A new approach for predicting near-surface wind using high-resolution characterizations of canopy architecture from hemispherical photography and LiDAR:

a preliminary assessment at the Santa Rita Experimental Range

Darin J. Law[1], Joel B. Sankey[2], David D. Breshears[1,3], Robert H. Webb[4]

[1]School of Natural Resources and the Environment, University of Arizona, [2]USGS Western Geographic Science Center and USA-National Phenology Network, [3]Department of Ecology and Evolutionary Biology, University of Arizona, [4]USGS Water Resources Division

Introduction:

Vegetation in drylands is often patchy, which creates complex wind patterns especially near the ground. These complex wind patterns drive biological and physical processes such as soil evaporation, soil litter mixing, and aeolian erosion. While wind flow above the vegetation canopy is relatively well understood, predicting wind patterns near the ground has not been previously possible because of the complexity of the vegetation. Current advances in digital photography and light detection and ranging (LiDAR, fig. 1) technology now allow us to measure complex vegetation structure at very high spatial resolution. For example, LiDAR and hemispherical digital photography can precisely measure amount, direction and distance to vegetation components (e.g. trunks, limbs, leaves) that function as wind obstructions. Combined with near ground measures of windspeed, we hypothesize that these measures can be used to predict near ground wind patterns.

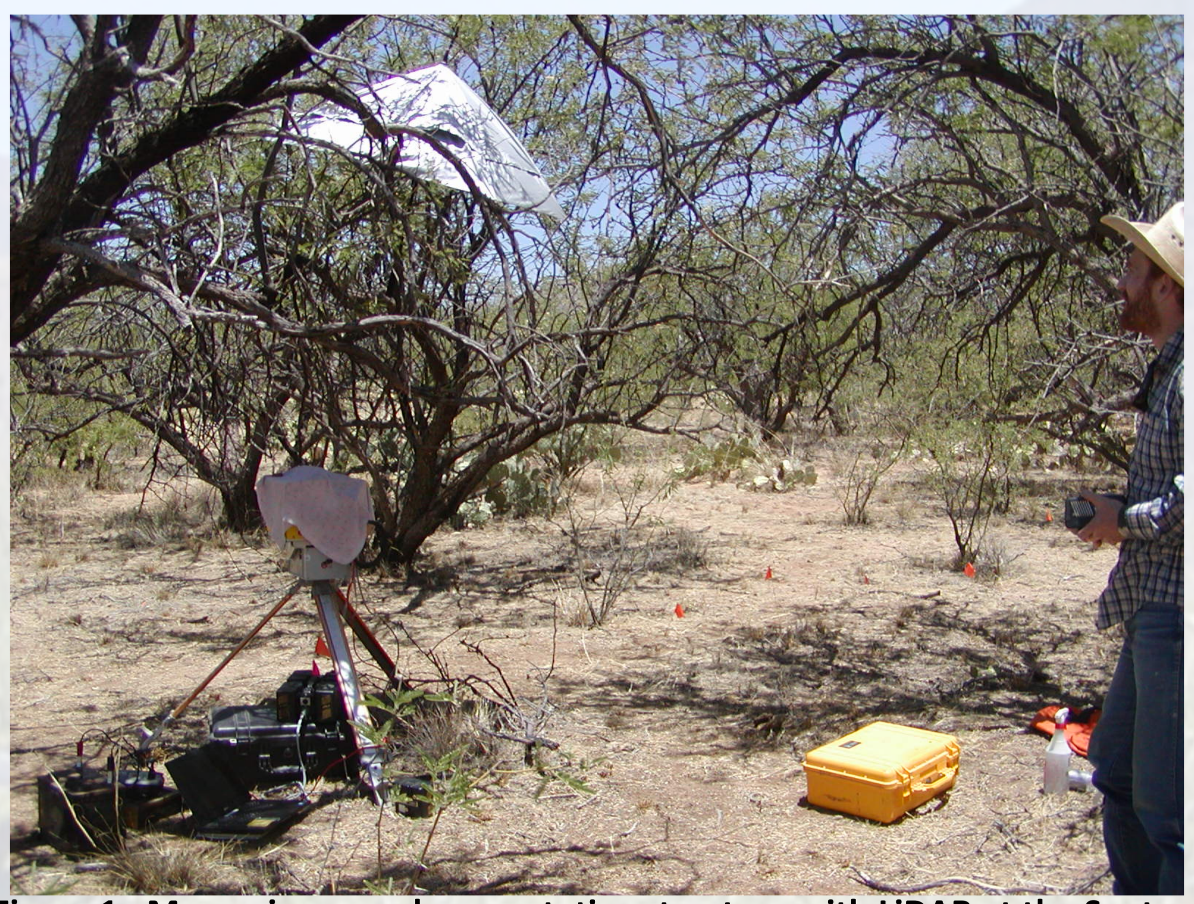

Figure 1. Measuring complex vegetative structure with LiDAR at the Santa Rita Experimental Range

Methods:

Gradients of mesquite canopy cover were located at the Santa Rita Experimental Range and included transects with: 2%, 16%, 26%, 37%, 56%, and 73% cover.

A LiDAR instrument was used to collect a 360⁰ horizontal view of the vegetation architecture at each cover transect (fig. 2).

LiDAR data was rasterized to determine height variability (roughness) of woody vegetation at 10 cm grid cell sizes and analyzed via GIS to determined the horizontal distance to the nearest vegetation component (DTRE) (fig. 2).

Hemispherical photos were taken horizontally at the same location as the LiDAR and percent openness was determined (fig. 3).

Windspeed was measured with mini anemometers at 25 cm, 50 cm and 100 cm from the soil surface also at the same locations over a 24 hour period.

Wind measurements were analyzed to determine height profiles, roughness lengths and friction velocities.

Results Lidar

DTRE and roughness measured by LiDAR were highly correlated with percent cover (figs. 3-4). Mean and maximum windspeed and friction velocity were correlated with DTRE, roughness and percent cover(figs. 5-8).

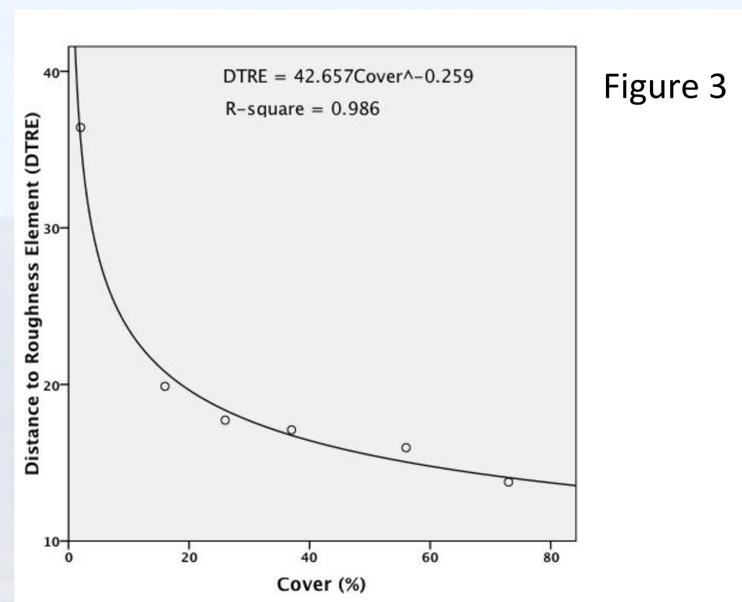

Figure 3

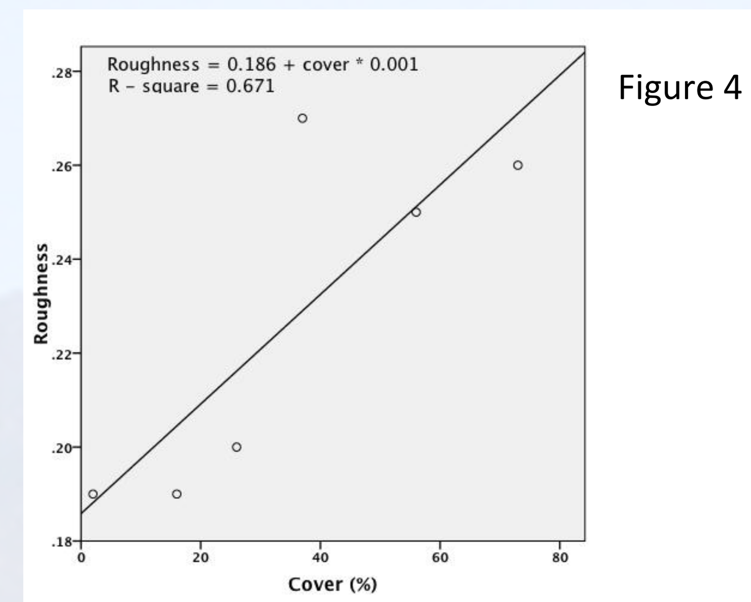

Figure 4

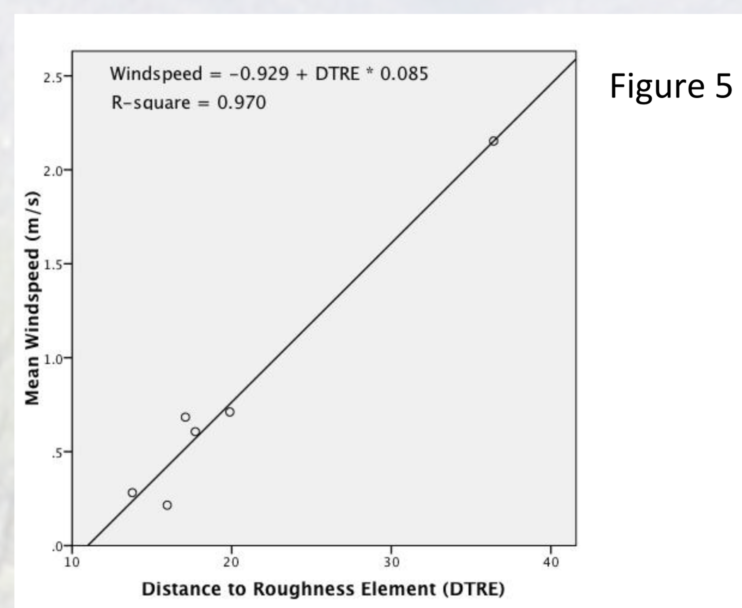

Figure 5

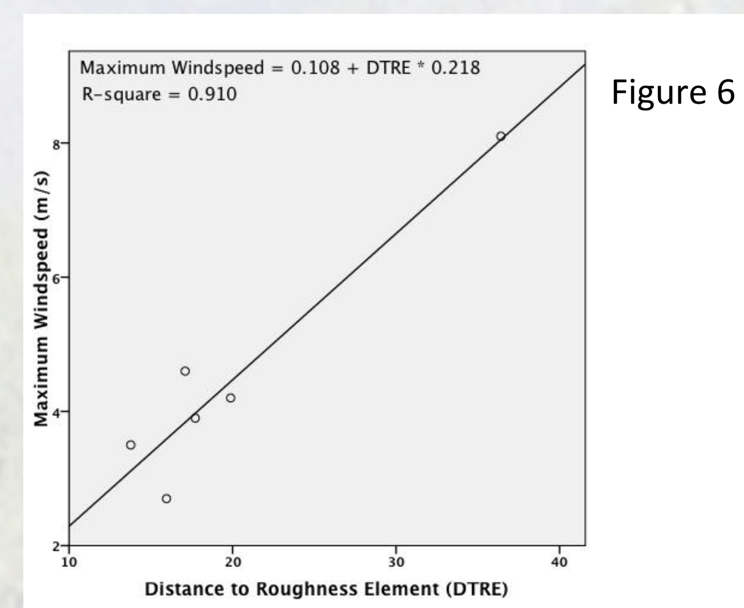

Figure 6

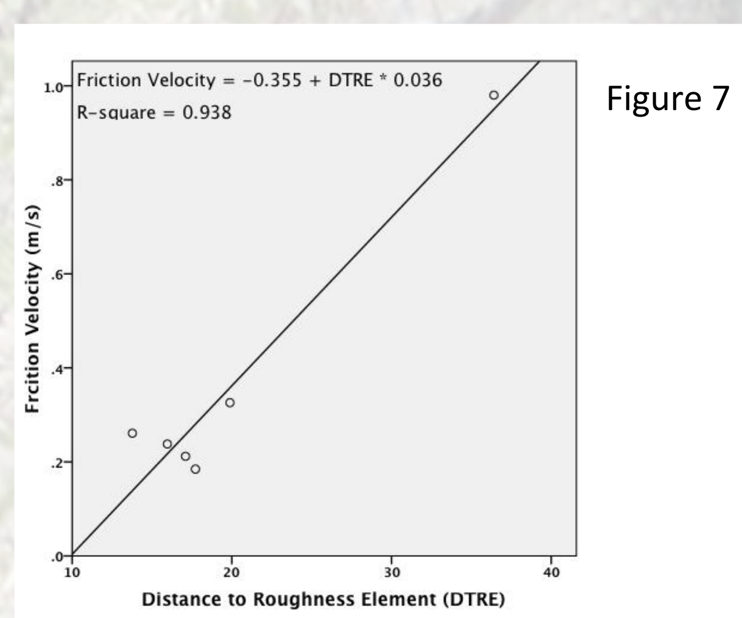

Figure 7

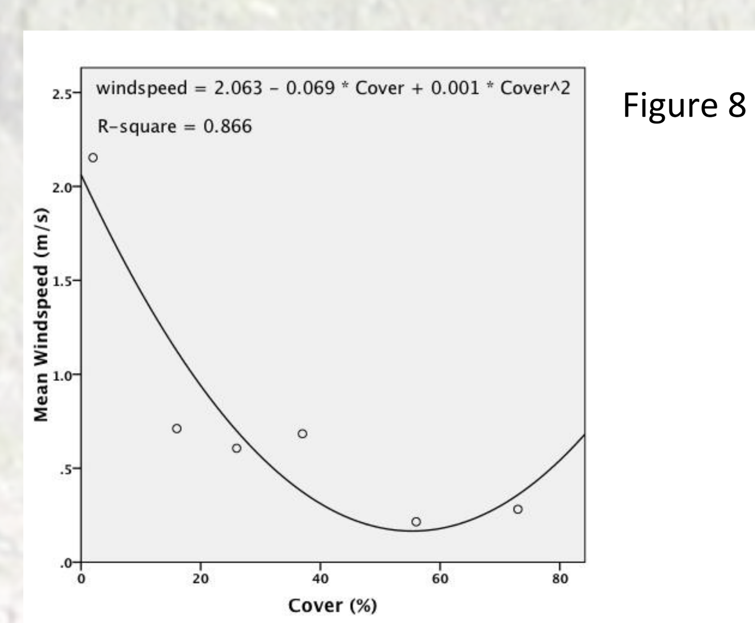

Figure 8

Results Hemiphotos

Percent openness was correlated with DTRE from the LiDAR (fig. 9).

Percent openness was correlated with friction velocity (fig.10)

Percent openness was correlated with percent cover (fig. 11)

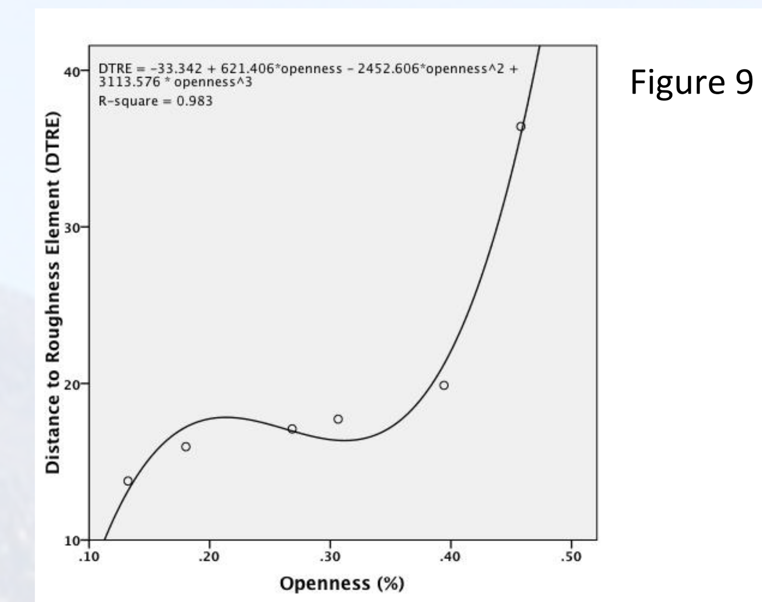

Figure 9

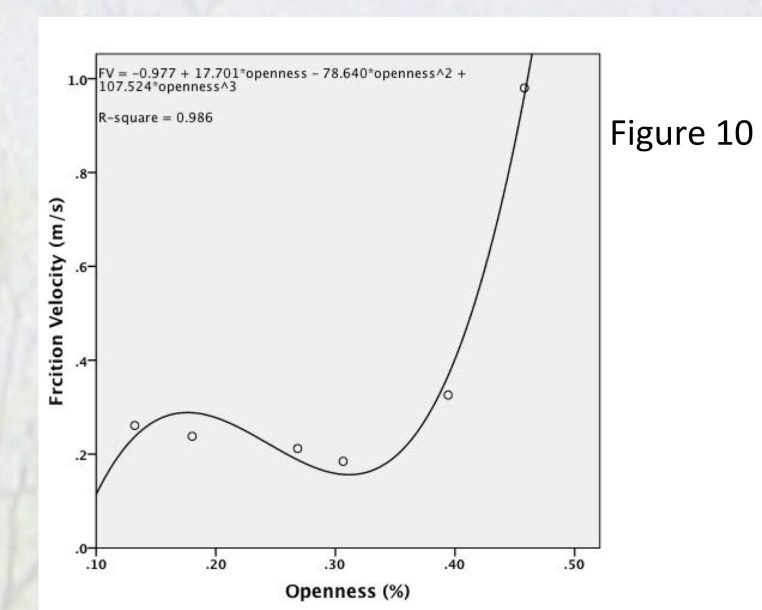

Figure 10

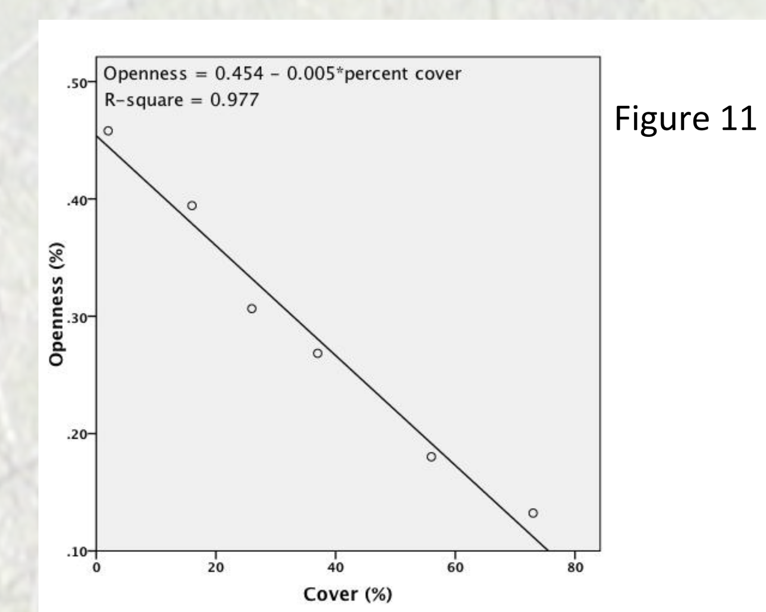

Figure 11

Discussion and Conclusion

The results of this pilot study show the potential utility of LiDAR and hemispherical photography to rapidly characterize canopy architecture at very high resolution not previously attained in a manner useful for estimating aerodynamic parameters such as friction velocity and roughness length. A new predictive capability to predict wind patterns near the ground could not only complement above-canopy measurements, but could also enable novel approaches to estimate fundamental near-ground processes such as soil evaporation, aeolian sediment transport, and soil-litter mixing.

Figure 2. LiDAR scans of each of the six transects from low to high cover