Linking Vegetation Change in Permanent Plots to Regional Ecosystem Change in Arctic Alaska

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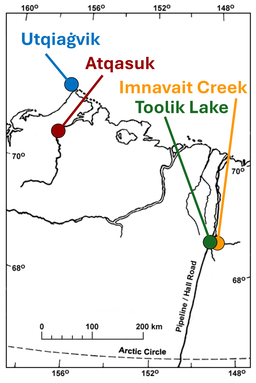
ITEX-AON
Understanding Tundra Ecosystem Change

Documenting vegetation change on long-term permanent plots provides the detailed information necessary to understand ecosystem changes occurring across the landscape (**FIG 1**). Here we show the change in plant cover, measured at the top of the canopy, across multiple sites in Arctic Alaska and show how the change in plant cover and plant height (**FIG 2**) correlates (**TABLE 1**) with NDVI measured from space (**FIG 3**) and near the surface (**FIG 4**). Plant height has consistently increased and the cover of shrubs and graminoids have increased, but the magnitude varies greatly across regions and by moisture groups within a region. The diversity of response within a region helps explain the NDVI measured from space. The mechanistic studies co-located also help predict future change. These observations are an essential component of international efforts aimed at understanding ecosystem change across the tundra (**FIG 5**).



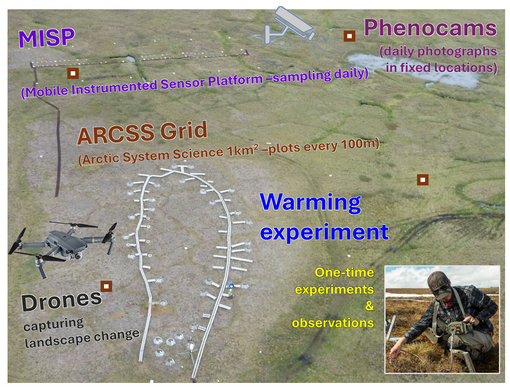


FIG 1 The US ITEX-AON is a collaborative project between GVSU, FIU, UTEP, and UAA that begun in 2010. Field sampling occurs primarily within Arctic System Science (ARCSS) grids established in the early 90s to document ecosystem change at Utqiaġvik, Atqasuk, Imnavait, and Toolik. At each site there is an integrated sampling regime which includes permanent plots, a long-term warming experiment, a mobile instrumented sensor platform (run across a 50m transect), drone sampling, fixed phenocams, and many one-time observations or experiments. The goal is to identify the drivers of ecosystem change across the landscape and communicate the implications of the observed changes.

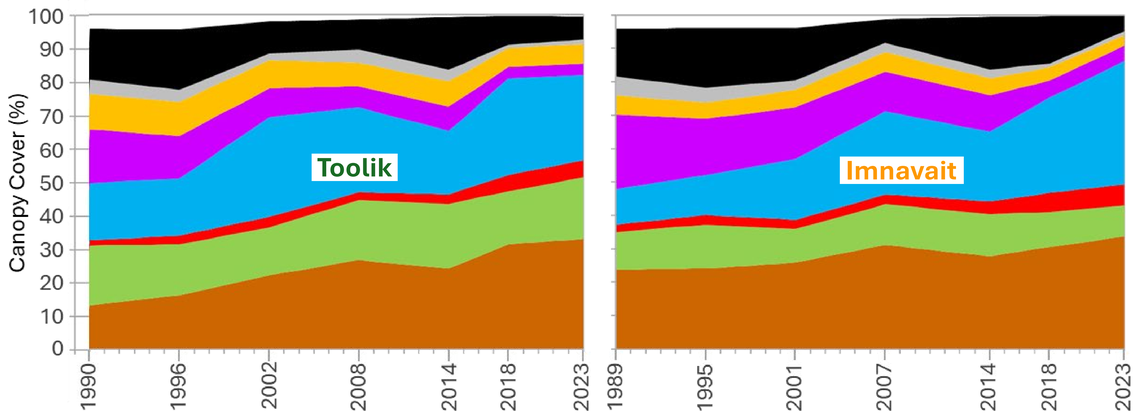
NDVI from space (regional)

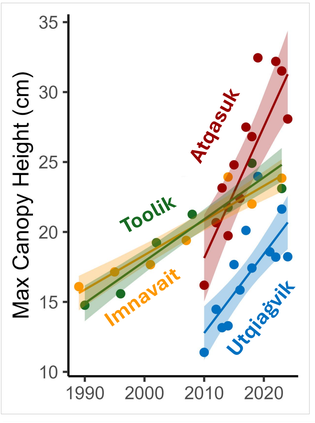
	Canopy Height	Cover Top Hit Plants	All Hits Plants	Vascular	D Shrub	E Shrub	Graminoid
Toolik	0.85	0.02	0.44	0.32	0.78	0.58	-0.58
Imnavait	0.91*	0.58	0.68	0.84	0.43	0.26	0.89*
Atqasuk	0.53	0.61*	0.64*	0.59*	0.63*	0.58*	0.50
Utqiaġvik	0.33	0.27	0.42	0.41	-0.11	-0.09	0.40

NDVI from near the surface (plots)

	Canopy Height	Cover Top Hit Plants	All Hits Plants	Vascular	D Shrub	E Shrub	Graminoid
Atqasuk	0.05	0.12	0.06	0.04	-0.03	0.00	0.06
Utqiaġvik	0.11*	0.22*	0.15*	0.15*	0.01	-0.01	0.08

TABLE 1 Correlations between Peak season NDVI and vegetation parameters. The top table is the relationship with NDVI measured from space (**FIG 3**), while the bottom is NDVI near the surface from individual plots (**FIG 4**).





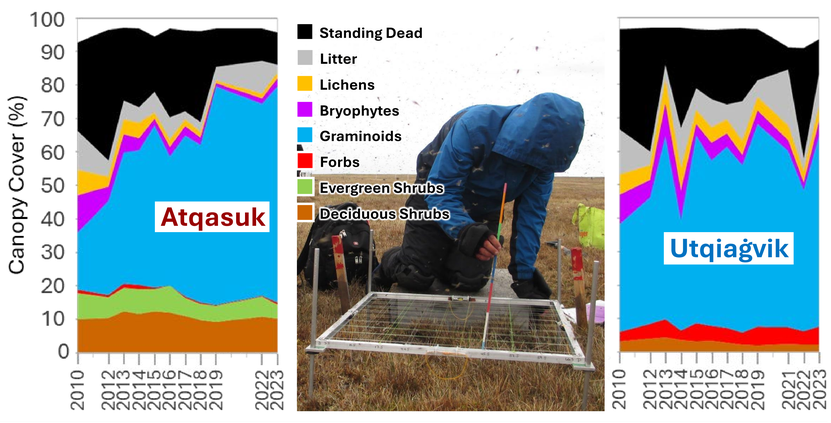


FIG 2 Vegetation change at Toolik, Imnavait, Atqasuk and Utqiaġvik. Vegetation was sampled using a point frame. Displayed are the top encounters/hits only because these show the largest observed change; the years when vegetation was sampled are listed on the x-axis (Harris et al. 2022; Betway-May et al. 2025). Note, measurements are recorded by species and changes in plant species are of interest in themselves and provide the bases for herbivore populations (García Criado et al. 2025; Lemieux et al. 2025; Barrio et al. 2025). Plant height (lower left insert), measured here as the maximum height above the ground observed in a plot, has increased across sites. Increasing plant height is one of the most widespread observations of vegetation change across the Arctic (Bjorkman et al. 2018) and is a function of both a change in the abundance of taller plant species and increases in the height of previously existing plants. At Toolik and Imnavait sampling started earlier and we show all plots; at Atqasuk and Utqiaġvik the same sampling protocols were begun as part of the ITEX-AON (**FIG 1**) and we show a subset of 30 plots with frequent sampling.

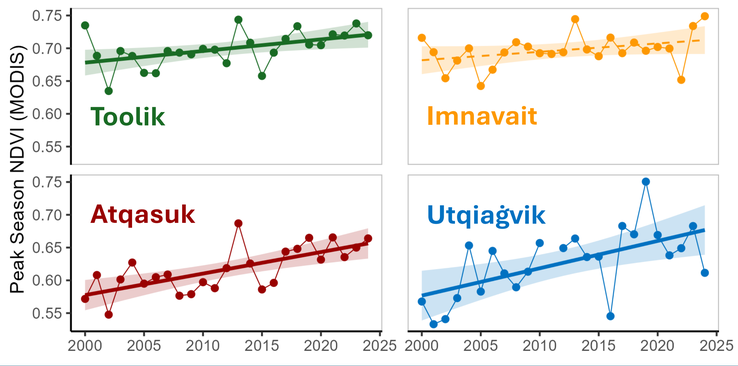


FIG 3 Peak season NDVI measured from space for the area of the ARCSS grids at Toolik, Imnavait, Atqasuk and Utqiaġvik. All four sites show a statistically significant greening trend except Imnavait.

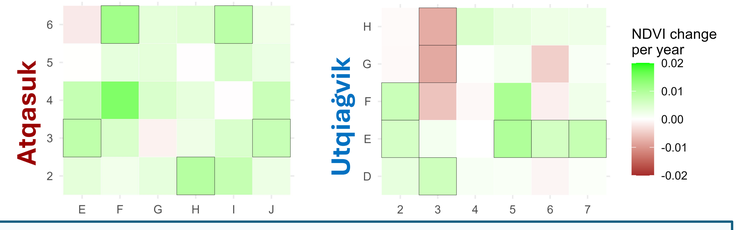


FIG 4 Trends in NDVI measured near the surface on plots at Atqasuk and Utqiaġvik. Colors indicate intensity; a box around the plot denotes a statistically significant trend. Understanding the variability in change requires detailed, long-term measurements (Myers-Smith et al. 2020, Hollister 2024).

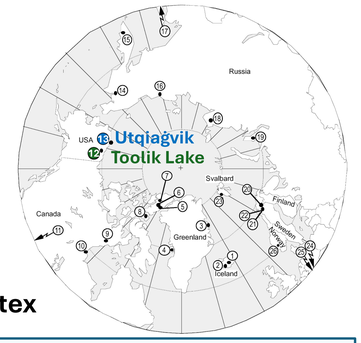


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FIG 5 The US-led sites at Utqiaġvik and Toolik were among the first ITEX sites (both were established in 1994). The focus of ITEX is on understanding ecosystem change across the tundra biome. The power of ITEX is the ability to perform synthesis across many sites due to common protocols (Henry et al. 2022).

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