CHARACTERIZING ENVIRONMENTAL CHANGE IN INTERIOR ALASKA (1982-2012) USING MULTI-TEMPORAL, MULTI-SCALE REMOTE SENSING DATA AND FIELD MEASUREMENTS

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Abstract.—We investigate how vegetation in the Tanana Valley of interior Alaska (120,000 km^2) has responded to a changing climate over the preceding three decades (1982-2012). Expected impacts include: 1) drying of wetlands and subsequent encroachment of woody vegetation into areas previously dominated by herbaceous and bryoid vegetation types, 2) changes in forest composition resulting from succession processes within burned areas, 3) mortality and defoliation from increased insect activity attributable to a warming climate, 4) effects on tree growth attributable to drought stress and/or reduced photosynthetic capacity, and 5) expansion of woody vegetation at the tree line. To characterize and quantify these changes occurring over the full range of environmental conditions present in this vast region, we plan to use a unique resource of multi-temporal and multi-scale remote sensing data to analyze changes observed between 1) field data and large-scale photographs collected in 1982 over a selection of inventory plots within the western Tanana Valley region, and 2) low-altitude airborne digital imagery collected over these same inventory plots in 2012. Detailed stand- and plant-level changes observed over 40-ha remeasured photo plots will be scaled up and used to inform an analysis of changes in vegetation condition observed in spectral trajectories obtained from a time series of Landsat Thematic Mapper/Enhanced Thematic Mapper Plus imagery over this 30-year period.

INTRODUCTION

The impacts of climate change on the condition and productivity of vegetation are likely to be particularly significant in the boreal forest regions of the world, such as interior Alaska, where observed rates of temperature change over the last three decades are significantly higher than in other terrestrial biomes. High northern latitudes have experienced the strongest warming trend during the era of satellite observations (1972-present), leading to a variety of climate-driven changes in vegetation growth and mortality (e.g., Wolken et al. 2011). These impacts are highly varied across the region's wide range of environmental (e.g., hydrological, elevation) gradients. The changes occurring in interior Alaska have important implications for local community subsistence through impacts on wildlife (Kofinas et al. 2010) and biomass for energy (Fresco and Chapin 2009). Due to the vast spatial extent and lack of infrastructure in the region, there has been very little systematic repeated sampling as typified by the permanent plots, such as those of the Forest Inventory and Analysis Program, that can be found in other regions. As a result, insights about changes in interior Alaska have come from localized field studies and broad-scale remote sensing efforts, often carried out independently (Hollingsworth et al. 2010, Parent and Verbyla 2010).

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OBJECTIVES

In this study, we are investigating how vegetation in interior Alaska has changed over three decades (1982-2012) and link those changes to shifts in climate regime during that time. We will develop a hierarchical approach to evaluating vegetation change using a unique resource of multi-temporal and multi-scale remote sensing data along with remeasured field plots over a 17,000-km^2 area in the vicinity of Fairbanks, AK (Fig. 1). We expect changes in climate to be manifested in a variety of ways that will be visible across multiple scales of observation. Expected ecological impacts include: 1) drying of wetlands and subsequent encroachment of woody vegetation into areas previously dominated by herbaceous and bryoid vegetation types, 2) increase in deciduous vegetation postfire due to increased fire severity, 3) tree mortality and defoliation due to increased insect activity attributable to a warming climate, 4) impacts on tree growth attributable to drought stress and/or reduced photosynthetic capacity, and 5) expansion of woody vegetation at tree line. A unique feature of this study will be that we will capitalize on the permanent plot remeasurements to provide more robust insights into changes.

APPROACH

Field data and large-scale photographs collected for a previous inventory of the Tanana Valley in interior Alaska carried out in the early 1980s will be compared with field data and low-altitude airborne digital imagery collected over plots in 2010 in a previous study and in 2012 (Fig. 1). Detailed stand- and plant-level changes observed at field plots and 40-ha remeasured photo plots will be scaled up and used to inform an analysis of changes in vegetation condition observed in spectral trajectories obtained from a time series of Landsat Thematic Mapper/Enhanced Thematic Mapper Plus (TM/ETM+) imagery over this 30-year period.

Remeasurement of Adaptive Infrared Imaging Spectroradiometer Field Data

We plan to revisit a subset of seven Adaptive Infrared Imaging Spectroradiometer (AIRIS) field plots in the vicinity of Fairbanks to confirm and clarify patterns seen at broader scales (repeat air photography and satellite) and to assess feasibility of remeasuring field plots over a broader geographic range in the future (Fig. 1). Revisited plots will be prioritized by those that: 1) are in areas that are near roads (to reduce sampling costs), 2) have undergone the greatest change (increase or decrease) in Normalized Difference Vegetation Index (NDVI) across the study area, and 3) have not been burned (to simplify analyses for this study). Each AIRIS field plot consisted of 19 sample points distributed uniformly throughout the 8-ha photo plot area. Field data from the 1982-1983 inventory are readily available (MS Access database), as are scanned copies of the field manual with detailed sampling notes, and photos taken on the plot. Monuments were placed at all plots to make them easier to find.

Remeasurement of AIRIS Photo Plots

We will refly 30 AIRIS photo plots in the vicinity of Fairbanks with low-altitude (large-scale) digital stereo imagery, to characterize stand- and plant-level processes of change, including shrub and tree establishment, mortality, species replacement or succession, and changes in surface hydrology, for assessment of impacts on carbon flux and habitat. Forest-type polygons interpreted in the 1982 and 2012 photos will provide a large footprint (40 ha) to compare with changes observed in a time series of satellite imagery. Several of the AIRIS photo plots within the proposed study area have already been reflown for a previous project.

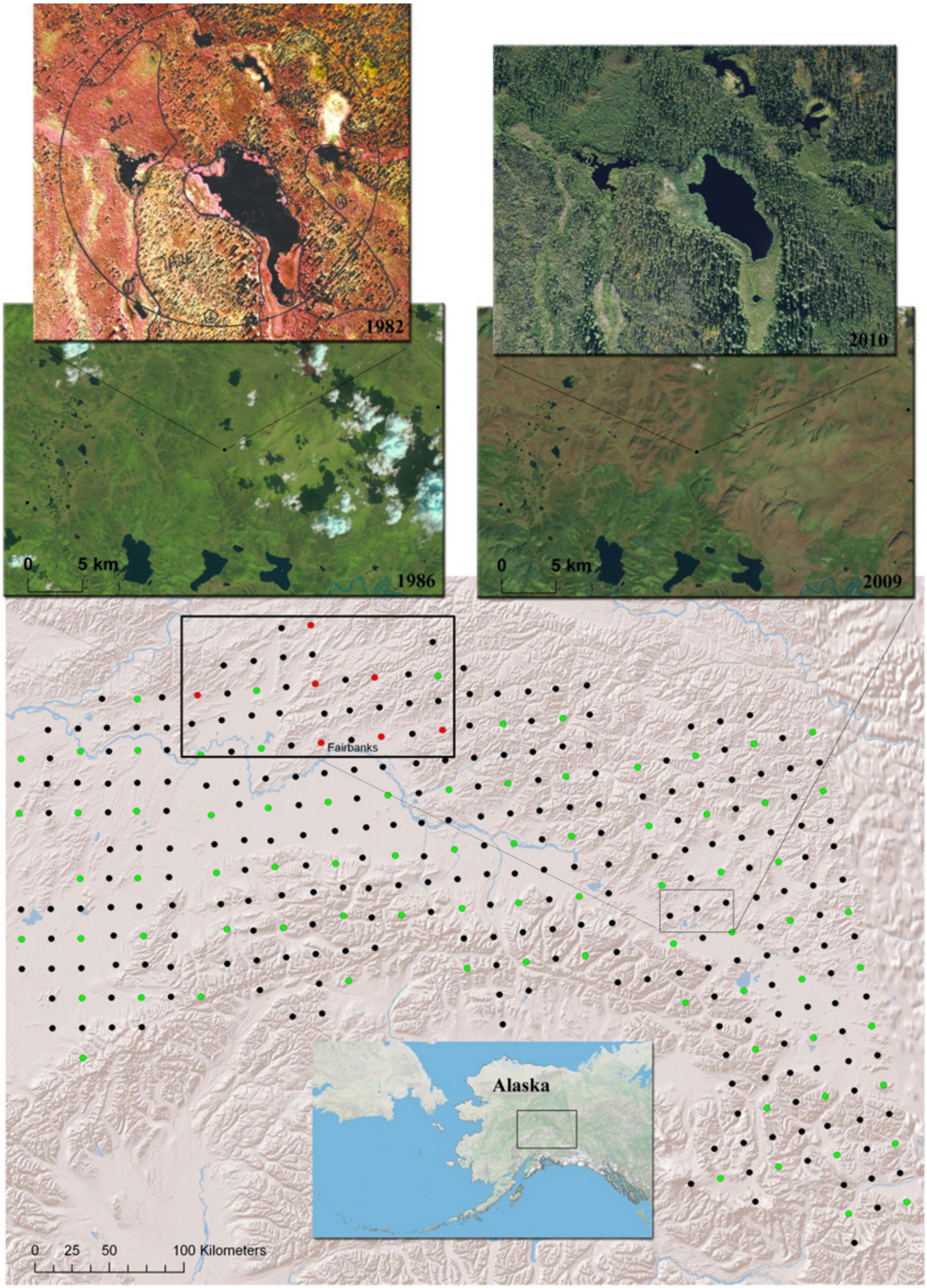

Figure 1.—Location of AIRIS photo plots (black dots) and AIRIS field plots (green) within Tanana Valley, interior Alaska. Black rectangle in upper left area of main map shows proposed 17,000-km^2 study area for this project; red dots indicate the accessible AIRIS field plots to be visited. Inset graphics show Landsat TM imagery and low-altitude aerial photos from the mid-1980s and late-2000s. Photo-interpreted forest type polygons within the 1982 8-ha photo plot are also shown. Note terrestrialization and shrinkage of pond area, as well as burned areas evident in Landsat TM imagery.

Time-Series Analysis of Changes in Satellite Imagery

All field-visited (~7) and reflown photo plots (~30) will be also be examined with a 30-year time- series analysis of changes in key spectral indices (e.g., NDVI) from Landsat TM/ETM+ using TimeSync (Cohen et al. 2010). This analysis will allow us to compare how these field and photo plots fit into other regionwide satellite-based studies of changes in key indices (Parent and Verbyla 2010) and will provide a foundation for regionwide (i.e., "wall-to-wall") assessment of changes to the entire Tanana Valley by using the 30-year Landsat TM/ETM+ record with other approaches such as Landsat-based Detection of Trends in Disturbance and Recovery (LandTrendr) (Kennedy et al. 2010) in the future.

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