Biomass, NDVI, and LAI Data and Relationships Across Spatial Scales in Arctic Tundra

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Photo G.V. Frost (Kharp, Russia)
Circumpolar Scale

Data Collection Sites along the North America and Eurasia Arctic Transects

From Walker et al. 2012 (ERL)
North American Arctic Transect

Subzone A (Isachsen)

Subzone B (Mould Bay)

Subzone C (Green Cabin)

Subzone D

Subzone E

(Photos D.A. Walker and H.E. Epstein)
Spatial Biomass Extrapolations using Field-Based Biomass-NDVI Relationships

Raynolds et al. 2012 (RSL)
Epstein et al. 2012 (ERL)
Walker et al. 2012 (ERL)

Plot-scale biomass vs. AVHRR
“Greening” since 1982, particularly in the mid- to Low-Arctic (20-26%)
Epstein et al. (2012 ERL)

Epstein et al. 2013 (NOAA Arctic Report Card)
Bhatt et al. 2013 (Remote Sensing)
Regional Scale

Data from Primary ATLAS Sites (northern Alaska)

(from Walker et al. 2003 PPP)
(also Walker et al. 2003 JGR, Edwards et al. 2000 and Raynolds et al. 2002 ATLAS Data Reports)
NSF Biocomplexity of Patterned Ground – further development and completion of the North American Arctic Transect (NAAT)
(Walker et al. 2008 JGR)

(Walker et al. 2011 AVS)
NAAT Synthesis – Vegetation Type Biomass (absolute) vs. SWI

(Epstein et al. 2008 JGR)
NAAT Synthesis – Vegetation Type Biomass (relative) vs. SWI

(Epstein et al. 2008 JGR)
Comparison with Eurasian Arctic Transect (2007-2010)

Walker et al. 2012 (ERL)
LAI and Total Aboveground Biomass along both transects

\[ y = 0.0054x^{1.4039} \]
\[ R^2 = 0.50998 \]

\[ y = 108.4e^{0.052x} \]
\[ R^2 = 0.70401 \]
Relationships between LAI / NDVI (hand-held) and biomass

**Overstory Biomass (g m\(^{-2}\))**

\[ y = 451.64x + 44.564 \]

\[ R^2 = 0.86256 \]

**PS Biomass (g/m\(^2\))**

\[ y = 921.79x^{2.2344} \]

\[ R^2 = 0.52207 \]
Ivotuk (Western Alaska Transect – Subzone E) 1999

Ivotuk MAT (photo by D.A. Walker)
www.geobotany.uaf.edu/atlas/atlas_sites.html

Ivotuk Shrub Tundra

Ivotuk Mossy Tussock Tundra

Ivotuk MNT

Ivotuk Vegetation:
Field names and codes are listed in parentheses. Codes in parentheses correspond to the first number at grid points on the vegetation maps.

Dry tundra
1. Hydrophyllum japonicum – Herbaceous (subzone dry nonglacial tundra, 3)
2. Potentilla fruticosa – Potentilla fruticosa (subzone dry nonglacial tundra, 3)
3. Salix arctica – Salix arctica (subzone dry nonglacial tundra, 3)

Dry tundra
4. Betula nana – Betula nana (shallow-nutricic tussock tundra on mineral stripes, 16)
5. Empetrum hermaphroditum – Empetrum hermaphroditum (shallow-nutricic tussock tundra, 16)

Snowbed
6. Sedum aestivum – Sedum aestivum (shallow-nutricic tussock tundra with dwarf willows, 19)
7. Potentilla erecta – Potentilla erecta (shallow-nutricic tussock tundra, 19)

Moist acid tundra (shrub = 0 cm tall)
8. Melilotus alpinus – Melilotus alpinus (shallow-nutricic tussock tundra, 16)
9. Betula nana – Betula nana (shallow-nutricic tussock tundra, 16)
10. Empetrum hermaphroditum – Empetrum hermaphroditum (shallow-nutricic tussock tundra, 16)
11. Comarostaphylis rupestris – Comarostaphylis rupestris (shallow-nutricic tussock tundra, 16)
12. Agrostis capillaris – Agrostis capillaris (shallow-nutricic tussock tundra, 16)

Moist acid tundra (shrub = 50 cm tall)
13. Dicranum scoparium – Dicranum scoparium (shallow-nutricic tussock tundra with dwarf shrubs, 16)
14. Saxifraga oppositifolia – Saxifraga oppositifolia (shallow-nutricic tussock tundra with dwarf shrubs, 16)

Wet tundra
15. Agrostis capillaris – Agrostis capillaris (shallow-nutricic tussock tundra, 50 cm tall)
16. Salix herbacea – Salix herbacea (shallow-nutricic tussock tundra, 50 cm tall)
17. Empetrum hermaphroditum – Empetrum hermaphroditum (shallow-nutricic tussock tundra, 50 cm tall)

Methods:
All aerial photographs for Ivotuk 2, 3, and Ivotuk 4 were rectified using ENVI image processing software and Adobe Photoshop (Gainesville, FL) software to create a representation of aerial photographs taken perpendicular to the ground. Adobe Photoshop software was used to create maps from these aerial photographs using a red band as a reference for calculating ranges of values. Results of grid point surveys were used to determine the appropriate color range for each vegetation type. While the light reflectance values are associated with the taxonomic classification of the vegetation, knowledge of the site from field work was applied to model the color range values correctly.

Vegetation mapping, soil photo rectification, and poster layout by J. A. Anderson and D. A. Walker at the Tundra Ecosystem Analysis and Mapping Laboratory, University of Colorado at Boulder, March 1999.
Iivotuk (Western Alaska Transect – Subzone E) 1999

- Four 100 x 100 m grids (MAT, MNT, ST, MT)
- LAI and NDVI collected bi-weekly at 20 random grid points
  (same grid points sampled at each time period)
- Biomass samples were harvested bi-weekly near 10 of the 20 random grid points
  (again, same grid points used each time period)
  (20 x 50 cm quadrats – all 20 grid points sampled at peak growing season)

Riedel et al. 2005 (AAAR and IJRS)
Biomass-NDVI relationships across and within plant communities

Riedel et al. 2005 (IJRS)
Hyperspectral Data

Buchhorn et al. 2013 (RS)

Ivotuk 1999 – Grid-point variability
Period 1 – June 7-10

Period 4 – July 16

Period 7 – Aug. 22-26

Ivotuk – 1999 Seasonal Hyperspectral Sampling
Bratsch et al. (in prep.)
Iivotuk – 1999 Seasonal Hyperspectral Sampling Discriminant Function Analysis

Bratsch et al. (in prep.)

Period 1 – June 7-10
(blue, green red edge, NIR)

Period 4 – July 16
(blue, red, NIR)

Period 7 – Aug. 22-26
(blue, green, yellow, NIR)
Summary / Acknowledgements

1) Aboveground biomass, NDVI, and LAI data have been collected at a wide range of plots across northern Alaska (ATLAS, NSF Biocomplexity – NAAT), the western Canadian Archipelago (NSF Biocomplexity – NAAT) and northwestern Siberia (NASA LCLUC).

2) These data have been and can continue to be used to develop biomass-NDVI-LAI relationships across spatial scales (circumpolar, regional, landscape, plot / plant community). Synthesis of this information across the NAAT and EAT is being conducted as part of a new NASA LCLUC project.

3) These relationships have been and can continue to be used along with satellite-based remote sensing information to extrapolate biomass quantities and dynamics across space and time scales.

4) We have begun to use hyperspectral information to develop biomass-spectral relationships at the landscape / plant community levels, where coarser spectral indices (e.g. NDVI) are insufficient to distinguish among vegetation types (NASA pre-ABoVE).