RESOLVING SHADOWS IN HIGH RESOLUTION SATELLITE IMAGES FOR ESTIMATING CARBON UPTAKE IN URBAN-SUBURBAN AREAS

Jindong Wu [1] and Marvin E. Bauer [2]

[1] Department of Geography, California State University, Fullerton, CA 92834, USA
[2] Department of Forest Resources, University of Minnesota, Saint Paul, MN 55108, USA

Vegetation is a basic component of urban-suburban environments with significant area coverage. Urban trees and grass provide a full range of goods and services that are vital to human health and livelihood [1]. For instance, urban vegetation has the potential to affect regional biogeochemical cycles, such as the carbon cycle, through photosynthesis and respiration.

Quantification of the contribution of urban vegetation to regional carbon budget is important for understanding and mitigating many aspects of carbon sinks and sources and by extension global climate change. A wide array of remote sensing and ecological modeling approaches has been developed for estimating carbon budgets of natural and agricultural ecosystems, but relatively few are available for urban and suburban landscapes [2].

The estimation of carbon budgets with remotely sensed imagery becomes more difficult in urban-suburban areas because of increased spatial heterogeneity and the relatively low resolution of imagery data. High spatial resolution remote sensing provides great opportunities to detect fine details on the ground. However, significant shadows in acquired images also create problems in applying these images to land cover classification [3]. Shaded areas are usually left unclassified or simply classified as shadows. As a result, a significant portion of land cover including vegetation coverage is lost, and thus the accurate estimation of vegetative carbon uptake becomes difficult.

QuickBird imagery data of Roseville in Minnesota were used in this study to estimate primary production and carbon uptake by turf grass. We first developed a multi-stage image classification scheme to map major land cover types including turf grass. One of the land cover classes was inevitably shadows, which accounted for about 7% total land cover in the study area. The analysis of spectroradiometric properties of shadows (e.g., shadows on impervious surfaces and shadows on turf grass) indicated that they are sectroradiometrically different. We took advantage of the high radiometric resolution of QuickBird images, recognized the land cover under shadows, and re-classified shadows to different informational classes. The shadow-resolved land cover map was used to extract urban vegetation and determine the spatial patterns of turf grass.

To restore spectral information of shadow areas in the QuickBird imagery, K-nearest neighbor algorithms were applied to resample digital numbers for every single shadow pixels. The shadow restoration was conducted separately for each of the four spectral bands of the QuickBird data. The shadow-free multispectral images were used to estimate necessary input parameters, e.g., NDVI, in a remote sensing-driven carbon model. Both shadow-resolved turfgrass cover map and shadow-free QuickBird images were introduced to the carbon model to estimate the net primary production and carbon uptake of turf grass. The result showed that urban vegetation accounted for about 60% of the land surface in this residential neighborhood, among which more than 50% was turf grass. The carbon uptake of turf grass varied significantly across the study area. However, golf grass constantly had high productivity and contributed considerably to carbon uptake.

REFERENCES

[1] Pickett, S.T.A., M.L. Cadenasso, J.M. Grove, C.H. Nilon, R.V. Pouyat, W.C. Zipperer, and R. Costanza, "Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas," *Annual Review of Ecology and Systematics*, vol. 32, pp. 127−157, Nov. 2001.

[2] Pataki, D.E., R.J. Alig, and A.S. Fung, N.E. Golubiewski, C.A. Kennedy, E.G. Mcpherson, D.J. Nowak, R.V. Pouyat, P. Romero Lankao, "Urban Ecosystems and the North American Carbon Cycle," *Global Change Biology*, vol. 12, no. 11, pp. 2092–2102, Nov. 2006.

[3] Dare, P. M., "Shadow Analysis in High-resolution Satellite Imagery of Urban Areas," *Photogrammetric Engineering & Remote Sensing*, vol. 71, no. 2, pp. 169−177, Feb. 2005.