Vegetation changes related to 45 years of heavy road traffic along the Spine Road at Prudhoe Bay, Alaska

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INTRODUCTION AND METHODS

Introduction: Changes in infrastructure and climate are affecting the vegetation of the Prudhoe Bay, Alaska area. Oilfield roads and warming temperatures have affected the permafrost and soils, modifying the conditions for plant growth.

This study, initiated in 2014, builds on baseline data collected in the same area by the International Biological Program, Tundra Biome Project in the 1970s (Brown 1975, Everett and Parkinson 1977, Walker et al. 1980, Walker 1985, Walker and Everett 1991).

Methods: Maps were prepared from aerial photographs taken in 1972 (shortly after construction of the Spine Road) and 2013 to determine changes in the extent of the major physiognomic-level vegetation units within the 60 x 400 m area of the transects. We used a simple categorization of moist tundra, wet tundra, aquatic tundra, and water based mostly on density of gray tones of the vegetation evident in black and white images [see figure 1].

Vegetation plots were set up in polygon centers and troughs at 5, 10, 25, 100 and 200 m from both sides of the heavily-traveled Spine Road. Sorted-table analysis (Westhoff and van der Maarel 1978) was used to examine changes in vegetation species composition between1974-75 and 2014. Plot data collected from the same vegetation types in the 1970s (Walker 1985) were used to determine diagnostic taxa of the original vegetation, and compared with plot data from this study [2]. The changes in vegetation are also displayed using a Nonmetric Multidimensional Scaling (NMS) ordination approach (McCune and Grace 2002) [3].

Cover was estimated for species and lifeforms at each plot [4, 5]. Leaf area index (LAI), a measure of productivity and biomass, was measured using an AccuPAR LP-80 PAR/LAI Ceptometer [6,8]. Point sampling, using a 100-point quadrat, was used to determine quantitative changes in the major species and growth forms [7, 8]. Soil characteristics such as organic matter, pH and thaw depth were sampled [7].

Other posters from this project describe the transects in detail (Buchhorn et al.) and the permafrost characteristics determined from core drilling (Kanevskiy et al).

CONCLUSIONS

Major vegetation changes occurred over 42 years: Aquatic vegetation and water increased on both sides of the road, but most dramatically on the southwest side which is regularly flooded during spring snow melt period [see figures 1 and 3]. Major changes in the species composition of the dominant moist and wet vegetation types due mostly to dust [2, 3]. For moist vegetation types (Types U3 and U4), 20 of 27 diagnostic species recorded in the 1970s (mostly lichens and small forbs) were either not recorded or recorded in greatly reduced abundance [2]. For wet vegetation types (M2 and M4), 4 of 12 diagnostic species diagnostic species recorded in the 1970s (mostly lichens and small forbs) were either not recorded or recorded in greatly reduced abundance [2].

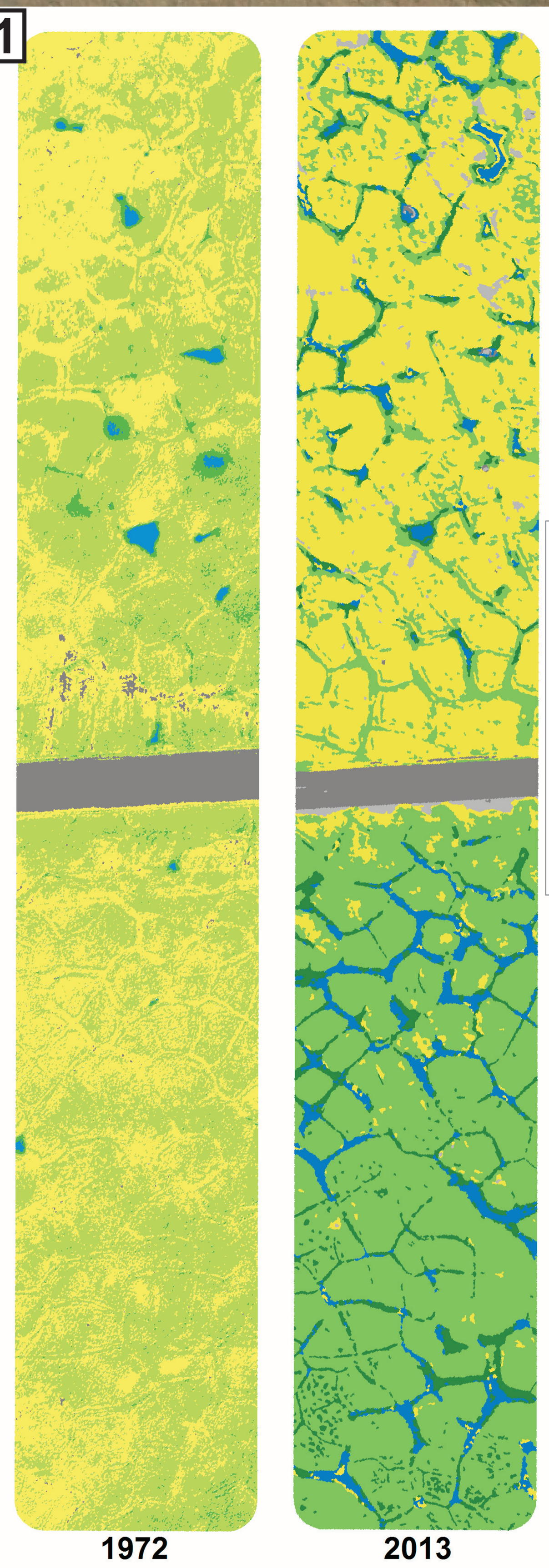
A few species showed major changes in plant productivity and abundance most likely due to flooding and disturbance (mostly *Carex aquatilis, Eriophorum angustifolium*, and some salt tolerant species (e.g. *Braya purpurascens*) [2]. Shrub abundance (*Salix richardsonii, Salix arctica*) was noticeably higher [2, 4], probably due to a combination of road-related disturbance factors and regional warming.

The ordination showed major shifts in species composition over time [3]. Moist tundra plots got wetter and less diverse, with lower moss cover; wet tundra plots got drier and somewhat more diverse, and aquatic tundra, while experiencing some of the greatest changes, did not show a consistent direction in the ordination space [3].

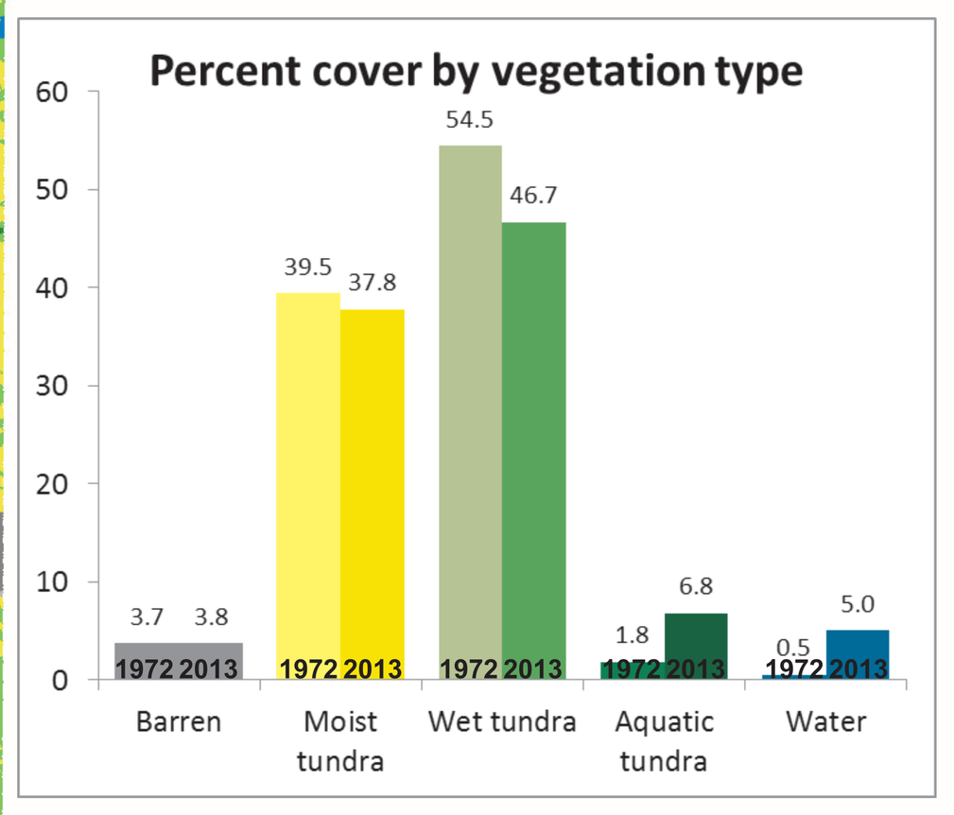
Variation with proximity to road:
The effects of the road were evident on both the vegetation and physical environment. Moss cover decreased and bare soil cover increased with road proximity [5]. Total plant cover also decreased, especially on the north side. Organic matter in the thawed soil horizons decreased [8A], pH increased [8B], and thaw depth increased, especially on the south side of the road [8C].

Differences between the north side vs. south side of the road: The south side of the road had greater LAI [6], greater cover of live and dead vascular vegetation (mostly graminoids) [7], and deeper thaw [8C].

1



Prior to road construction in 1969, the north side of the road had more wet tundra and thermokarst pits than the south side of the road. After the road was built, extensive deep thermokarst developed along polygon troughs on the south side of the road and aquatic vegetation increased. Other more subtle changes occurred to the species composition of the major vegetation types.



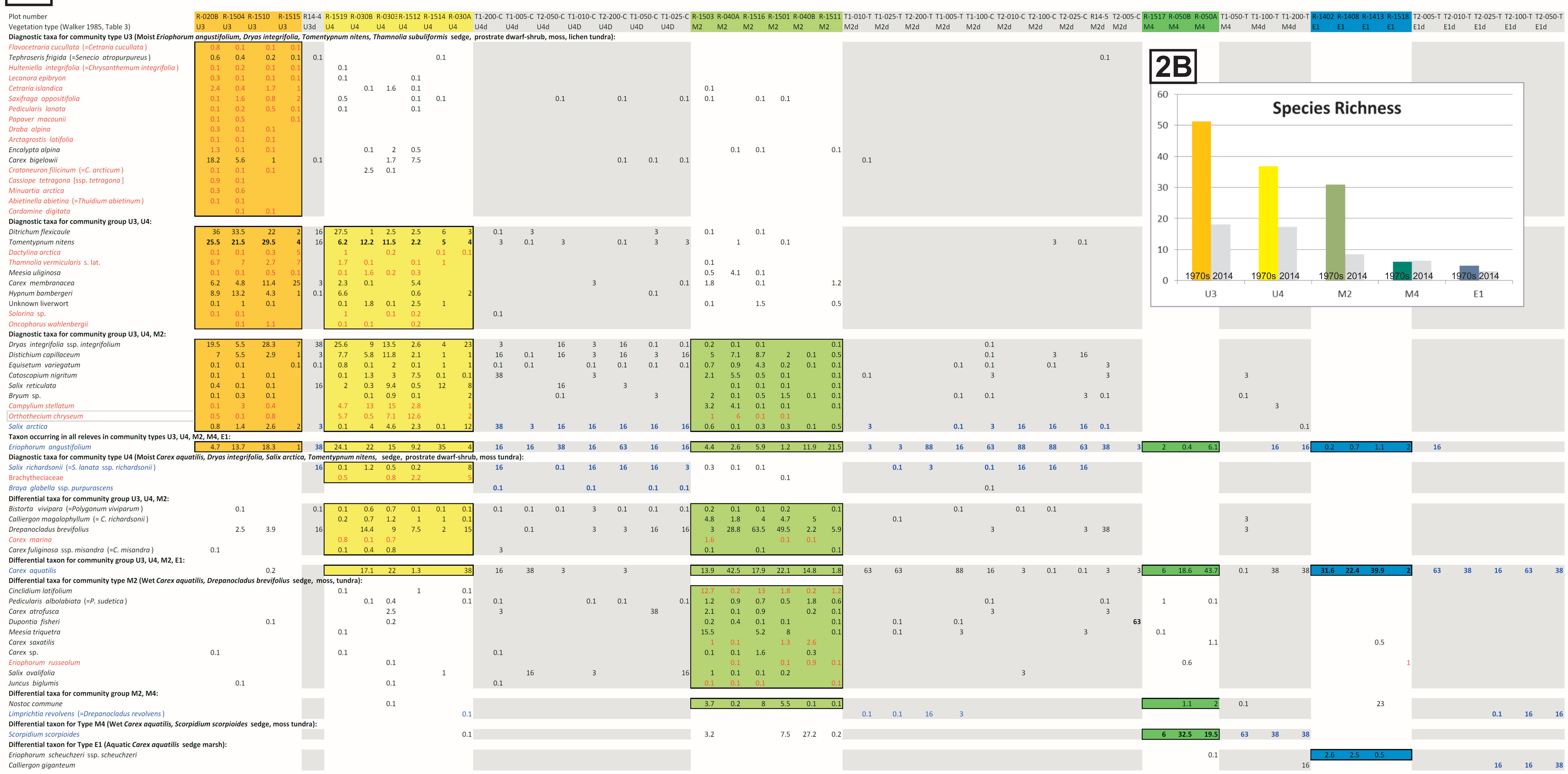
Legend

1972
- Road and Gravel from road construction
- Moist tundra (Types U3 + U4)
- Wet tundra (Types M2)
- Aquatic tundra (Types M4 + E1)
- Unvegetated water

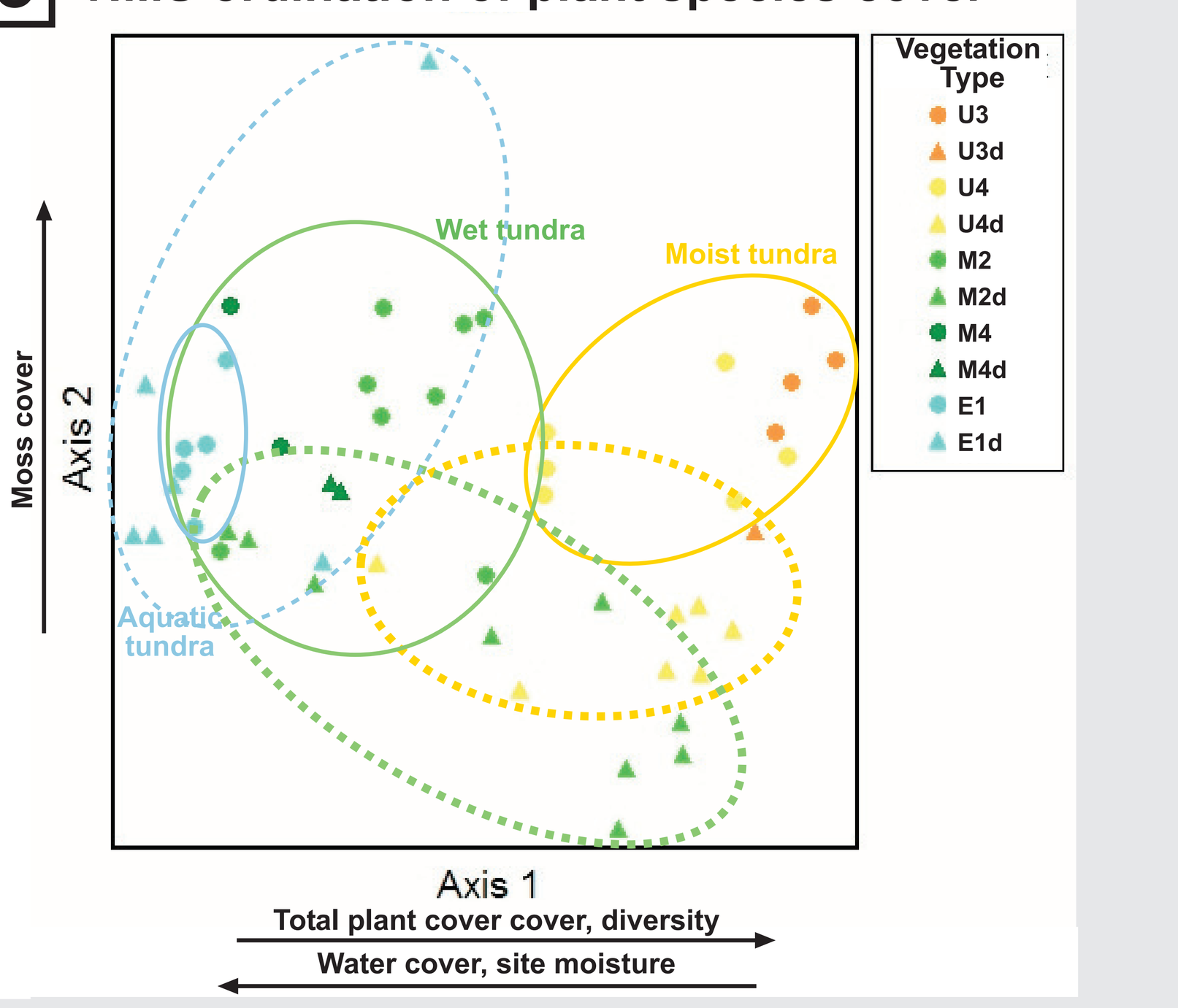
2013
- Road
- Unvegetated silt and gravel
- Disturbed moist tundra (Types U3d + U4d)
- Disturbed wet tundra (Types M2d)
- Disturbed aquatic tundra (Types M4d + E1d)
- Unvegetated water

0 25 50 Meters

2A **Sorted table** of undisturbed plots (Walker 1980) and matching disturbed plots (2014, in gray). Species in red are uncommon or do not occur in disturbed plots. Species in blue occur more commonly in disturbed plots. Note much species richness in undisturbed plots, especially in the drier types, U3, U4 and M2.

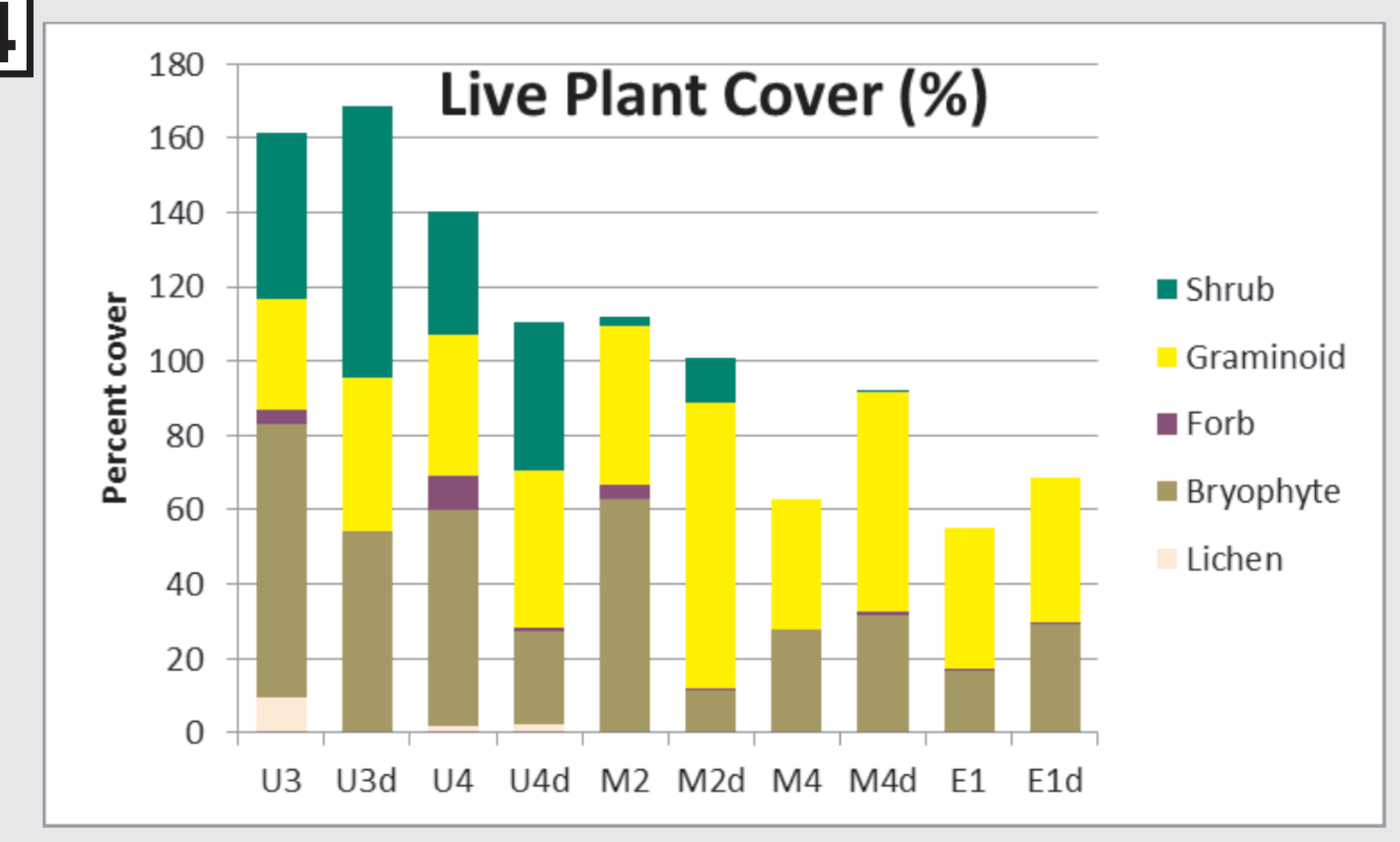


3 **NMS ordination of plant species cover**



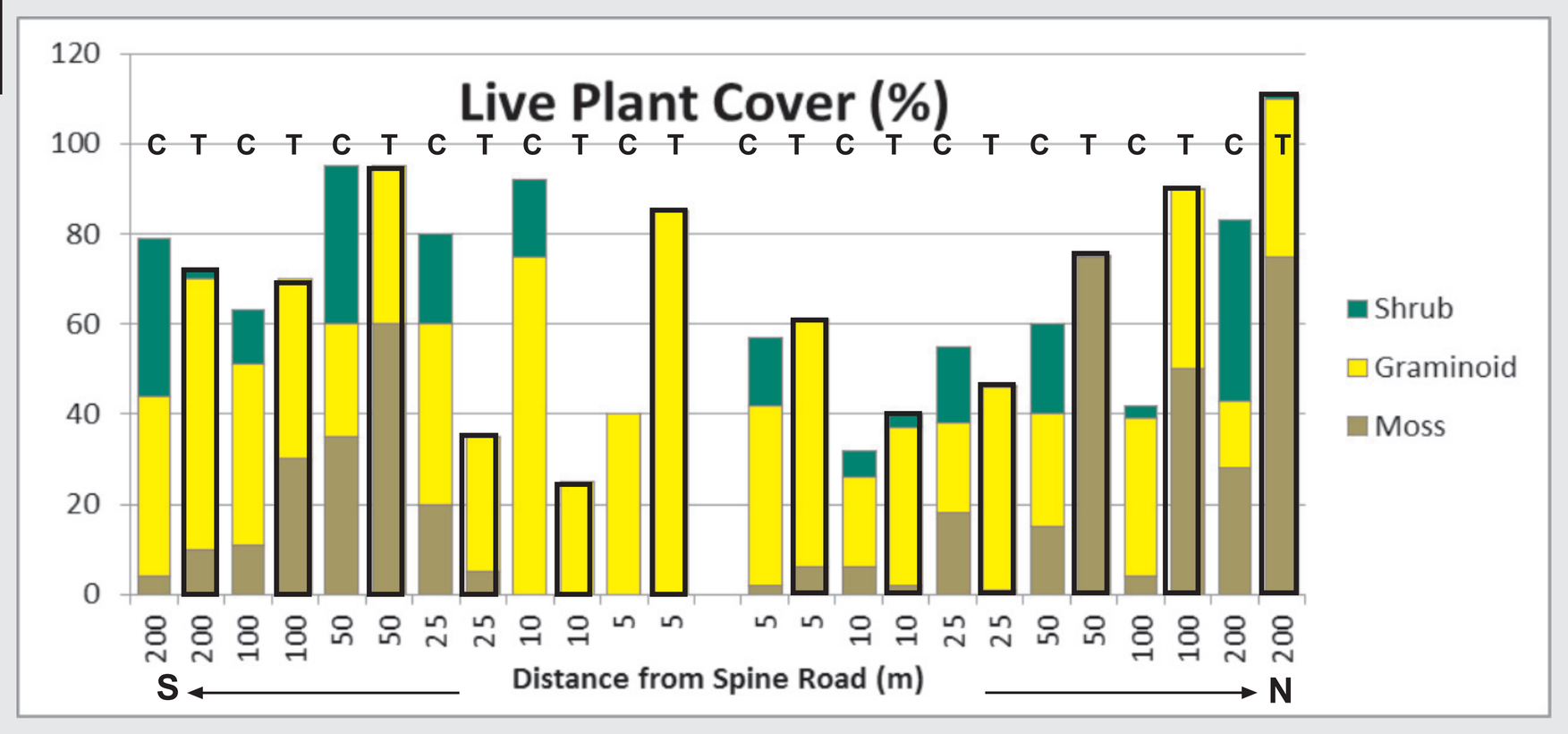
NMS ordination of plant species cover with explanatory environmental data. Circles (and solid ovals) are plots sampled in 1974-75 (Walker 1985). Triangles (and dashed ovals) are plots in similar, but disturbed habitat, sampled in 2014. See details of vegetation types in table above. Disturbed moist tundra plots changed to an area of the ordination with more moisture, less plant cover, less moss cover and less diversity than non-disturbed plots. Disturbed wet tundra plots had less moss cover, but slightly greater diversity and plant cover. Effects of disturbance on aquatic tundra were more variable.

4



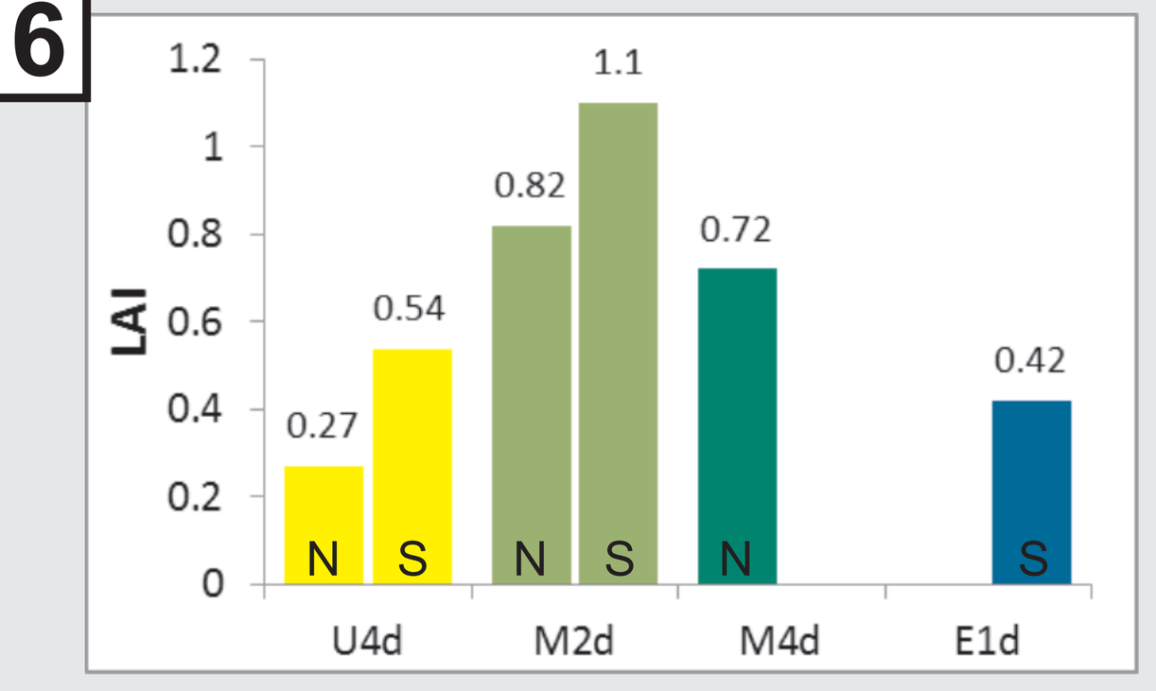
Estimates of percent live plant cover for different vegetation types on 1-m^2 plots in undisturbed areas (Walker 1985) and matching disturbed (d) areas (2014 data). See table above for detailed description of vegetation types. Disturbance almost eliminated cover of forbs and lichens, and greatly reduced cover of mosses in U4 and M2. Disturbance increased cover of shrubs and increased cover of graminoids in moist tundra (M2 and M4).

5



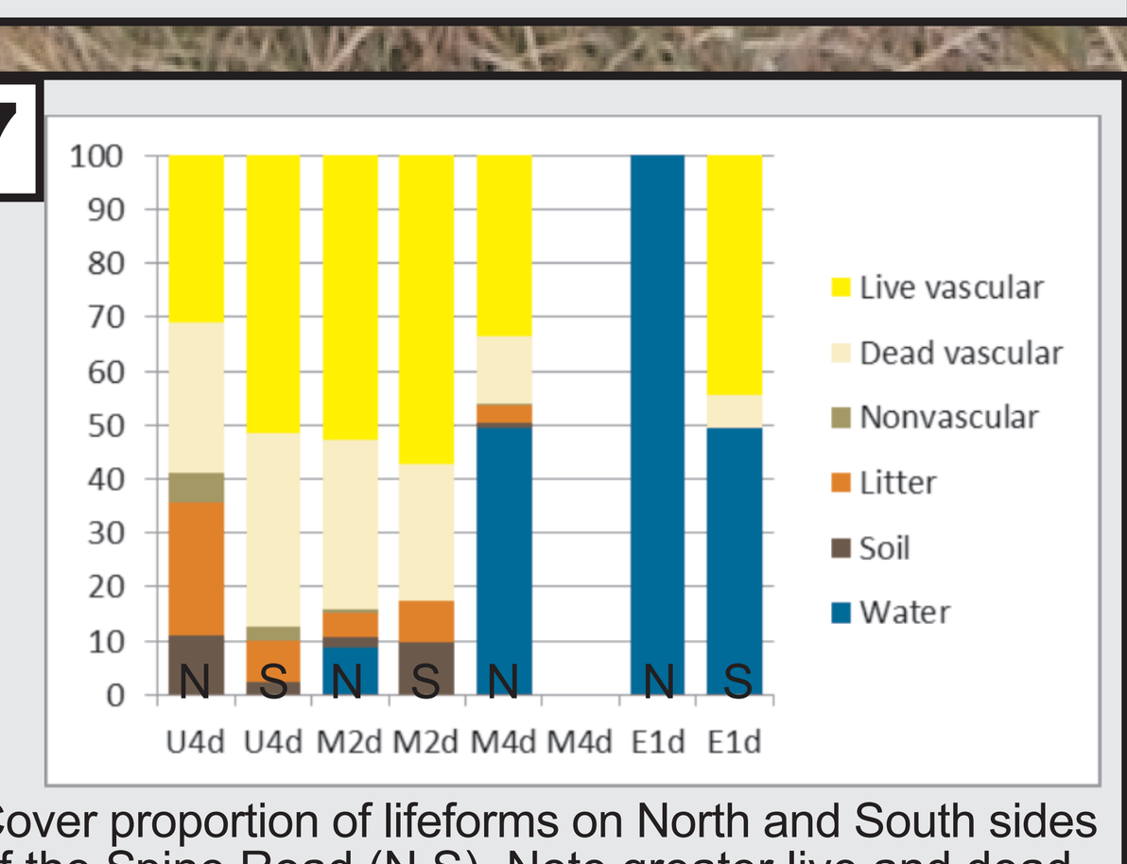
Estimates of percent live plant cover for different lifeforms on 1-m^2 plots. Dark outline - polygon troughs (T); North side on right. Compared to polygon centers, troughs had almost no shrub cover, high graminoid cover and higher moss cover (often below water). Moss cover increased with distance from road, and total plant cover increased with distance from road on N side, but not on S side.

6



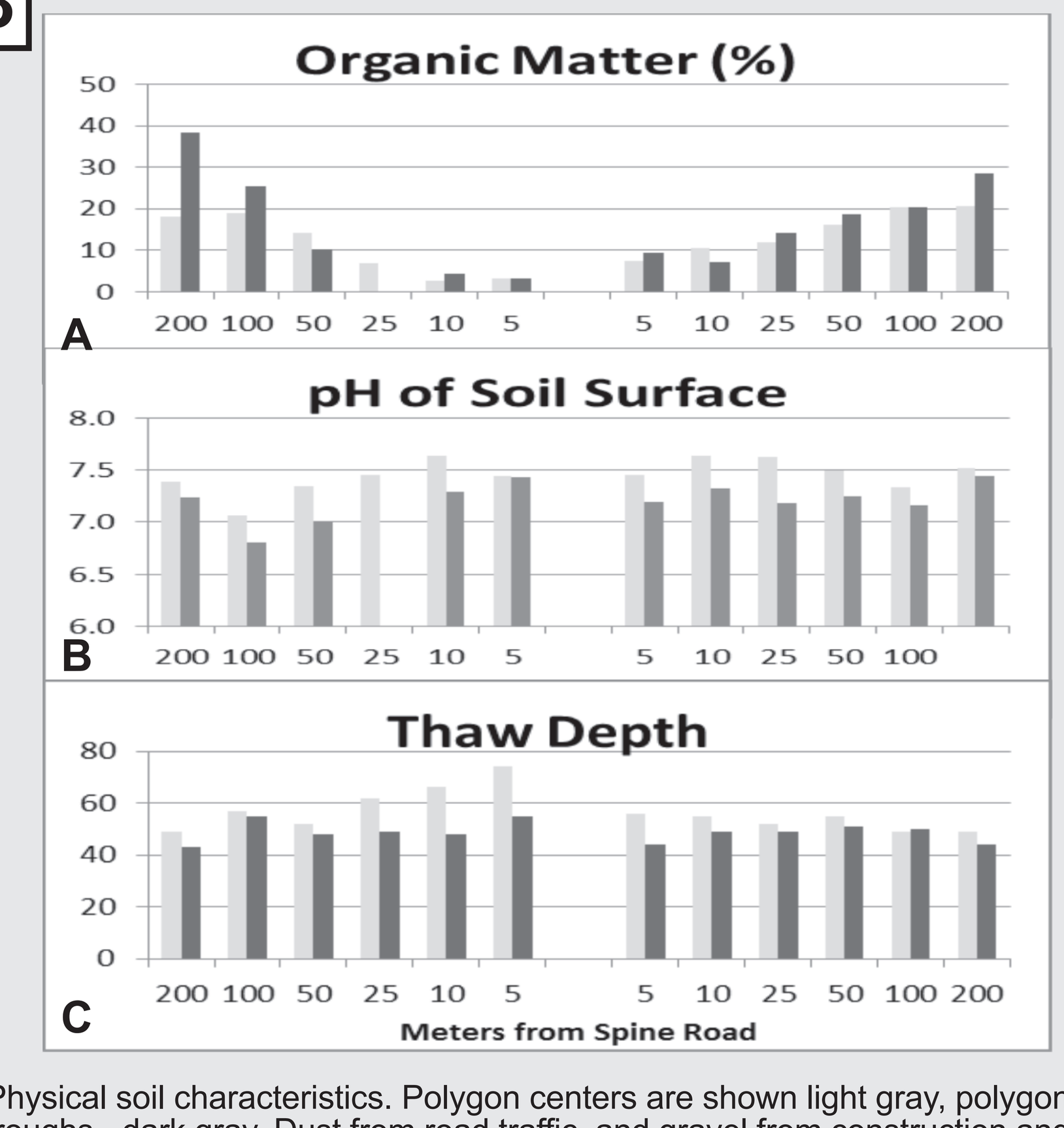
LAI (Leaf Area Index) of different vegetation types on North and South sides of the Spine Road (N,S). Note higher LAI for the same vegetation type on the South side of the road. Vegetation type descriptions are in the table above.

7



Cover proportion of lifeforms on North and South sides of the Spine Road (N,S). Note greater live and dead vascular cover on the South side of the road. Vegetation type descriptions are in the table above.

8



Physical soil characteristics. Polygon centers are shown light gray, polygon troughs - dark gray. Dust from road traffic, and gravel from construction and maintenance changed the characteristics of the soil along the road, creating surface soils with low organic matter (A) and higher pH (B) than soils away from the road. The road also blocked surface water drainage, which increased thaw depths (C) to the south (left in graphs), adjacent to Lake Colleen.

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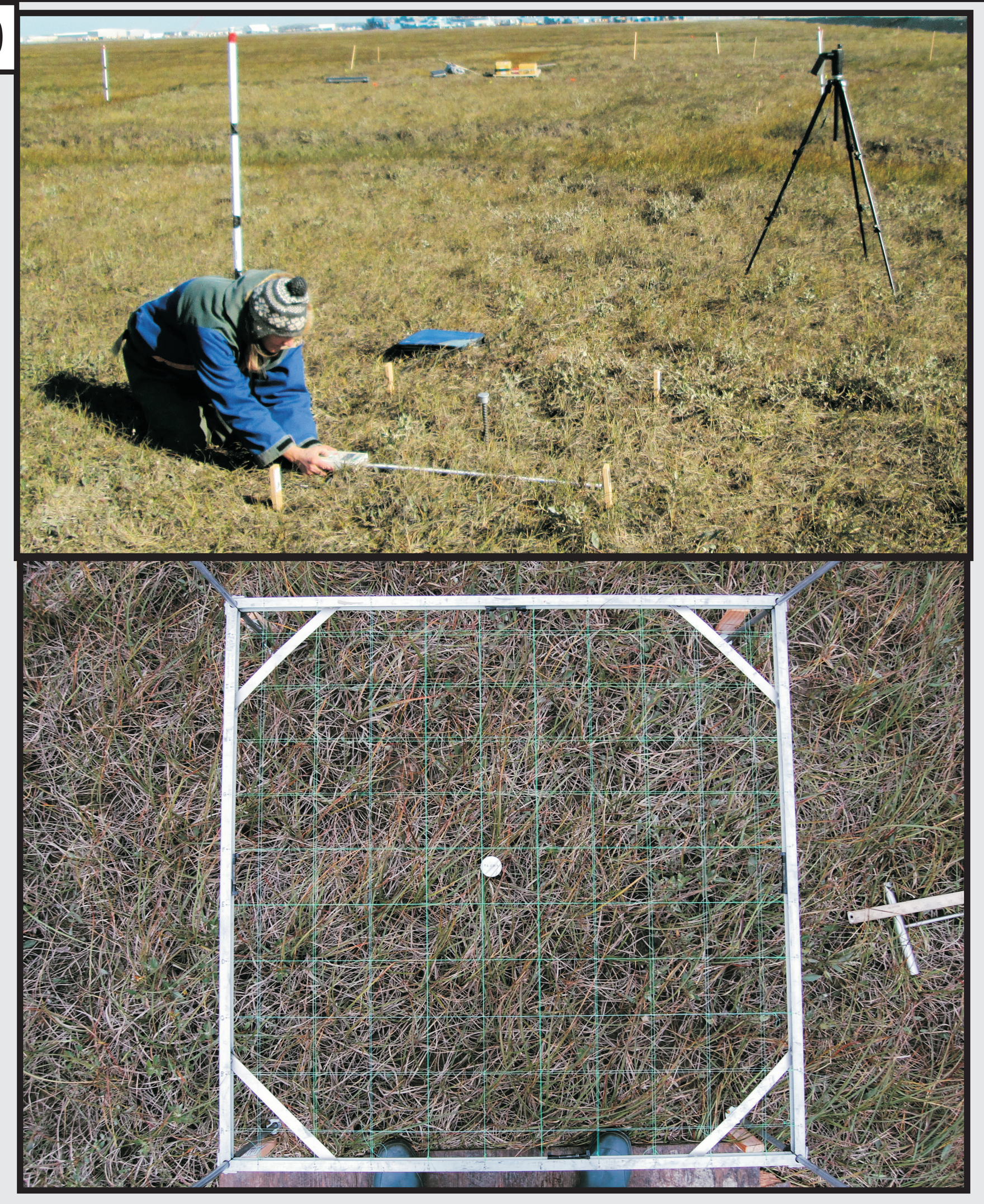

Top: Measuring LAI (Leaf Area Index) at a 1x 1-m permanent plot using an AccuPAR LP-80 PAR/LAI Ceptometer. The ground sensor measures radiation below the canopy, the sensor on the tripod measures incoming radiation above the canopy.. **Bottom:** 1 x 1-m grid on permanent plot with photo-point re-bar and identifying cap in center, four wooden posts at corners, and washers for grid legs.

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Acknowledgements

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