1.3

DISSIPATION AND PARTITIONING OF ENERGY WITHIN JACK PINE AND DOUGLAS-FIR

Eugénie S. Euskirchen[1*1], Jiquan Chen[2], Kyaw Tha Paw U[3]
[1]Michigan Technological University, Houghton, MI
[2]University of Toledo, Toledo, OH
[3]University of California, Davis, CA

1. INTRODUCTION

The partitioning of energy fluxes (net radiation, sensible heat flux, latent heat flux, and soil heat flux) within coniferous ecosystems can indicate the water status of the forest and soils over the course of a growing season. Those forests that are not restricted by water will have average Bowen ratios (ratio of sensible to latent heat) close to one, while those that are water-limited will have much larger Bowen ratios. Furthermore, the trends of the energy fluxes over time can demonstrate how the componenets of the energy budget differ on a seasonal basis both within and between ecosystems. With this in mind, we investigated the diurnal and seasonal patterns of energy fluxes within three coniferous forests of different composition: a 12-year old jack pine stand and two Douglas-fir stands 20 and 40 years of age.

2. SITE AND MEASUREMENTS

At all three sites, we used eddy covariance methods to measure the fluxes of sensible and latent (evapotranspiration) heat, and microclimate stations to measure heat flux and net radiation. Further information pertaining to these systems can be found in Chen et al., 2002.

The naturally regenerating 12-year old jack pine (*Pinus banksiana)* stand is located in Michigan's Upper Peninsula, USA. The site was clear-cut about 15 years previously and is dominated by well-drained sandy soils. Measurements were made between June and October of 2001.

The Douglas-fir sites are located within the Wind River Valley in southern Washington State, USA. Measurements were made between June and September of 1998 in the 40-year old plantation, and of June to October of 1999 in the 20-year old plantation. Detailed site information is available in Chen et al., 2002.

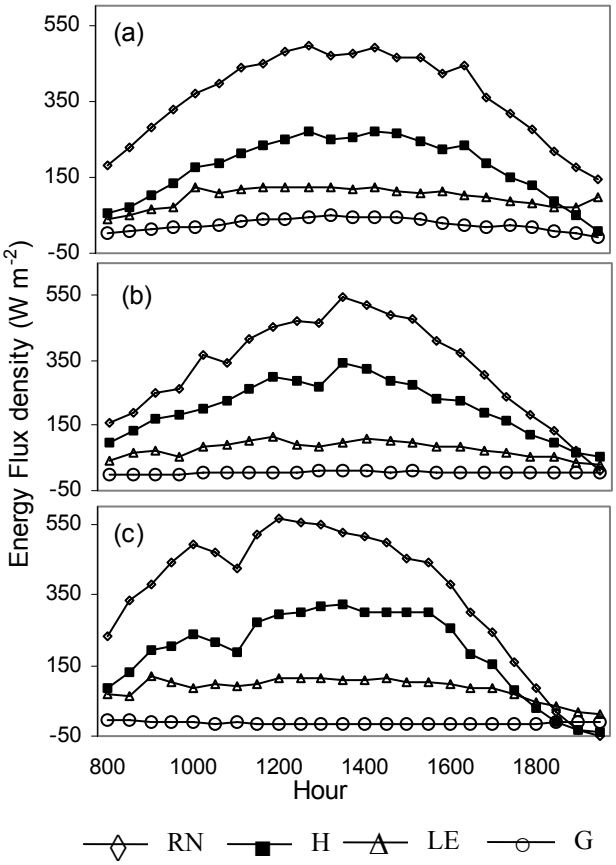

Figure 1. Average energy balance components of the three coniferous forests during daylight hours in the month of August. (a) 12-year jack pine, (b) 20-year Douglas-fir, and (c) 40-year Douglas-fir. Rn, net radiation; H, sensible heat flux density; LE, latent heat flux density; G, soil heat flux density

**Corresponding author address:* Eugénie S. Euskirchen, Michigan Technological University, School of Forestry, 1400 Townsend Dr., Houghton, MI, 49931;
e-mail: eseuskir@mtu.edu

3. **RESULTS**

On a monthly basis, the energy balance closure (e.g., $R_n + G = H + L$), an indication of the reliability of the eddy flux measurements, was generally highest at the jack pine site ($R^2 = 0.95$-0.97), and lowest at the 20-year old Douglas-fir stand ($R^2 = 0.74$-0.94). At all four sites there were close linkages between net radiation (R_n) and the sensible (H) and latent (L) heat fluxes over the course of the day (Fig. 1). Average heat flux (G) was negligible at all three sites, but showed the most diurnal variation at the jack pine stand (Fig. 1). Furthermore average R_n was highest in the jack pine stand (392 W m^{-2}) and lowest in the 20-year old stand (212 W m^{-2}).

Over the course of the sampling period, H accounted for about 75% of the total available energy (e.g., H + L) in the 20-year old stand as indicated by an average Bowen ratio of 3.7. At the 40-year old Douglas-fir stand, the average Bowen ratio was 2.4, and H accounted for 70% of available energy. Finally, at the jack pine site, the average Bowen ratio was 1.8, and the partitioning between H and L was slightly more equal with H accounting for 65% of available energy.

4. **CONCLUSIONS**

Although the energy budget closure was generally high (e.g., > 90%) we did not observe complete equality. However, our deficit is comparable to that of other coniferous sites (Berbigier et al., 2001; Turpinseed et al., 2001). Furthermore, even though soil heat flux was small during the course of a day, it cannot be neglected in the energy budget on a monthly basis.

As indicated by the generally high average Bowen ratios throughout the measuring periods, evapotranspiration at all three sites was low. Therefore, it is likely that these stands are all somewhat water-limited during the growing season. It is also possible that during periods when sensible heat is less dominant, the productivity of the forest will increase. At this point, more water will move through the plants, thereby increasing rates of growth and photosynthesis.

Perhaps one of the most interesting findings in this study concerns the dissimilarity of energy budget terms among the three stands. These differences are most likely due to the variations in vegetation types, microclimates, soils, and disturbance regimes. Comparative studies, such as this one, can help us more accurately assess how modifications in land-use will affect productivity across a variety of ecosystems.

5. **REFERENCES**

Berbigier, P., J.-M. Bonnefond, P. Mellmann, 2001: CO_2 and water vapour fluxes for 2 years above Euroflux forest site. Ag. For. Met., **108**: 183-197.

Chen, J. M. Falk, E. Euskirchen, K.T. Paw U, T.H. Suchanek, S.L. Ustin, B.J. Bond, K.D. Brosofske, N. Phillips, R. Bi, 2002: Biophysical controls of carbon flows in three successional Douglas-fir stands based on eddy-covariance measurements. Tree Phys., **22**, 169-178.

Turpinseed, A.A., P.D. Blanken, D.E. Anderson, R.K. Monson, 2002: Energy budget above a high-elevation subalpine forest in complex topography. Ag. For. Met. **110**: 177-201.

ACKNOWLEDGMENTS

This research was funded by the Western Regional Center (WESTGEC) of the National Institute for Global Environmental Change (NIGEC), the U.S. Department of Agriculture NRI Competitive Grants program (contract no. 97-35101-4318), the U.S. Department of Energy (cooperation agreement nos. DE-FCO3-90ER61010 and W/GEC 98-103), and the National Science Foundation -MRI program (contract no. DBI-0079566).