peninsula. Researchers at the *Earth Cryosphere Institute (ECI)* in Moscow have been studying permafrost, vegetation and land processes on the Yamal Peninsula since the early hydrocarbon exploration in the region in the 1970s. They have developed extensive climate and geocryological spatial data bases for much of West Siberia and northern Russia (Melnikov 1998, Melnikov and Minkin 1998, Drozdov et al. 2005), and considerable field knowledge about each of the key sites along the Yamal transect. Our project will draw substantially upon these data and will use them for extrapolating our data to broader areas of the Yamal region through remote sensing and the ground information obtained along the Yamal transect. Five senior scientists from ECI (Marina Leibman, Nataliya Moskalenko, Natalia Ukraintseva, Dmitri Drozdov, and George Matyshak) and three Russian graduate students are involved in the project.

The Arctic Centre, in Rovaniemi, is collaborating in conjunction with its Environmental and Social Impacts of Industrialization in Northern Russia (ENSINOR) project. This study is a thorough multi-disciplinary analysis of the social and environmental consequences of energy development in the Yamal region in 2004-2007 (Forbes 1999b, a, 2008). The project was funded by the Academy of Finland to make comparative case studies of oil and gas activities in two key federal districts - the Nenets Autonomous Okrug (NAO) and Yamalo-Nenets Autonomous Okrug (YNAO) (Stammler and Burgess 2007). The study incorporated knowledge that stems from different traditions among both scientists and herders and their respective ways of knowing about contemporary social-ecological systems. The ENSINOR project is providing the key background information on the Nentsy, their reindeer and historical vegetation and landscape changes that have occurred in the Bovanenkovo gas field and elsewhere on the Yamal. Two senior scientists (Bruce Forbes and Florian Stammler) and four graduate students are involved in the project. Additionally, it is the intersection of three International Polar Year (IPY) initiatives: (1) the Greening of the Arctic (GOA) project, (2) Cold Land Processes in NEESPI (CLPN) and (3) the Circum-Arctic Rangifer Monitoring and Assessment (CARMA) project. GOA is examining the rates and causes of changes in vegetation biomass and productivity across the Arctic using remote sensing and ground-based studies. CLPN is a permafrost monitoring and modeling program examining environmental changes over Northern Eurasia. CARMA is a monitoring and assessment program for human-Rangifer (reindeer and caribou) systems across the Arctic.

TECHNICAL APPROACH

Component 1. Analysis of climate/ sea-ice/ vegetation interactions

In 2007, Arctic sea ice extent declined to the lowest level in recorded history: 24% lower than the previous record in 2005 (Comiso 2007). These changes have caused increased concern regarding the consequences to permafrost and terrestrial vegetation, particularly in areas immediately adjacent to the Arctic Ocean. Coupled climate models suggest that land-warming trends during the next few decades could be 3.5 times greater than the 21st century climate change trends (Lawrence et al. 2008).

The primary questions that we will address in this part of the research are: (1) How do ground-based measurements of zonal vegetation vary with climate, soil type, and disturbance along the Yamal bioclimate gradient? (2) How do satellite-based measurements of sea-ice concentrations, land-surface temperatures, and vegetation greenness in the Kara Sea-Yamal region vary spatially and temporally along the Yamal bioclimate gradient? (3) Has there been detectable changes in the timing (seasonality) of greening on the Yamal Peninsula? (4) How do these changes compare with other regions of the Arctic? (5) How do these changes correspond to trends in climate patterns?

Ground-based observations of natural vegetation-climate relationships

One objective of the project is to see how the natural vegetation varies across the long bioclimate gradient on the Yamal Peninsula in comparison with another similar transect in North America (Fig. 3). Our approach is to analyze how vegetation, soils, biomass and site factors vary along the natural climate gradient at study sites where change can be measured in future years. The Yamal Peninsula is a good region to study vegetation changes across the Arctic climate gradient because four of the five Arctic bioclimate subzones of the Circumpolar Arctic Vegetation Map (Walker et al. 2005) occur on the peninsula (Fig. 3). The locations of our study sites are chosen to be representative of the zonal soils and vegetation, but also include variation

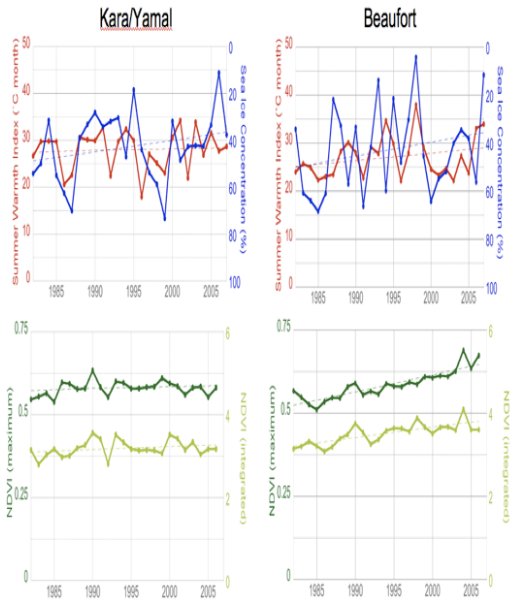

Figure 4. (Top) *1982-2007 trends in sea ice concentration (blue lines) and temperature (red lines).* ***(Bottom)*** *Trends in Maximum (dark green) and Integrated NDVI (light green.* ***(Left)*** *Kara/Yamal region.* ***(Right)*** *Beaufort Region. Bhatt et al. in prep. 2008.*

Table 1. *Change along trend lines of sea-ice concentration, summer land-surface temperatures (SWI), and maximum and integrated NDVI for 1982 to 2007 (sea ice and SWI) and to 2006 (for NDVI) for the 50-km coastal strip seaward (for sea ice) and 50-km strip inland (for SWI and NDVI) along the Beaufort Sea and Kara sea coasts. * = significant trend at p = 0.05. From Bhatt et al. (in prep. 2008).*

	Kara/Yamal		Beaufort	
Variable	Magnitude	Pct. Change	Magnitude	Pct. Chang
Sea ice cover (% cover, Jul 2-22)	-12.9	-25%	-15.2	-29%
Summer warmth (SWI, ˚C mo):	1.07	4%	4.08	16%
Maximum NDVI:	0.02	3%	0.125	24%*
Integrated NDVI:	0.17	5%	0.625	19%*

regarding substrate (clayey vs. sandy soils) at each location. Usually this involves sampling sites of different geologic age at each location. From north to south, the proposed locations for the ground observations are Belyy Island (subzone B[1]), Kharasavey (subzone C), Vaskiny Dachi (near Bovananekovo, subzone D), Laborovaya (subzone E), and Nadym (northern boreal forest)**.** Nadym, Laborovaya, Vaskiny Dachi, and Kharasavey were sampled during 2007 and 2008. Here we are proposing to extend the Yamal transect into the High Arctic to include Belyy Island (subzone B of the Circumpolar Arctic Vegetation Map) 2010 and if the opportunity presents itself, into subzone A on Franz Josef Land or Novaya Zemlya in 2011. We will use the same procedures as used at the other sites along the transect and will include observations of biomass, leaf-area index, plant community composition, climate, soil properties, active layer and permafrost conditions (Walker et al. 2008a). Data reports will be prepared with general descriptions literature reviews and photographs of each locality, maps of the study plots and transects, summaries of sampling methods used, vegetation data (species lists, species cover), leaf-area index (LAI), Normalized Difference Vegetation Index (NDVI), soil data (profile descriptions and chemical and physical soil properties), and active-layer depth (Walker et al. 2008a).

Satellite-based analysis of climate-vegetation relationships

Our earlier work has shown that between 1982 and 2007, sea ice in the 50-km coastal strip of Yamal/Kara Sea area during the period 18 June - 22 July decreased 25% (Fig. 4 and Table 1). Land-surface temperatures (as indicated by the summer warmth index (SWI), increased 1.07 ˚C mo (4% increase). The greening response of the vegetation (as indicated by the summer maximum NDVI and the total integrated NDVI) increased modestly 0.02 and 0.17 (3% and 5% respectively). The trends are consistent with most other coastal areas studied in the Arctic — i.e.,

[1] Key plant limits and mean July temperature (MJT) that define the subzones are: A: cushion forb subzone, *Saxifraga oppositifolia* , MJT < 3 ˚C. B: prostrate-dwarf-shrub subzone, *Dryas integrifolia*, 3 ˚C < MJT < 5 ˚. C: hemiprostrate-dwarf-shrub subzone, *Cassiope tetragona,* 5 ˚C < MJT < 7 ˚C. D: erect-dwarf-shrub subzone, *Betula nana/exilis,* 7 ˚C < MJT < 9 ˚C. E: low-shrub subzone, *Alnus viridis,* 9 ˚C < MJT < 12 ˚C (Walker et al. 2005).

periods of lower sea-ice concentration are correlated with warmer land-surface temperatures and higher NDVI values. However, the magnitude of the land warming trends and NDVI are much smaller on the Yamal than in North America where SWI increased 16% and the maximum NDVI increased 24% (Table 1) (Bhatt et al. 2007, Bhatt et al. 2008, Bhatt et al. 2008 in prep.) (Table 1). Similar analyses for all the Arctic sea areas show that there is a consistent pattern of decreased summer sea-ice concentrations, and warmer summer temperatures across the Arctic, but the trend in the NDVI is more variable. The NDVI in the region from the East Siberian Sea eastward to the Canadian Archipelago has increased while much of the northern Russian coastline west of the East Siberian Sea has shown a slight decrease (Bhatt et al. 2007, 2008a, b). The Beaufort Sea region shows the greatest increase in NDVI — possibly associated with the large summer sea-ice retreat and strong land-surface warming that has occurred in the Beaufort region.

The causes of the much smaller increases in land surface temperatures and NDVI of the Kara/Yamal region compared to the Beaufort will be a topic of investigation in the new study. We will look at differences in the climate including differences in wind and snow regimes as well as differences in the ocean and atmospheric circulation patterns, climatic indices, and geographic differences between the two regions that can be derived from regional GIS databases (Drozdov et al. 2005) and in each region. We will do a first-cut analysis of seasonal NDVI snow-depth relationships using the Global Precipitation Climatology Project (GPCP version 2), which is based on merging infrared and microwave satellite estimates of precipitation with rain gauge data and will be used to investigate the role of moisture and snow-depth in recent vegetation changes. We will also examine how the green-up varies with vegetation types, bioclimate subzones and other variables in the Yamal GIS database. The new NDVI analyses will also use a much needed recalibration of the circumpolar AVHRR-NDVI data set that is in progress by Josefino Comiso.

Analysis of plant succession on landslides

One possible cause of the very different NDVI responses on the Yamal compared to North America may be differences in disturbance regimes in each region. Land temperatures explain 58% of the variance in the circumpolar NDVI, but only 22% of the NDVI variance on the Yamal (Raynolds et al. 2008al, Raynolds et al. 2008b). We hypothesize that the large discrepancy between the observed and expected NDVI trends along the Yamal climate gradient is due largely to the abundance of the naturally disturbed landscapes that are occupied by willow shrublands. Large-scale landslides have affected approximately 16% of the typical tundra region of the Yamal (Ukraintseva 2008). The landslides bring salty and nutrient-rich marine clays to the surface. Once the salts are leached out of the landslides, lush willow-dominated shrublands form and persist for hundreds to thousands of years. The nutrient content of the soils and plants on the landslides is considerably higher than that of the zonal plant communities (Ukraintseva et al. 2003, Ukraintseva and Leibman 2007, Leibman and Kizyakov 2007, Ukraintseva 2008). Such extensive shrublands are highly unusual in other typical tundra regions of bioclimate subzone D (Walker et al. 2005).

A more detailed analysis of the vegetation-succession patterns on the landslides and on lichen-rich uplands will be conducted and will include vegetation mapping and plant-community description and analysis. A vegetation map of the Yamal peninsula will be derived from the Landsat-Mid-Decadal Global Land Survey 2000 (GLS 2000) product for Eurasia that is expected by late 2008. This moderate-spatial-resolution (30-m) vegetation data will help us in the analysis of the vegetation-landscape relationships. We will not be able to obtain helicopter support for an accuracy assessment of the product, but we expect that we can make a simple 8-category classification similar to the products developed for northern Alaska and the Seward Peninsula (Muller et al. 1999), based on the extensive field experience of the group at the Earth Cryosphere Institute and existing vegetation maps and GIS databases (Melnikov 1998, Drozdov et al. 2005). We will conduct a vegetation analysis of the ground-based data using the Braun-Blaun classification approach (Dierschke 1994, Tichy 2002) and the methods that we have used along the North American Arctic transect (Kade et al. 2005, Vonlanthen et al. 2008 in press). We will examine the relationship between landslide age, community biomass, soil chemistry, plant tissue nutrients and LAI and NDVI along 50-m transects in plant communities on slides of known ages. Relationships between the vegetation and environmental variables will be analyzed using a variety of multivariate statistical approaches including detrended correspondence analysis (DCA) and nonmetric multidimensional scaling (NMDS) available in the software program PC-Ord 5.0 (McCune and Mefford 1995).

Predictive models of vegetation change

The first phase of the Yamal LCLUC project resulted in a wealth of field and remote sensing data on plant communities, soil properties, climate, and patterns of human impact. In order to investigate vegetation change on the Yamal Peninsula in a spatially coherent manner and to make scenario predictions of how changes in climate and anthropogenic activities may affect the land cover of Yamal in the future, it is essential to apply predictive models of land cover change.

Here we propose use these data with a modified version of the ArcVeg model to simultaneously examine the effects of predicted changes in summer temperature, different reindeer foraging regimes, rate of succession following denuding of the land, and responses on different soil types. The model uses a set of twelve plant functional types for five arctic subzones that range from the coldest areas at high latitudes to the relatively warm Low Arctic near tree line (Epstein et al. 2007, Yu and Epstein 2008).

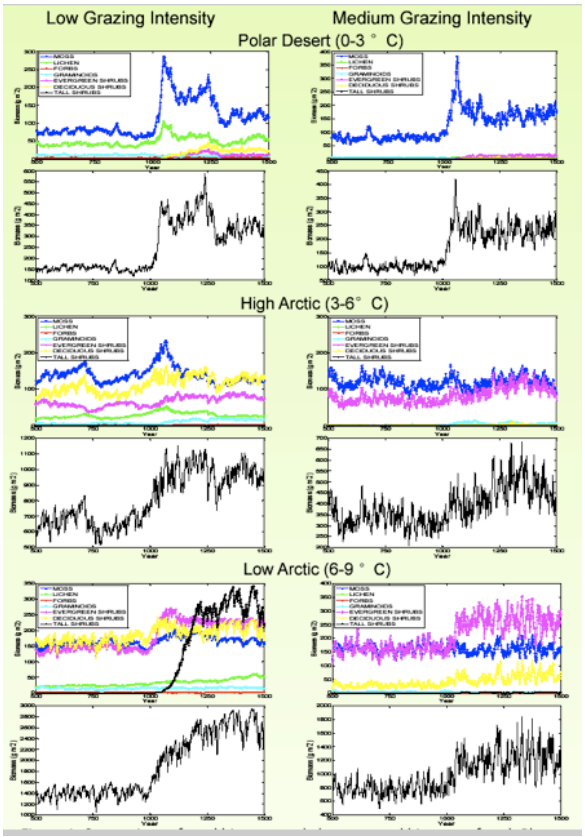

Figure 6. *Output of the ArcVeg model showing the biomass response of dominant plant functional types (colored lines) in each bioclimate subzone along the Yamal Transect to high and low reindeer grazing regimes. The x-axis spans 1000 years of change with a ramp-up of a 2˚ C change in temperature starting in year 500. (Epstein et al. 2007).*

The managed reindeer herds of the Yamal graze and trample the range more intensely and more frequently than do caribou of North America. Frequent grazing also increases the inter-annual variability in tundra primary productivity. In the final year of the project, we will incorporate the soil data from the Yamal into the model, improve the reality of the grazing subroutine, add a component that will examine succession on barren mineral soils, and conduct a rigorous sensitivity analysis of the effect of grazing on tundra productivity and functional type composition with a more comprehensive representation of plant functional types and enhancements to our grazing and nitrogen fixation sub-components. An evaluation of model results will now be conducted in light of the field observations and other available data.

We will compare our model simulations with observed parameters that include, but are not limited to, vegetation distribution (land cover classes), above- and below-ground biomass, LAI, NDVI, and plant and soil nutrient content. This work will lead to significant improvements in our confidence in model predictions and allow us to assign error estimates to many of the variables simulated in our models. The improvements in our models will be applicable not only to our simulations of the Yamal Peninsula region, but to the NEESPI region and entire circumpolar Arctic.

Component 2. Social-ecological studies:

Overall, the Yamal Nentsy favor of the ongoing gas development due to numerous economic and social benefits resulting from development. Many reindeer herding regions across Russia suffered drastic socio-economic consequences after the demise of the Soviet Union, but the Yamal has faired relatively well. The positive effects of development include access to health care, extensive gas-company support for urban-based populations, jobs, extensive markets for reindeer meat in the new rapidly growing urban areas to the south and the oil camps on the peninsula, and the possibility to barter or pay cash for goods during migrations on the tundra. Helicopter transport and relations between oil and gas workers and reindeer herders are now central aspects of life on the tundra.

These positive aspects are offset by major concern and conflicts over land use on the peninsula. Between 1984 and 2004, the number of nomadic households on the Yamal Peninsula increased from 693 to 964, and the reindeer increased from about 54,000 to 158,000 animals (Stammler 2005). Large withdrawals of pasturelands for gas development are placing additional major stresses on the land and the herders, who must manage larger herds within shrinking available space. For example, two brigades that traditionally used the Bovanenkovo region for their summer pasturelands now avoid these areas and have lost 22 and 25% of their total summer pasturelands due to the presence of the gas development (Kumpula et al. 2006). The problems go beyond simple overgrazing of the land and involve a variety of social issues related to relationships between herding brigades, competition between private and collective herding approaches and unintentional mixing of herds. It is predicted that 165 families of nomadic Nenets people will move to live in the settlements as a result of reduction of the pastures, and 286 families will have to change the pasture routes for the same reason. As development accelerates the Nentsy wish to be more carefully consulted about plans for new infrastructure and to receive appropriate compensation for lost pastures and access for migrations. The major concerns of Nentsy are the effects of the resource development on the pasturelands of their reindeer. There is also growing concern about the effects of rapidly growing herds.

Effects of resource development on reindeer pastures

The major questions for this subcomponent are: (1) What is the total extent of industrial development on the Yamal Peninsula? (2) What is the extent of the planned (direct)impacts

compared to the unplanned (indirect) impacts? (3) What has been the historical progression of development? (4) How do the expanding networks of roads and pipelines affect the reindeer pasturelands? (5) How do the impacts on the Yamal compare with those in northern Alaska?

Environmental impact assessments normally consider the planned footprint of infrastructure (e.g., roads, quarries and construction pads) but not the indirect effects associated with off-road vehicle trails, seismic trails, roadside dust and areas flooded by road construction (Walker et al. 1987, NRC 2003). We will quantify the direct and indirect impacts associated with infrastructure. We will use Quickbird imagery (60-70 cm panchromatic resolution and 2.4- 2.8-m multi-spectral resolution) to distinguish nearly all the impacts that can be identified at the ground level, with exception of most trash and debris (Kumpula et al. 2006). Preliminary analysis of the impacts of development in the Bovanenkova field indicated that indirect impacts associated with off-road vehicle trails exceed the direct impacts by a factor of 3, and the total area influenced by the industrial development was about 40 times the area of the industrial footprint (Kumpula et al. 2006).

We will do a comparative study of the Yamal road network with that at Prudhoe Bay, Alaska. We will compare the new Quickbird images from both the Yamal and Prudhoe Bay regions with detailed historic photos and GIS data bases and compare the physical impacts from different aged roads (Walker and Everett 1987, Walker et al. 1987). Prudhoe Bay has a much longer historic record of change than is available for the Bovanenkovo gas field, and should be able to provide more insights regarding how roadside changes proceed over time. A historic record of the expansion of infrastructure at Prudhoe Bay for the years 1968-2001 has already been completed (NRC 2003). We will build on this with more detailed examination of dust-affected tundra and thermokarst adjacent to selected roads of different age and different traffic loads. We will also evaluate whether or not the Mid-Decadal Global Land Survey (GLS-2000) data (30-m sharpened to 15-m resolution) can be used to inventory the total extent of the road networks on the Yamal and the North Slope.

Effects of reindeer foraging and trampling

The major questions for this subcomponent are: (1) How do the expanding populations of Nentsy and their reindeer affect the rangelands? (2) Do the unusual extensive willow shrublands on the Yamal affect the foraging patterns and migrations of the reindeer? (3)Are the reindeer preferentially foraging in landslide-induced willow shrublands or recent landslides dominated by graminoids, forbs, and horsetails?

The reindeer exert important controls over the structure and function of the Yamal tundra. When the animals are concentrated in small areas on organic substrates, dense graminoid swards can develop (grassification). These can be seen in and around campsites and along migration routes, particularly near the slaughterhouse locations where the animals are often concentrated for several days before they can be processed. On well-drained, sandy substrates with minimal organic content, concentrated trampling can thin and eventually break through the otherwise closed vegetation mat, leading to erosion by wind. Perhaps most significant to the vegetation is the projected simultaneous reduction in available pasturelands due to infrastructure expansion and the simultaneous increases in the Nenets and reindeer populations that will make heavy demands on the pasturelands in the future.

In this portion of the study, we will examine Quickbird images to see if the effects of reindeer trampling can be detected, particularly around known camp sites and near the slaughterhouse locations. Areas of eolian deflation are clearly visible on the Quickbird imagery (Khomutov and

Leibman 2008), and we will determine if there is correspondence of known high reindeer use and areas of high eolian deflation.

It would also be highly useful to use fences to exclude reindeer from patches of tundra to see the effects of their foraging on productivity and the spectral properties of the landscapes as observed from space. Building exclosures has proven difficult because of the high cost of transporting fencing material to the peninsula. We will, however, continue to pursue this possibility in collaboration with the Nenets herders.

In North America *Salix* is a favorite *Rangifer* food at certain times of the year, and other plants, such as forbs and horsetails, found abundantly in the willow communities are also favorite foods (Kuropat 1984). From our experience in northern Alaska, these shrublands might be favored areas for a variety of wildlife. It is currently unknown if the willow communities affect the migration patterns of the reindeer, but we hypothesize that the higher nutrient content and low amount of plant protective compounds found in willow leaves compared to many other tundra species affect the palatability of the plants in these communities and that reindeer would favor these areas for forage. There may be other reasons reindeer (or the herders) on the Yamal avoid them. For example, predators may lurk in these areas or animals can easily lie down and be out of view during migrations. A preliminary study will be directed at how the Nentsy travel through these areas and how the reindeer use the willow communities on the abundant landslides of the Yamal vs. the lichen upland areas that dominate much of the peninsula.

The Nentsy probably already know most of what we need to know regarding reindeer foraging habits. Florian Stammler will conduct interviews with the Nentsy as part of a separately funded study and will determine if the Nentsy perceive preferential foraging by reindeer on the disturbed landscapes, and how this might vary spatially and temporally along the route of the migration, especially in comparison to the sandy lichen-rich uplands that are favored by the reindeer during much of their migration. If the reindeer do either preferentially use or avoid areas of high willow concentrations, this would suggest that large-scale natural-disturbances (in this case landslides) play a major role in foraging patterns during migration. This could also have major implications for understanding possible climate-change related impacts to reindeer and caribou foraging patterns in other locations in the circumpolar region.

A synthesis of approaches addressing the issue of cumulative effects

Resource development often proceeds in a piecemeal fashion — a process called "nibbling" in the cumulative effects literature (Horak et al. 1983, Beanlands et al. 1986, Lee and Gosselink 1988). The US Regulatory definition of cumulative impacts is:

> *…an impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable-future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (CEQ 1978).*

Our aim is to look further into the future and anticipate the combined effects from several agents of change. Climate and demographic changes also occur subtly and over long periods of time. The approach used here expands the concept of cumulative impacts to include the simultaneous and interactive effects of developing many gas fields and other ongoing social and ecological factors such as population growth and climate change. A cumulative effects analysis that employs a variety of predictive tools could provide a vision of what is to come and a means to develop alternative best practices scenarios.

We will follow the Arctic Centre's model of involving the Nentsy strongly in the cumulative effects analyses. Adapting to the impending changes that are coming on the Yamal is a daunting prospect for the Nentsy. It is not possible for the people of the region to protect their interests without first gaining an understanding of what the future could look like. The problem of expanding road and pipeline networks is an especially difficult-to-address Arctic-wide problem faced by other indigenous Arctic people. A 2050 scenario developed by the UNEP GLOBIO project estimated that with the same growth rates of industrial development that occurred between 1940-1990, 50-80% of the Arctic will be affected by expanding road networks and infrastructure by 2050 (UNEP 2001). A planning process is needed that utilizes models that can predict the footprint of development and test various scenarios that will minimize the impacts. Such tools are being developed in other areas of gas development (e.g., Weller et al. 2002, Holroyd 2008).

The larger value of an analysis of cumulative effects of resource development, reindeer herding and climate change on the Yamal Peninsula will be in the lessons learned and the applications of those lessons to other areas of development. We propose an international workshop entitled "Advancing Cumulative Effects Analysis for Arctic Oil and Gas Development" to be held Fairbanks in Fall 2010. The goals of the workshop will be to (1) compare the cumulative effects analysis approaches in different areas of the Arctic, and (2) find common threads that could be used to develop more explicit adaptive management approaches for the future. Adaptive management practices call for close collaboration and integration of management, research, and monitoring practices through explicit feedback mechanisms to refine and improve future management decisions. These might include among other things comprehensive region-wide planning, a focus on ecosystem-level research, approaches to defining the true area affected by the industrial development (rather than reporting only the footprint of gravel placement and mining), social-ecological approaches that involve closer analysis of the effects on human communities, and how to deal with the uncertainties of the interactions between different types of perturbations. The proposed workshop will involve scientists and indigenous participants from across the Arctic including the members of the National Research Council's Committee on Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope (NRC 2003), researchers involved in new modeling approaches to examine scenarios of infrastructure expansion (e.g., Bright 2008, Fresco 2008, Holroyd and Retzer 2005), the Saami in northern Norway (Mathiessen 2008), and Nentsy and scientists involved in the Yamal studies. The goal of the workshop will be to develop a series of recommendations to encourage the fruitful coexistence between resource extraction, the people who live in these regions, and other stakeholders who have a vital interest in the ecological integrity of these regions. A specific product from the workshop will be a comparative analysis by Forbes and Stammler (Arctic Centre) and Kofinas (UAF) that examines the relative effects of industrial development on high latitude indigenous livelihoods. The study will draw on the findings of the Fairbanks workshop and will specifically focus on the Nentsy, whose nomadic livelihoods persist in spite of gas development, and the Alaska Inupiat communities that continue to participate actively in subsistence hunting and fishing activities. This herding-hunting comparison will serve as a powerful way of integrating aspects of the project and addressing its policy relevance.

GENERAL PLAN OF WORK

We are requesting a 1 Jun 2009 start date, at the end of our current LCLUC project. During the first year (2009) we would continue the GIS analysis of the roads and infrastructure on the

Yamal using the GLS-2000 data set and begin a detailed analysis of the seasonal variations in sea-ice, land-surface temperatures, snow cover, and NDVI, on the Yamal. During the second year (2010) the major focus would be the field work on Belyy Island and a site in subzone A if the opportunity arises for transportation. This would complete the Eurasian Arctic bioclimate transect. Remote sensing surveys of the road effects at Bovanenkovo and Prudhoe Bay will also be conducted in 2010. In 2011, field work would focus on the willow communities at Vaskiny Dachi. Studies of the changes related to reindeer would also be conducted in 2010-2011 by the Arctic Centre mainly with funds from other sources. Modeling development would progress steadily during all four years of the project. The fourth year of the study would be devoted mainly to synthesis activities. An International Arctic Oil and Gas Cumulative Effects Workshop would be held in early 2010 in Fairbanks. A Yamal LCLUC Workshop would be held in Moscow or Rovaniemi in early 2011 to synthesize information from the Yamal transect.

Tasks	2009	2010	2011	2012	2013
Component 1: Analysis of climate/ sea-ice / vegetation interactions					
Ground based observations of natural vegetation-climate relationships					
Field work at Belyy Island, Kharasavey (UAF, U Va. ECI, AC)		X			
Field Work at Vaskiny Dachi, analysis of landslides and lichen uplands (UAF, U Va, ECI)			X		
Satellite-based analysis of climate-vegetation relationships (Bhatt, Raynolds, Comiso, UAF)	X	X X X X	X X X X		
Predictive models of vegetation change, ArcVeg (Epstein, Yu)	X X	X X X X	X X X X		
Component 2: Social-ecological studies					
Changes due to resource development					
GIS analysis of road, infrastructures on Yamal using GLS-2000 (Kumpula, AC)	X	X X X X	X X		
GIS analysis of roads and infrastructure at Prudhoe Bay using GLS-2000 (Raynolds, UAF)	X	X X X X	X X		
Changes related to reindeer					
Effects of resource development on reindeer pastures (Kumpula, Stammler, Forbes AC)		X X	X X		
Effects of reindeer foraging and trampling (Kumpula, Forbes and Khomutov, AC and ECI)		X X	X X		
Analysis of reindeer use of landslide areas (Kumpula, Stammler, Forbes, AC)		X X	X X		
Comparative analysis of cumulative effects of change					
Program management and outreach					
Data management					
Data reports (Walker, Kaärlejarvi, Barbour)	X	X			
Website development and maintenance (Barbour)	X	X	X	X	X
Data management (Maier)	X	X	X	X	X
Meetings					
LCLUC meetings		X	X	X	X
NEESPI meetings and paper presentations	X	X	X	X	X
Yamal Cum. Effects Workshop (Moscow, UAF, ECI)			X		
Internat'l Cum. Effects of Oil and Gas Develop. Workshop (Fairbanks AC, UAF)		X			
Synthesis papers				X X X X	X X

DATA SHARIING, DATA MANAGEMENT AND OUTREACH

The project will have a science management team composed of the collaborators (Bhatt, Comiso, Epstein, Forbes, Jia, Kofinas, Orekhov, Leibman, Romanovsky, Walker). For purposes of this submittal, Dr. D.A. Walker will serve as Principal Investigator of the project, but decisions will be made with the consensus of the co-PIs The project will be coordinated with other NEESPI projects, other IPY projects, and ongoing circumpolar mapping and modeling. Data will be centrally managed at the Alaska Geobotanical Center (AGC), University of Alaska Fairbanks. Hilmar Maier will facilitate day-to-day activities and be the data manager of the project. Annual hard-copy data reports will be prepared for each of the field locations. Metadata will be written for each data set following national protocols and made available to the wider science community through the Joint Office for Science Support (JOSS) as soon as it becomes available and is quality checked. Final archiving will be done through the Arctic Data Coordination Center and Geographic Information Network of Alaska (GINA) at UAF. Outreach will be via publications, presentations, and a web page that is maintained by Edie Barbour http://www.geobotany.uaf.edu/yamal/. The project will produce annual reports, including hard-copy data reports that will be available through the web page and through the national archives.

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BIOGRAPHICAL SKETCHES

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

Areas of Specialization: Tundra Ecology, Vegetation Mapping, Landscape Ecology, Quantitative Ecology Methods, Vegetation of Northern Alaska and the Arctic, Snow-Ecosystem Interactions, Landscape Response to Climate Change, Geographic Information Systems and Remote Sensing, Disturbance and Recovery of Arctic Ecosystems.

Statement of relevant background: I have worked in the Arctic for 35 years and written extensively on the topics of cumulative impacts of oil field development and disturbance and recovery in arctic ecosystems. I served on the National Research Council Committee on Cumulative Environmental Effects of Alaskan North Slope Oil and Gas Activities (2000-2003). I have directed several large interdisciplinary and international projects, including the recent Circumpolar Arctic Vegetation Map project (http://www.geobotany.uaf.edu/cavm/abstract.shtml) the production of a web-based Arctic geobotanical atlas, a large Biocomplexity in the Environment project (http://www.geobotany.uaf.edu/cryoturbation/), and the Yamal land-cover land-use change project **(**http://www.geobotany.uaf.edu/yamal/). I've written numerous papers regarding tundra and landscape ecology; application of remote sensing for vegetation classification; and the use of NDVI to examine landscape change, greening in Alaska, and estimating circumpolar biomass. Finally, I have worked on the Yamal Peninsula and the Kolyma River area in Siberia, and collaborated extensively with the researchers at the Earth Cryosphere Institute in Moscow and the Arctic Centre, in Rovaniemi.

Professional Experience:

University of Alaska Fairbanks: Director Alaska Geobotany Center, 1999 to present; Professor, Department of Biology and Wildlife, 1999 to present.

University of Colorado Boulder: Assistant Professor Attendant Rank 1989-93; Associate Professor Attendant Rank 1996-1998; Professor Attendant Rank 1998-1999, University of Colorado Boulder; Fellow, 1985-1999; Institute of Arctic and Alpine Research (INSTAAR, University of Colorado;
Senior Research Associate, 1998-1999, INSTAAR; Co-Director, Tundra Ecosystem Analysis and Mapping Laboratory, 1989-1999; INSTAAR Research Associate, University of Colorado: Herbarium, 1990-1999

Publications: 147 refereed publications: 9 major publications (large maps, atlases, and major edited works), 10 book chapters, 105 refereed articles, 54 refereed government publications and maps and published abstracts. Plus 188 un-refereed works, including: 9 book reviews, 121 unpublished conference papers and lectures (16 invited), 55 other data reports and reports and maps to government agencies and consulting firms, and 2 theses.

Most recent and relevant publications:

Walker, D.A., U.S. Bhatt, M.K. Raynolds, V.E. Romanovsky, G.P. Kofinas, J.P. Kuss, B.C. Forbes, F. Stammler, T. Kumpula, E. Kaarlejärvi, M.O. Leibman, N.G. Moskalenko, A.A. Gubarkov, A.V. Khomutov, D.S. Drozdov, H.E. Epstein, Q. Yu, G.J. Jia, J.O. Kaplan, J.C. Comiso. 2008 (submitted). Cumulative effects of rapid land-cover and land-use changes on the Yamal Peninsula, Russia**.** *In:* Gutman, G. and P. Groisman, and Reissell. (ed.) *Eurasian Arctic Land Cover and Land Use in a Changing Climate.*

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Academic Training:

Degree	*Year*	*Institution,Major*
B.A.	1986	Cornell University, Computer Science
M.S.	1995	Colorado State University, Rangeland Ecosystem Science
Ph.D.	1997	Colorado State University, Ecology

Professional Experience:

2004-present, *Associate Professor*, Dept. of Env. Sci., Univ. of VA, Charlottesville, VA
1998-2004, *Assistant Professor*, 1997-1998, Dept. of Env. Sci., Univ. of VA, Charlottesville, VA
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 Science, Colorado State University, Fort Collins, Colorado.

5 Relevant Journal Articles (67 total peer-reviewed articles and chapters):

Epstein, H.E., D.A. Walker, M.K. Raynolds, G.J. Jia, and A.M. Kelley. Phytomass patterns across the full temperature gradient of the arctic tundra. Journal of Geophysical Research - Biogeosciences in press.

Epstein, H.E., J.O. Kaplan, H. Lischke, and Q. Yu. 2007. Simulating future changes in arctic and sub-arctic vegetation. Computing in Science and Engineering 9:12-23.

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.

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.

Epstein, H.E., M.D. Walker, F.S. Chapin III and A.M. Starfield. 2000. A transient, nutrient-based model of arctic plant community response to climatic warming. Ecological Applications 10:824-841.

5 Other Related Journal Articles

Cook, B.I., G.B. Bonan, S. Levis, and H.E. Epstein. The thermal insulative effect of snow in the climate system. **Climate Dynamics** in press.

Daanen, R.P., D. Misra, and H.E. Epstein. Hydrological complexity in non-sorted circle ecosystems of the arctic tundra. **Journal of Geophysical Research-Biogeosciences** in press.

Kelley, A.M, and H.E. Epstein. Effects of nitrogen fertilization on plant communities of non-sorted circles in moist nonacidic tundra, northern Alaska **Arctic, Antarctic, and Alpine Research** in press**.**

Ping, C-L., G.J. Michaelson, M.T. Jorgenson, J.M. Kimble, H.E. Epstein, V.E. Romanovsky, and D.A. Walker. High stocks of soil organic carbon in the North American Arctic region. **Nature-Geosciences** in press.

Walker, D.A., H.E. Epstein, W.A. Gould, C.L. Ping, V.E. Romanovsky, Y. Shur., C.T. Tarnocai, R.P. Daanen, G. Gonzalez, A.N. Kade, A.M. Kelley, W.B. Krantz, P. Kuss, N.V. Matveyeva, G.J. Michaelson, C.A. Munger, D.J. Nicolsky, R.A Peterson, M.K. Raynolds, C.M. Vonlanthan. Biocomplexity of small patterned-ground features along the North American Arctic Transect. **Journal of Geophysical Research –Biogeosciences** in press.

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PROFESSIONAL PREPARATION:

M.S. - 1975; Geophysics (Honor Diploma), Moscow State University
M.S. - 1985; Mathematics (Honor Diploma), Moscow State University
Ph.D. - 1982; Geology, Moscow State University
Ph.D. - 1996; Geophysics, University of Alaska, Fairbanks

APPOINTMENTS:

Professor of Geophysics, University of Alaska Fairbanks, Alaska, 2006-presentAssociate
Professor of Geophysics, University of Alaska Fairbanks, Alaska, 1999-2006Research Associate
Professor, Geophysical Institute, U 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

Brown, J. and V. E. Romanovsky, Report from the International Permafrost Association: State of Permafrost in the First Decade of the 21st Century, *Permafrost and Periglacial Processes*, 19: 255–260, 2008.

Romanovsky, V. E., Sazonova, T. S., Balobaev, V. T., Shender, N. I., and D. O. Sergueev, Past and recent changes in permafrost and air temperatures in Eastern Siberia, *Global and Planetary Change*, 56: 399-413, 2007.

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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.

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.

Five other significant publications:

Nicolsky, D. J., Romanovsky, V. E., Alexeev, V. A. and D. M. Lawrence, Improved modeling of permafrost dynamics in Alaska with CLM3, *Geophysical Research Letters*, VOL. 34, L08501, doi:10.1029/2007GL029525, 2007.

Mölders, N. and Romanovsky, V.E., Long-term evaluation of HTSVS' frozen ground/permafrost component using observations at Barrow, Alaska. *J. Geophys. Res*., 111: doi:10.1029/2005JD005957, 2006.

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.

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 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.

SYNERGISTIC ACTIVITIES:

1. Service to the scientific community as a President of the US Permafrost Association, 2004-2006.
2. Service on the "Task Force on Climate Change, Permafrost and Civil Infrastructure" of the Arctic Research Commission, 2001-2004.
3. Service to the scientific community as a Chair of "Modeling of Permafrost" Subgroup of the International Permafrost Association (IPA), 2003-2008.
4. 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.
5. Service to the scientific community as a member of the CliC scientific steering group (SSG), 2008-present.
6. Service to the scientific community as a member of the Executive Committee of the International Permafrost Association (IPA), 2008-present.

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Education: University of Pittsburgh (1977-1983) - Mechanical Engineering B.E. and Russian Language B.A; University of Wisconsin Madison, Atmospheric Sciences, M.S. (1989), Ph.D. (1996).

Areas of Specialization: Climate Variability on Interannual to Multi-decadal Scales, Global Climate Modeling, Air-Sea Interactions, Air-Ice Interactions, Climate Downscaling, Climate-Vegetation Interactions, Glacier-Climate Interactions, Climate of Alaska.

Statement of relevant background: My main area of research is to understand how the surface of the earth interacts with the atmosphere on climate time scales. This includes the role of sea ice, land surface heat and moisture, and the ocean in shaping climate variability. I have recently conducted interdisciplinary research focused on the Arctic in the area of tundra vegetation and glacier mass balances in Alaska. I have extensive experience analyzing large climate data sets from observations, global models, and regional models. The primary tool that I use to investigate climate mechanisms and sensitivity are Global Climate Models (GCM). I have 20 years of experience at modifying GCM codes to suite the needs of a particular study.
I have a broad understanding of relevant topics in Arctic system science from my service experience. I have served as a member and the chair of the American Meteorological Society Committee on Polar Meteorology and Oceanography. I also co-guest edited a series on the IPY for Computing in Science and Engineering. In addition, I teach the graduate level course *Climate and Climate Change* at the University of Alaska that caters to a scientifically broad audience and has been taken by a tour guide and a journalist.

Professional Experience:

University of Alaska Fairbanks
- Associate Professor Univ. Alaska Fairbanks in the Atmospheric Science Program & Geophysical Institute (2004 - present), tenured in July 2008.
- Research Associate Professor Univ. Alaska Fairbanks at IARC-Frontier (2003)
- Research Assistant Professor Univ. Alaska Fairbanks at IARC-Frontier (1998 - 2003)

Center for Land-Ocean-Atmosphere Studies
- Post Doctoral Researcher (1997 - 1998)

Ross Computational Resources
- Research Scientist (1996 - 1997)

U.S. Peace Corps
- Volunteer at Sochoi Secondary School in Kenya (1983 - 1985)

Publications: 22 peer-reviewed publications that focus on mechanisms of climate variability that spans research focused on climate variability in the tropics, northern midlatitudes and the Arctic.

Most recent and relevant peer-reviewed publications:

Walker, D.A., **U.S. Bhatt**, M.K. Raynolds, V.E. Romanovsky, G.P. Kofinas, J.P. Kuss, B.C. Forbes, F. Stammler, T. Kumpula, E. Kaarlejärvi, M.O. Leibman, N.G. Moskalenko, A.A. Gubarkov, A.V. Khomutov, D.S. Drozdov, H.E. Epstein, Q. Yu, G.J. Jia, J.O. Kaplan, J.C. Comiso. 2008 (submitted). Cumulative effects of rapid land-cover and land-use changes on

the Yamal Peninsula, Russia**.** *In:* Gutman, G. and P. Groisman, and Reissell. (ed.) *Eurasian Arctic Land Cover and Land Use in a Changing Climate.*

Goetz, S. J. ,Epstein, H,E, D. Alcaraz, **U.S. Bhatt**, J. Comiso, G.J. Jia, J.O. Kaplan, H. Lischke, A., Lloyd, Q. Yu, and D.A. Walker 2008 (submitted). Recent Changes in Arctic Vegetation: Satellite Observations and Simulation Model Predictions. In: Gutman, G. and P. Groisman, and Reissell. (ed.) *Eurasian Arctic Land Cover and Land Use in a Changing Climate.*

Bhatt, U. S., M.A Alexander, C. Deser, J.E.Walsh, J.S. Miller, M. Timlin, J.D. Scott, and R. Tomas, 2008, The Atmospheric Response to Realistic Reduced Summer Arctic Sea Ice Anomalies, to appear in AGU monograph: E. DeWeaver and C. Bitz, (ed.) *Arctic Sea Ice Decline: Observations, Projections, Mechanisms, and Implications*.

Li, Z., **U.S. Bhatt**, and N. Mölders, 2008. Impact of doubled CO2 on the interaction between the global and regional water cycles in four study regions. Climate Dynamics , pp 255-275, 10.1007/s00382-007-0283-4.

Bhatt U.S., J. Zhang, W.V. Tangborn, and C.S. Lingle, L. Phillips, 2007, Examining Glacier Mass Balances with a Hierarchical Modeling Approach, Computing in Science and Engineering, 9 (2), 61-67.

Polyakova E.I. , A.G. Journel, I.V. Polyakov, and **U.S. Bhatt**, 2006, Changing relationship between the North Atlantic Oscillation and key North Atlantic climate parameters, Geophys. Res. Lett., 33, L03711, doi:10.1029/2005GL024573.

Polyakov I. V., **U.S. Bhatt**, H.L. Simmons, D. Walsh, J.E. Walsh, X. Zhang, 2005: The 20th Century Variability of North Atlantic Temperature and Salinity, J. Climate, (18)21, 4562-4581.

Bhatt U.S., D. E. Newman, B. A. Carreras, I. Dobson, Understanding the Effect of Risk Aversion on Risk, HICSS, p. 64b, Proceedings of the 38th Annual Hawaii International Conference on System Sciences (HICSS'05) - Track 2, 2005.

Polyakov I.V. , G.V. Alekseev, L. Timokhov, **U.S. Bhatt**, R.L. Colony, H.L. Simmons, D. Walsh, J. Walsh, 2004: Variability of the intermediate Atlantic Water of the Arctic Ocean over the last 100 years, J. Climate,17(23), 4485-4497.

Zhang X., J.E. Walsh, J. Zhang, **U.S. Bhatt**, and M. Ikeda, 2004: Climatology and Interannual Variability of Arctic Cyclone Activity, 1948 – 2002, J. Climate, 2300-2317.

Alexander M. A., **U.S. Bhatt**, J. Walsh, M. Timlin, and J. Miller, 2004: The Atmospheric Response to Realistic Arctic Sea Ice Anomalies in an AGCM during Winter, J. Climate 17, 890-905.

Bhatt U. S., E.K. Schneider, and D. Dewitt, 2003: Influence of North American land processes on North Atlantic SST variability, Global and Planetary Change, 37, 33-56. doi:10.1016/S0921-8181(02)00190-X.

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Education: University of Vermont, Environmental Studies, B.A. (1984); Vermont College of Norwich University M.A. (1987); McGill University, Ecological Biogeography, Ph.D. (1993).

Areas of Specialization: Tundra Ecology, Vegetation Science, Applied Ecology/Geography, Land Use Change, Climate Change, Indigenous Knowledge, Rangeland Ecology, Disturbance and Recovery of Arctic Ecosystems. Human-*Rangifer* Interactions, Resilience in Social-Ecological Systems, Integrated Human-Environmental Studies, Remote Sensing.

Statement of relevant background: I have worked in boreal and arctic regions for 23 years and written extensively on the topics of anthropogenic disturbance and patterns of recovery in tundra ecosystems. My experience is nearly circumpolar, with field research in Alaska, the Canadian High Arctic, Fennoscandia, Western and Eastern Siberia. I have coordinated two large interdisciplinary and international projects in northernmost Europe and Russia in the last eight years, including RENMAN 2001-2004 (http://www.arcticcentre.org/renman) and ENSINOR 2004-2007 (http://www.arcticcentre.org/ensinor). I've written numerous papers regarding the short- and long-term responses of tundra vegetation and soils to different anthropogenic and zoogenic disturbance regimes with special emphasis on the types of impacts associated with oil & gas development and intensive reindeer grazing/trampling. I have worked closely with indigenous peoples in Canada, Fennoscandia and Russia, especially Sami and Nenets reindeer herders. I also collaborate and publish regularly with social scientists and have written on the resilience of integrated social-ecological systems in the Arctic. I have worked extensively in the Russian Arctic since 1991, including numerous leading numerous large expeditions in both summer and winter to the Yamal Peninsula, in addition to fieldwork in the Nenets Autonomous Okrug and the Kolyma River area. I currently lead the Global Change Research Group at the Arctic Centre, University of Lapland and collaborate extensively with researchers at the Institute of Arctic Biology, University of Alaska, Fairbanks.

Professional Experience:

Arctic Centre, University of Lapland, Finland
- Research Professor in Global Change, 2004 to present
- Senior Scientist in Environmental Science, 1996 to 2003
- Fulbright Scholar in Arctic and Environmental Studies, 1994-1995

Faculty of Science, University of Oulu, Finland
- Docent in Plant Ecology/Biogeography, 2000 to present

Ecosystem Health, University of Guelph, Ontario
- Post-Doctoral Fellow in Ecosystem Health, 1993-1994

Most recent and relevant publications:

Forbes, B.C. (2008) Equity, vulnerability and resilience in social-ecological systems: a contemporary example from the Russian Arctic. *Research in Social Problems and Public Policy* **15**:203-236.

Willard, B.E., D.J. Cooper and **B.C. Forbes** (2007) Natural regeneration of alpine tundra vegetation after human trampling: a 42-year data set from Rocky Mountain National Park, Colorado, USA. *Arctic, Antarctic and Alpine Research* (in press).

Chapin, F.S., III, M. Berman, T.V. Callaghan, A.-S. Crepin, K. Danell, H. Ducklow, **B.C. Forbes**, G. Kofinas, A.D. McGuire, M. Nuttall, R. Virginia, O. Young, and S. Zimov

(2006) Polar Systems. In: R. Hassan, R. Scholes and N. Ash (eds.) *Millennium Ecosystem Assessment, Current State and Trends Vol. 1*. Island Press, Washington, D.C., pp. 717-743.

Forbes, B.C., M. Bölter, L. Müller-Wille, J. Hukkinen, F. Müller, N. Gunslay, and Y. Konstantinov (eds.) (2006) Reindeer management in northernmost Europe: linking practical and scientific knowledge in social-ecological systems. Ecological Studies 184. Springer-Verlag, Berlin,

Nuttall, M., F. Berkes, **B.C. Forbes**, G. Kofinas, T. Vlassova and G. Wenzel (2005) Hunting, herding, fishing and gathering. In: *Arctic Climate Impact Assessment*, Cambridge University Press, Cambridge, pp.649-690.

Forbes, B.C. (2004) Impacts of energy development in polar regions. In: C.J. Cleveland (ed.) *Encyclopedia of Energy*. Academic Press, San Diego, pp. 93-105.

Forbes, B.C., N. Fresco, A. Shvidenko, K. Danell and F.S. Chapin III (2004) Geographic variations in anthropogenic drivers that influence the vulnerability and resilience of high latitude social-ecological systems. *Ambio* **33**:377-382.

Chapin, F.S. III, P. Angelstam, M. Apps, F. Berkes, C. Folke, **B.C. Forbes**, G. Juday and O. Peterson (2004). Vulnerability and resilience of high-latitude ecosystems to environmental and social change. *Ambio* **33**:344-349.

Weladji, R. and **B.C. Forbes** (2002) Disturbance effects of human activities on *Rangifer tarandus* habitat: implications for life history and population dynamics. *Polar Geography* **26**:171-186.

Forbes, B.C. and J.D. McKendrick (2002) Polar tundra. In: M. Perrow and A.J. Davy (eds.) Handbook of Ecological Restoration. Cambridge University Press, Cambridge, pp. 355-375.

Forbes, B.C., J.J. Ebersole and B. Strandberg (2001) Anthropogenic disturbance and patch dynamics in circumpolar arctic ecosystems. *Conservation Biology* **15**:954-969.

Forbes, B.C. and G. Kofinas (eds.) (2000) The human role in reindeer and caribou grazing systems. Proceedings of an International Arctic Science Committee Workshop held 10-14 February 1999 in Rovaniemi, Finland. *Polar Research* **19**(1):1-142.

Forbes, B.C. (1999) Land use and climate change in the Yamal-Nenets region of northwest Siberia: some ecological and socio-economic implications. *Polar Research* **18(2)**:1-7.

Forbes, B.C. and O.I. Sumina (1999) Comparative ordination of low arctic vegetation recovering from disturbance: reconciling two contrasting approaches for field data collection. *Arctic, Antarctic and Alpine Research* **31**:389-399.

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

Forbes, B.C. and R.L. Jefferies (1999) Revegetation in arctic landscapes: constraints and applications. *Biological Conservation* **88**:15-24.

Forbes, B.C. (1997) Tundra disturbance studies. IV. Species establishment on anthropogenic primary surfaces, Yamal Peninsula, northwest Siberia, Russia. *Polar Geography* **21**:79-100.

Forbes, B.C. (1996) Plant communities of archaeological sites, abandoned dwellings, and trampled tundra in the eastern Canadian Arctic: a multivariate analysis. *Arctic* **49**:141-154.

Forbes, B.C. (1995) Tundra disturbance studies. III. Short-term effects of aeolian sand and dust, Yamal Region, northwest Siberia, Russia. *Environmental Conservation* **22**:335-344.

Forbes, B.C. (1994) The importance of bryophytes in the classification of human-disturbed high arctic vegetation. *Journal of Vegetation Science* **5**:875-882.

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OVERVIEW

Dr. Comiso's research is focused on the following topics: (a) the detection of climate change from historical satellite and in situ data; (b) polynyas, Odden, and bottom water formation; (c) air-sea-ice interactions and biological processes in the polar regions; and (d) radiative transfer modeling studies and satellite algorithms for sea ice and snow. The primary research tool is satellite remote sensing in the microwave, infrared, and visible regions with emphasis on passive microwave techniques. He is currently a member of the Advanced Microwave Scanning Radiometer (AMSR) science team in both EOS-AQUA and NASDA-ADEOS-2 satellites and is responsible in developing standard algorithms for sea ice in both systems. He has generated and analyzed more than 20 years of satellite data on ice concentration, surface temperature, albedo, and cloud statistics in the polar regions with a view of improving our understanding of recently observed global warming that may be associated with greenhouse gases. Also, he has been a principal investigator in three Antarctic field programs and was the chief scientist of a NASA aircraft flight program over a nuclear submarine in the Arctic.

REFEREED PUBLICATIONS

Koh, M., D. Perovich, and J.C. Comiso, Permittivity of Antarctic sea ice, *Geophy. Lett.Res.,* (submitted, 2005).

Comiso, J.C. and G. Cota, Spatial and interannual variations in pigment concentrations in the Arctic and peripheral seas and their correlations with surface temperature, clouds, and wind, *J. Geophys. Res.* (in review, 2005).

Gordon, A.L., M. Visbeck, and J.C. Comiso, A link between the Great Weddell Polynya and the Southern Annular Mode, *J. Climate* (in review, 2005).

Comiso, J.C., Impacts of the variability of 2nd year ice types on the decline of the perennial ice cover, *Ann. of Glaciology, 44* (accepted, 2005).

Massom, R.A., T. Worby, V. Lytle, T. Markus, I. Allison, T. Scambos, H. Enomoto, K. Tateyama, T. Haran, J. Comiso, A. Pfaffling, T. Tamura, A. Muto, B. Giles, N. Yong, and G. Hyland, ARISE (Antarctic Remote Ice Sensing Experiment) in the East 2003: Validation of satellite- derived sea-ice data products, *Ann. of Glaciology, 44* (accepted, 2005).

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Comiso, J.C., Arctic warming signals from satellite observations, *Weather,* 61(3), 70-76, 2006.

Comiso, J.C., Impact Studies of a 2o C global warming on the Arctic sea ice cover, in *2o is too much! Evidence and implications of Dangerous Climate Change in the Arctic*, ed. Lynn Rosentrater, WWF International Arctic Programme, Oslo, Norway, pp 44-56, 2005.

Wang, Jian, G.F. Cota, and J.C. Comiso, Phytoplankton in the Beaufort and Chukchi Seas; Distributions, dynamics, and environmental forcing, *Deep Sea Res. II, 52*, 3355-33688, (2005). Comiso, J.C., Sea ice algorithm for AMSR-E,*Rivista Italiana di Telerilevamento (Italian Journal of Remote Sensing)*, *30/31*, 119-130, 2004.

Comiso, J.C. and C.L. Parkinson, Satellite observed changes in the Arctic, *Phys. Today 57*(8), 38-44, 2004.

Worby, A.P. and J.C. Comiso, Studies of Antarctic sea ice edge and ice extent from satellite and ship observations,*Remote Sensing of the Environment*, *92*(1), 98-111, 2004.

Massom, R.A., M.J. Pook, J.C. Comiso, N. Adams, J. Turner, T. Lachlan-Cope, T. Gibson, Precipitation over the interior East Antarctica ice sheet related to mid-latitude blocking high activity, *J. Climate*, *17*, 1914-1928, 2004.

Cota, G., G. Wang, and J.C. Comiso, Transformation of global satellite chlorophyll retrievals with a regionally tuned algorithm, *Rem. Sensing of the Environment*, 90, 373-377, 2004. Schneider, D. P., E. J. Steig, and J. C. Comiso, Recent climate variability in Antarctica from satellite-derived temperature data , *J. Climate*, *17*, 1569-1583, 2004.

Yang, J., J.C. Comiso, D. Walsh, R. A. Krishfield, and S. Honjo, Storm-driven mixing in the upper Arctic Ocean and its relation to the Arctic Oscillation, *J. Geophys. Res.*, *109*, C04008, doi:10.1029/2001JC001248, 2004.

Comiso, J.C., J. Yang, S. Honjo, and R.A. Krishfield, The detection of change in the Arctic using satellite and buoy Data, *J. Geophys. Res. 108*(C12), 3384, doi:1029-2002jc001247, 2003.

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Education:

College # 1, Ashhabad (1993-1995), Chemical and bacteriological analisis.
Moscow State Open Pedagogical University (2001-2006), Ecology
Moscow State University for the Humanities (2002-2007), Biology
Earth Cryosphere Institute SB RAS (2006 to present), PhD candidate

Areas of Specialization: Tundra and Taiga ecology, Interactions between biotic and abiotic components of landscapes, Vegetation mapping, Zoogeographical mapping, Landscape ecology, Landscapes of Northern West Siberia and the Arctic , Landscape response to climate change, Remote sensing, Disturbance and recovery of Tundra and Taiga ecosystems, Temporal and spatial dynamics of ecosystems in West Siberia.

Professional Experience:

Earth Cryosphere Institute SB RAS, Moscow department, 2007 to present,research associate.
Moscow State Open Pedagogical University (MSOPU), 2004-2006
dispatcher 2004-2005. MSOPU
teaching methods specialist 2005-2006. MSOPU
Antiplague station of Turkmenistan, 1998-2001, laboratory assistant.
Exploratory expedition #4 of Water-resources Development Institute, 1996-1998, chemist-analyst.
Institute of Oil and Gas, 1995-1996, laboratory of researches of boreholes and geological layers, laboratory assistant
Institute of chemistry, 1993-1995, laboratory of toxicology, laboratory assistant

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Publications:

Moskalenko N.G., Orekhov P.T., Sorokina N.V., Yeroshenko V.I., “Assessment of a biological diversity along Nadym - Punga gas main". VI International conference "Development of the north and issues of environmental remediation" Syktyvkar, October, 10-14th 2006. (in print) 3 pages

Moskalenko N.G., Eroshenko V.I., Orekhov P.T., Sorokin N.V. "Survey of dynamics of restoration of eko-systems along Nadym-Punga gas main by bio-indicator methods" // Actual problems of regional ecological monitoring: scientific and educational aspects. Materials of the All-Russia scientific school on November, 28-30th, 2006, edition. IY, Kirov, 2006. p.177-179.

Orekhov P.T. “Impacts of man impact on dynamics of communities of petite mammals in the Arctic and subarctic conditions of Western Siberia”. The international conference "Cryogenic resources of polar regions" Salekhard, June 2007. P. 46-48.

Orekhov P.T. “Comprehensive assessment of impact of transport infrastructure of a gas complex on ecosystems of northern taiga and dynamics of its restoration”. Nekrasov’s readings. Tyumen, 09 II. 2007. (in print) 3 p.

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Orekhov P.T., Eroshenko V.I., Reaction of vegetation of the north of Western Siberia to man-made violations”. Materials of the All-Russia scientifically-practical conference with the international participation on November, 27-29th, 2007 Kirov 2007. P. 147-151.

Orekhov P.T.” Aquatic complexes of the northern taiga of Western Siberia. Materials of the All-Russia scientifically-practical conference with the international participation on November, 27-29th, 2007 Kirov 2007. P. 151-155.

Orekhov P.T. Aquatic natural complexes of oil and gas-bearing areas of the north of Western Siberia”. Materials of 3-rd all-Russian conference of research organizations "Prospects of development of engineering researches in construction in the Russian Federation". Moscow, December 20-21, 2007. (in print)

Orekhov P.T. Lake ecosistems in different landscapes in the Nadim region. // Yamal Land-Cover Land-Use Change Workshop, Moscow, 28-30 Jan. 2008. Project NNG6GE00A funded by NASA Land-Cover Land-Use Change (LCLUC) Program. – 2008. pp. 14.

Orekhov P.T., Nikitin A.J. “Habitat distribution of small mammals in the northern taiga of Western Siberia. Materials of XV international scientific conference of students, post-graduate students and young scientists "Lomonosov" Moscow, 2008 (in print)

Orekhov P.T. “Landscape differentiation of a temperature mode of soils of the northern taiga of Western Siberia”. Materials of the international conference "Cryogenic resources of polar and mountain regions". Tyumen 2008. (in print)

Orekhov P.T. Reaction of northern taiga ecosistems on human-induced degradation of permafrost in West Siberia. IX International conference on permafrost “Permafrost on a warming planet: impact on ecosystems, infrastructure and climate. Fairbanks, Alaska. (in print)

Moskalenko N. G., Ponomareva O.E., Matyshak G.V., Orekhov P.T., Kazantseva L.A, Ustinova E.V. Vegetation and Permafrost Long-term Monitoring in West Siberia Subarctic. IX International conference on permafrost “Permafrost on a warming planet: impact on ecosystems, infrastructure and climate. Fairbanks, Alaska. (in print)

NATALIYA MOSKALENKO

Earth Cryosphere Institute SB RAS, Moscow department, Russia, 119991, Moscow, Vavilov str. 30/6, 85, 7 (095) 135 98 71; Email: nat-moskalenko@hotmail.com

Education: Lomonosov Moscow State University (1954-1959), Botany, candidate dissertation (1966), doctor dissertation (1991).

Areas of Specialization: Tundra and Taiga Ecology, Vegetation Mapping, Landscape Ecology, Vegetation and Landscapes of Northern West Siberia and the Arctic, Vegetation-Permafrost Interactions, Landscape Response to Climate Change, Remote Sensing, Disturbance and Recovery of Tundra and Taiga Ecosystems, Dynamics of Northern Taiga Ecosystems in West Siberia.

Statement of relevant background: I have worked in the Northern Siberia for 46 years and studied seasonal rhythmic, horizontal structure of vegetation, interactions between vegetation and permafrost, vegetation dynamics in natural and disturbed conditions, compiled landscapes and vegetation maps using aero and space images. Since 1970 I have performed ecosystem monitoring in West Siberia northern taiga at the Nadym station and studied biomass on permanent plots. I have taken part in the Circumpolar Arctic Vegetation Map project, in the Circumpolar Active Layer Monitoring project and in the Thermal State Permafrost project. I have written numerous papers in Russian and some papers in English regarding interactions between vegetation and permafrost, vegetation recovery after disturbance, vegetation and landscape mapping, landscape response to climate changes. In 1993 I took part in the expedition on the Alaska and later collaborated with the researchers at the University of Alaska Fairbanks and University of Delaware.

Professional Experience:

Earth Cryosphere Institute SB RAS, Moscow department, 1995 to present, head scientist.
All-Russian Institute of hydrogeology and engineering geology (VSEGINGEO), 1959-95.
Assistant 1959-1961, VSEGINGEO.
Junior scientist 1961-1975, VSEGINGEO.
Senior scientist 1975-1989, VSEGINGEO.
Leading scientist 1989-1995, VSEGINGEO.

Publications: 130 refereed publications: 1 book, 12 book chapters, 2 published maps, 59 abstracts.

Most relevant publications:

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.

Reviewed articles:

Moskalenko, N.G. Microphytocoenoses of some landscapes of Northern Siberia and their indicator significance. 1973. *New techniques in Geology and Geography, Consultants Burean, New York-London*: 76-83.

Moskalenko, N.G., Slavin-Borovsky V.B., Shur J.L. and other. 1980. The effect of developing a territory on the heat balance and the thermal and moisture regime of the ground in the northern

part of Western Siberia. *Third Int. conf. on permafrost. Edmonton, July 1978. Soviet papers, Ottawa:* 55-60.

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Melnikov E.S., Grechischev S.E., Burgess M.M., Kurfurst P.I., **Moskalenko N.G.** 1993. Monitoring of Engineering-Geological processes along pipeline routes in permafrost terrain in Mackenzie River valley, Canada and Nadym area, Russia. *Proceedings of the Sixth International Conference on Permafrost, vol.1.*

Moskalenko, N.G. Role of vegetation cover in the cryolithozone. 1995. *Russian Geocryological volume, 1:*58-65.

Melnikov E.S., Konchenko L.A**., Moskalenko N.G.** 1998. Possibilities of applying a small-scale Russian Arctic Landscape Map to Circumpolar Vegetation Mapping. *Proceedings of the Third International Circumpolar Arctic Vegetation Mapping Workshop, U.S. Department of Interior, U.S. Geological Survey:* 36-46.

Moskalenko, N.G. 1998. Impact of vegetation removal and its recovery after disturbance on permafrost. *Proceedings, Permafrost Seventh Intern. Conf., Yellowknife*: 763-769.

N.G. Moskalenko, Pavlov A.V.2000. Ecosystem monitoring of West Siberia North. B*iodiversity and Dynamics of Ecosystems in North Eurasia, vol. 1, part 2:*195-197.

E.S. Melnikov, M.O. Leibman, **N.G. Moskalenko** and A.A. Vasiliev. 2004. Active-layer monitoring in the cryolithozone of West Siberia. *Polar Geography, 28, No 4:267-285.*

Moskalenko, N.G., 2002. Database on vegetation dynamics of West Siberia North. *The First Workshop on information technologies application to problems of biodiversity and dynamics of ecosystems in North Eurasia (WITA 2001), selected papers, Novosibirsk:76-79.*

Pavlov A.V., **Moskalenko, N.G.**, 2002. The Thermal regime of Soils in the North of Western Siberia. *Permafrost and Periglacial Processes, 13:* 43-51.

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*.

Moskalenko, N.G.. 2003. Interactions between vegetation and permafrost on some CALM grids in Russia. *Permafrost, Proceedings of the Eighth International Conference on Permafrost, 21-25 July 2003, Zurich, Switzerland, volume 2:* 789-794.

Moskalenko, N.G. The plant community map of West Siberia. 2004. Second International Workshop on Circumpolar Vegetation Classification and Mapping. Tromso, Norway. Pp. 70-75.

Melnikov E.S., Drozdov D.S., Konchenko L.A., Korostelev Y.V., Malkova G.V., **Moskalenko, N.G**. The recent advances in landscape mapping in Russia. 2004. Second International Workshop on Circumpolar Vegetation Classification and Mapping. Tromso, Norway. Pp. 67-69.

Moskalenko, N.G. Monitoring of the cryosphere in West Siberia northern taiga. 2005. 1st CliC International Science Conference, 2005, Beijinh, China. Pp. 64-65.

Moskalenko, N.G. Permafrost temperature regime of northern taiga landscapes in West Siberia. 2005. 2nd European Conference on Permafrost, 2005, Potsdam, Germany, Pp. 138-139.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: D. A. Walker	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Application of space-based technologies and models to address land-cover/land-use change problems on the Yamal Peninsula, Russia**

Source of Support: NASA
Total Award Amount: $755,534 Total Award Period Covered: 6/1/06-5/31/09
Contact name, phone, and e-mail: TBD
Person-Months Per Year Committed to the Project. Cal: 0.50 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Adaptation to multiple rapid changes on the Yamal Peninsula, Russia: Analysis and models for predicting cumulative effects**

Source of Support: NASA
Total Award Amount: $1,117,847 Total Award Period Covered: 6/1/09-5/31/13
Contact name, phone, and e-mail: TBD
Person-Months Per Year Committed to the Project. Cal: 0.75 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Remote Very High Arctic Terrestrial Observatory Stations: A Reconnaissance Expedition to Isachsen, Mould Bay and Green Cabin**

Source of Support: NSF
Total Award Amount: $ 213,758 Total Award Period Covered: 6/1/09-5/31/11
Contact name, phone, and e-mail:
Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:
Towards an arctic geographic network: a web based plant-to-planet scale geobotanical atlas centered on the Toolik Lake Field Station, Alaska

Source of Support: NSF
Total Award Amount: $819,460 Total Award Period Covered: 12/15/04-11/30/08
Contact name, phone, and e-mail: Simon Stephenson, 703-292-7435, sstephen@nsf.gov
Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

CO-INVESTIGATOR LETTERS OF COMMITMENT

Uma S. Bhatt
Associate Professor of Atmospheric Science
903 Koyukuk Drive
Fairbanks, AK 99775, USA

Email:bhatt@gi.alaska.edu
Phone: 907-474-2662
Fax: 907-474-7290

9/30/2008

Dear Dr. Walker,

I acknowledge that I am identified by name as a collaborator to the investigation entitled **"Adaptation to multiple rapid changes on the Yamal Peninsula, Russia: Remote sensing analysis and models for predicting cumulative effects**" that is submitted by Dr. Donald A. Walker to the NASA Research Announcement NNH08ZDA001N-LCLUC, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal.

Sincerely,

Uma S. Bhatt
Assoc. Professor
Geophysical Institute
IARC Room 307
University of Alaska Fairbanks
903 Koyukuk Dr.
Fairbanks, Alaska 99775-7320
tel: (907) 474-2662 fax: (907) 474-2643
bhatt@gi.alaska.edu
www.gi.alaska.edu/~bhatt/

UNIVERSITY OF ALASKA FAIRBANKS
INSTITUTE OF ARCTIC BIOLOGY
P.O. Box 757000
Fairbanks, Alaska 99775-7000 U.S.A.
907 474-7640
FAX 907 474-6967

September 29, 2008

Dear Dr. Walker,
I acknowledge that I am identified by name as a Co-PI to the investigation entitled **"Adaptation to multiple rapid Land-use and climate changes on the Yamal Peninsula, Russia: Remote sensing and models for analyzing cumulative effects**" that is being submitted by Dr. Donald A. Walker to the NASA Research Announcement NNH08ZDA001N-LCLUC, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal.

Sincerely,

Gary Kofinas
Associate Professor of Resource Policy and Management
SNRAS and IAB
University of Alaska Fairbanks

Date: 24 September 2008

To: Donald A. Walker

From: Vladimir Romanovsky

Subject: Letter of commitment for NASA LCLUC proposal

Dear Skip,

I acknowledge that I am identified by name as a collaborator to the investigation entitled **"Adaptation to rapid land-use and climate changes on the Yamal Peninsula, Russia: Remote sensing and models for analyzing cumulative effects"** that is submitted by Dr. Donald A. Walker to the NASA Research Announcement NNH05ZDA001N-LCLUC, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal.

Best regards,

V. Romanovsky

Vladimir Romanovsky

Date: August 11, 2008

To: Dr. Donald A. (Skip) Walker (ffdaw@uaf.edu)

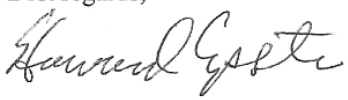
From: Howard Epstein (hee2b@virginia.edu)

Subject: Letter of commitment for NASA LCLUC/NEESPI proposal

Dear Dr. Walker (Skip),

I acknowledge that I am identified by name as a Co-Investigator on the proposal entitled **"Adaptation to multiple rapid changes on the Yamal Peninsula, Russia: Remote sensing analysis and models for predicting cumulative effects"** submitted by you to the NASA Research Announcement NNH08ZDA001N-LCLUC. I will act as the lead investigator on the Subaward to the University of Virginia. I intend to carry out all responsibilities identified for me in this proposal; this includes participating in the remote sensing analyses and field expeditions, and taking the lead on the modeling component of the project. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal.

Best regards,



Howard E. Epstein
Associate Professor
Department of Environmental Sciences
University of Virginia

Date: 8 August 2008

To: Donald A. 'Skip' Walker <ffdaw@uaf.edu>

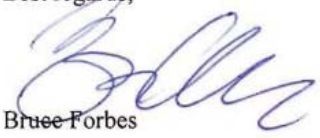
From: Bruce C. Forbes <bforbes@ulapland.fi>

Subject: Letter of commitment for NASA LCLUC proposal

Dear Skip,

I acknowledge that I am identified by name as a collaborator to the investigation entitled **"Adaptation to multiple rapid changes on the Yamal Peninsula, Russia: Remote sensing analysis and models for predicting cumulative effects"** that is submitted by Dr. Donald A. Walker to the NASA Research Announcement NNH08ZDA001N-LCLUC, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal.

Best regards,



Bruce Forbes

RUSSIAN ACADEMY OF SCIENCES
SIBERIAN BRANCH

Earth Cryosphere Institute

P.O.Box 1230
625000 Tyumen
Russia

Tel. 7-3452-251153
Fax: 7-3452-251153
e-mail: melnikov@ikz.ru

September 24, 2008

Prof. Donald A. Walker
Institute of Arctic Biology
University of Alaska Fairbanks
P.O. Box 757000
Fairbanks, Alaska 99775-7000

Re: Letter of Commitment for NASA proposal

Dear Prof. Donald A. Walker:

Earth Cryosphere Institute SB RAS is pleased to collaborate with the University of Alaska Fairbanks on the proposal entitled "Adaption to Multiple Rapid Changes on the Yamal Peninsula, Russia: Analysis and Models for Predicting Cumulative Effects" and is planning to contribute to the project fulfillment by covering all salaries and research expenses (i.e. intellectual efforts) and overhead expenses (facilities and administration) of the research for ECI SB RAS personnel (PI and 6 Co-I), should the proposal be funded by NASA.

Itemized Budget and Budget justification are attached.

Sincerely,

Deputy director of Earth Cryosphere Institute SB RAS,
Director of Moscow Department, Prof.

Dmitry Drozdov

BUDGET JUSTIFICATION

Direct labor: The role and commitment of each of the project team members is summarized in the section: "Summary of Personnel and Work Efforts".

Other direct costs:

Subcontracts: Descriptions of the subcontracts are contained in the "Summary of Personnel and Work Efforts" and summarized as follows:

Earth Cryosphere Institute, Moscow ($135K): Coordinate the field logistics and provide data collection and distribution services for the field work at Belyy Island and Vaskini Dachi. The subcontract will cover the helicopter logistics, costs of establishing the field camps, and collecting the climate, soil, and vegetation information at each of the sites. The contract will also cover the costs of updating the GIS coverages of the region and providing these data to the project. No salary will be derived from this subcontract.

University of Virginia ($100K): Provide one mo/yr salary support for Howie Epstien and partial support for a Ph.D. graduate student who will work on adapting the ArcVeg model to the Yamal transect.

Arctic Centre, Rovaniemi ($95K): Coordinate the field aspects of the study of the Nenets reindeer herding practices. Bruce Forbes and Florian Stammler will work closely with the team to develop a report and publication that addresses the implications of industrial development to indigenous residents whose livelihoods depend on maintaining a close relationship with land and animals. No salary will be derived from this subcontract.

NASA-Goddard ($40K): Provide the sea-ice and land-surface temperature (LST) data for the project. Joey Comiso will improve the LST data for the Yamal region by calibrating the satellite information to the available met-station data, and work closely with the team of Bhatt, Raynolds, and Walker to examine the dynamics of terrestrial NDVI in relationship to LST, snow and sea-ice distribution patterns. He will also provide a new long-term NDVI data set for the Arctic that is calibrated to Greenland that should eliminate some of the problems with the GIMSS data at high latitudes. $40K is budgeted for this with the understanding that the money will go to NASA-Goddard directly.

Commodities: We request $15K for climate stations at two of the sites along the Yamal transect. The $7.5K per station cost in years 2 and 3 is based on the price of identical stations that have been built at sites along the North American Arctic Transect and on the Yamal. We request $3K/yr in years 2 and 3 to cover incidental field costs incurred during the field work on the Yamal Peninsula.

Travel: *Domestic:* We request funds for 2 participants to attend the annual LCLUC meeting at an average cost of $3K per person including airfare, hotel and per diem costs. Meeting locations change annually and can be either domestic or foreign. Total $24K

Foreign: We are also requesting funds for 2 participants to attend the annual NEESPI meeting at an average cost of $3K per person including airfare, hotel and per diem costs. Total $24K.
We request 4 UAF investigators to attend the Moscow workshop in spring 2010 at $3K per person including airfare, lodging and per diem. Total $12K.

Foreign Field: Fieldwork will be conducted in Russia at Belyy Island in 2010 and at Vaskiny Dachi in 2011. We are requesting funds for the 4 US and 2 Finnish investigators to get to Moscow and Salekhard and return at an average cost of $3K per person. Costs include airfare, lodging and per diem. Total $36K.

Participant support:
The 2nd Yamal Land-Cover Land-Use Change Workshop will be held in Moscow in spring 2010. We are requesting funds for 15 participants including investigators and graduate students to attend a 3-day meeting at an average cost of $3.3K per person for travel and including 5 days per diem and 4 nights lodging in Moscow. Total $50K.
In spring 2011, we will hold a Cumulative Effects of Arctic Gas and Oil Development Workshop in Fairbanks. We are requesting funds for 10 participants including investigators and graduate students to attend a 3-day meeting at an average cost of $3.5K per person for travel and including 5 days per diem and 4 nights lodging in Fairbanks. Total $35K.

Contractual Services:
We request: (1) $3K/yr in years 2 to 4 to cover publication page charges. (2) $1K/yr for computer support in the Alaska Geobotany Center. These costs are for technical support, repair and maintenance of the computers, and annual software fees that are not covered by the University. (3) $1K/yr for communication, copies, and preparation of reports associated with management of the project.

Facilities and administrative costs:
Facilities and Administrative (F&A) Costs are negotiated with the Office of Naval Research. The predetermined rate for sponsored research is 45.1% of the Modified Total Direct Costs (MTDC). MTDC includes Total Direct Costs minus tuition, scholarships, subaward amounts over $25,000, and equipment.

All materials and service costs are estimates based on current information available at the time of the writing.

SUMMARY OF PERSONNEL AND WORK EFFORT

Donald. A. (Skip) Walker (UAF) will serve as project PI and coordinate the ground based studies of vegetation, soils and site factors. He is on a 9-mo university appointment and is requesting .75 mo/yr salary support in years 1 to 4 of the project.

Uma Bhatt (UAF) will perform the climate modeling aspects of the project, linking climate dynamics to sea-ice distribution, land-surface temperatures, and terrestrial NDVI. She is on a 6-mo university appointment and is requesting .75 mo/yr salary support in years 1 to 4 of the project.

Gary Kofinas (UAF) will coordinate the human dimensions aspects of the project in the study of Nenets reindeer-herding patterns. He is on a 9 mo university appointment and is requesting .75 mo/yr salary support in years 1 to 4 of the project.

Vladimir Romanovsky (UAF) will be responsible for establishing the climate stations at each field site and coordinating the climate/permafrost dynamics portion of the study. He is on a 9 mo university appointment and is requesting .75 mo/yr salary support in years 1 to 4 of the project.

Martha Raynolds, a post-doc on the project, will do much of the remote sensing and GIS analysis for the U.S. component of the project, including analyses of spatial and temporal NDVI trends on the Yamal Peninsula and develop a Landsat-based vegetation classification and map. She will also do a comparative analysis of Quickbird the Mid-Decadal Global Land Survey (GLS-2000) data to evaluate their application for inventorying roads and infrastructure on the Yamal Peninsula and the North Slope of Alaska. We are requesting a 50% post-doctoral appointment to support her research in years 1 to 4.

Howard Espstein (U Va) will coordinate the vegetation modeling aspects of the project. He will work under a subcontract to the University of Virginia ($50K/yr in years 1 and 2) which will provide one mo/yr salary support and partial support for Qin Yu, a Ph.D. graduate student who will work on adapting the ArcVeg model to the Yamal transect.

Josefino Comiso (NASA-Goddard) will provide the AVHRR-derived sea-ice, land-surface temperature, and NDVI data. He will improve the LST data for the Yamal region by calibrating the satellite information to the available met-station data, and work closely with the team of Bhatt, Raynolds, and Walker to examine the dynamics of terrestrial NDVI in relationship to LST and sea-ice distribution patterns. He will produce a new polar projection of NDVI calibrated to Greenland. He will work under a full-cost-accounting subcontract to NASA-Goddard for $20K/yr in years 1 and 2 of the project.

Bruce Forbes (Arctic Centre, Rovaniemi, Finland) will coordinate the field aspects of the study of the Nenets reindeer herding practices. The budget for a subcontract to the Arctic Centre includes $25K/yr in years 1, $30K in Year 2, and $20K in years 3 and 4. This will assure incorporation of the human dimensions component into the project and will provide logistic support for a graduate student to accompany the project to Belyy Ostrov and Vaskiny Dachi in years 2 and 3.

Hilmar Maier (UAF) is the GIS/Remote Sensing and Computer Systems Administrator for the Alaska Geobotany Center. He will help in all aspects of the remote sensing and GIS analyses and provide system support. We are requesting .50 mo/yr of salary support for him in years 2 to 4 of the project.

Edie Barbour (UAF) is the web page designer and lab coordinator and will handle day-to-day issues related to the project including web-page maintenance, communication and data

report preparation. We are requesting 1 mo/yr of salary support for her in years 1 to 4 of the project.

Pavel Orekov (Earth Cryosphere Institute, Moscow) will be responsible for coordinating the field logistics and providing data collection and distribution services for the field work at the Belyy Island and Vaskiny Dachi sites. A $135K subcontract to the Earth Cryosphere Institute will cover the helicopter logistics, costs of establishing the field camps, and collecting the climate, soil, and vegetation information at each of the sites. The contract will also cover the costs of updating the GIS coverages of the region and providing these data to the project.

FACILITIES AND EQUIPMENT

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.

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 electronic 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.