Transpiration in a small tropical forest patch

Giambelluca T.W., Ziegler A.D., Nullet M.A., Truong D.M., Tran L.T.

Department of Geography, University of Hawaii at Manoa, 2424 Maile Way, Honolulu, HI 96822, United States; Ctr. for Nat. Rsrc./Environ. Studies, Vietnam National University, Hanoi, Viet Nam; Earth System Science, Pennsylvania State University, University Park, PA 16802, United States

Abstract: A field study was conducted of microclimate and transpiration within a 12 ha patch of advanced secondary forest surrounded by active or recently abandoned swidden fields. Differences in microclimate among stations located within and near the patch, give evidence of the effects of the adjacent clearing on the environment in the patch. Volumetric soil moisture content at the end of the dry season was lowest at the two edge sites, suggesting greater cumulative dry season evapotranspiration (ET) there than at swidden and forest interior sites. Total evaporation, based on energy balance methods, was also higher at the two edge sites than at the swidden or forest interior sites. Spatial differences in evaporation decreased as conditions became wetter. Measurements of sap flow in nine trees near the southwestern edge of the patch and nine trees in the patch interior indicate considerable variability in transpiration among the three monitored tree species, Vernicia montana, Alphonsea tonkinensis, and Garcinia planchonii. Dry-period transpiration averaged about 39 and 43% of total evaporation for edge and interior trees, respectively, increasing to 60 and 68% after the start of rains. Transpiration in both zones was well-correlated with micrometeorological conditions in the adjacent clearing, implying that transpiration edge effect is greatest when conditions are favorable for high positive heat advection from the clearing to the forest edge. Transpiration rates of well-exposed trees were higher than poorly-exposed trees, and decreased with distance from the edge at a statistically significant rate of -0.0135 mm per day m^{-1}. Although the results on the strength of transpiration edge effect are somewhat equivocal due to variability within the small sample, there is clear evidence that ET within the patch is influenced by the surrounding clearings. If edges experience higher ET, greater fragmentation would result in higher regional evaporative flux, which would partly compensate for the reduction in regional ET due to deforestation. ?? 2003 Elsevier Science B.V. All rights reserved.

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Correspondence Address: Giambelluca, T.W.; Department of Geography, University of Hawaii at Manoa,

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Authors with affiliations:

1. Giambelluca, T.W., Department of Geography, University of Hawaii at Manoa, 2424 Maile Way, Honolulu, HI 96822, United States
2. Ziegler, A.D., Department of Geography, University of Hawaii at Manoa, 2424 Maile Way, Honolulu, HI 96822, United States
3. Nullet, M.A., Department of Geography, University of Hawaii at Manoa, 2424 Maile Way, Honolulu, HI 96822, United States
4. Truong, D.M., Ctr. for Nat. Rsrc./Environ. Studies, Vietnam National University, Hanoi, Viet Nam
5. Tran, L.T., Earth System Science, Pennsylvania State University, University Park, PA 16802, United States

References:

1. Blad, B.L., Rosenberg, N.J., Evaluation of resistance and mass transport evapotranspiration models requiring canopy temperature data (1976) Agron. J., 68, pp. 764-769
2. Brenner, A.J., Jarvis, P.G., A heated leaf replica technique for determination of leaf boundary layer conductance in the field (1995) Agric. For. Meteorol., 72, pp. 261-275
3. Bruijnzeel, L.A., (1990) Hydrology of Moist Tropical Forests and Effects of Conversion: A State of Knowledge Review, , UNESCO, Paris and Vrije Universiteit, Amsterdam
4. Bruijnzeel, L.A., Forest hydrology (2001) The Forests Handbook, , J.C. Evans (Ed.). Blackwell Scientific Publications, Oxford, UK (Chapter 12)
5. Chen, J., Franklin, J.F., Spies, T.A., Contrasting micro-climates among clearcut, edge, and interior of old-growth Douglas-fir forest (1993) Agric. For. Meteorol., 63, pp. 219-237
6. Choudhury, B.J., Reginato, R.J., Idso, S.B., An analysis of infrared temperature observations over wheat and calculation of latent heat flux (1986) Agric. For. Meteorol., 37, pp. 75-88
7. Clearwater, M.J., Meinzer, F.C., Andrade, J.L., Goldstein, G., Holbrook, N.M., Potential errors in measurement of nonuniform sap flow using heat dissipation probes (1999) Tree Physiol., 19, pp. 681-687
8. Famiglietti, J.S., Wood, E.F., Multiscale modeling of spatially variable water and energy balance processes (1994) Water Resour. Res., 30, pp. 3061-3078
9. Famiglietti, J.S., Wood, E.F., Effects of spatial variability and scale on areally averaged evapotranspiration (1995) Water Resour. Res., 31, pp. 699-712
10. Gascon, C., Williamson, G.B., Da Fonseca, G.A.B., Receding forest edges and vanishing reserves (2000) Science, 288, pp. 1356-1358
11. Gash, J.H.C., A note on estimating the effect of a limited fetch on micrometeorological evaporation measurements (1986) Boundary-Layer Meteorol., 35, pp. 409-413
12. Giambelluca, T.W., H??lscher, D., Bastos, T.X., Fraz?o, R.R., Nullet, M.A., Ziegler, A.D., Observations of albedo and radiation balance over post-forest land surfaces in eastern Amazon Basin (1997) J. Climate, 10, pp. 919-928
13. Giambelluca, T.W., Fox, J., Yarnasarn, S., Onibutr, P., Nullet, M.A., Dry-season radiation balance of land covers replacing

forest in northern Thailand (1999) Agric. For. Meteorol., 95, pp. 53-65

14. Granier, A., Une novuvelle m??thode pour la mesure du flux de s??ve brute dans le tronc des arbres (1985) Ann. Sci. For., 42, pp. 193-200
15. Granier, A., Evaluation of transpiration in a Douglas fir stand by means of sap flow measurements (1987) Tree Physiol., 3, pp. 309-320
16. Granier, A., Huc, R., Barigah, S.T., Transpiration of natural rain forest and its dependence on climatic factors (1996) Agric. For. Meteorol., 78, pp. 19-29
17. Hahmann, A.N., Dickinson, R.E., RCCM2_BATS model over tropical South America: Applications to tropical deforestation (1997) J. Climate, 10, pp. 1944-1964
18. Hatfield, J.L., Reginato, R.J., Idso, S.B., Evaluation of canopy temperature-evapotranspiration models over various crops (1984) Agric. For. Meteorol., 32, pp. 41-53
19. Henderson-Sellers, A., Gornitz, V., Possible climatic impacts of land cover transformations, with particular emphasis on tropical deforestation (1984) Climatic Change, 6, pp. 231-257
20. Henderson-Sellers, A., Dickinson, R.E., Durbridge, T.B., Kennedy, P.J., McGuffie, K., Pitman, A.J., Tropical deforestation: Modeling local- to regional-scale climate change (1993) J. Geophys. Res., 98, pp. 7289-7315
21. Hutjes, R.W.A., (1996) Transformation of Near Surface Meteorology in a Landscape with Small Scale Forests and Arable Land, , Ph.D. Dissertation, University of Groningen, The Netherlands
22. James, S.A., Clearwater, M.J., Meinzer, F.C., Goldstein, G., Heat dissipation sensors of variable length for the measurement of sap flow in trees with deep sapwood (2002) Tree Physiol., 22, pp. 277-283
23. Jipp, P.H., Nepstad, D.C., Cassel, D.K., Reis De Carvalho, C., Deep soil moisture storage and transpiration in forests and pastures of seasonally-dry Amazonia (1998) Climatic Change, 39, pp. 395-412
24. Kapos, V., Effects of isolation on the water status of forest patches in the Brazilian Amazon (1989) J. Tropical Ecol., 5, pp. 173-185
25. Kapos, V., Wandelli, E., Camargo, J.L., Ganade, G., Edge-related changes in environment and plant responses due to forest fragmentation in central Amazonia (1997) Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities, pp. 33-44. , Laurance, W.F., Bierregaard, R.O. Jr. (Eds.). University of Chicago Press, Chicago, USA
26. Kelliher, F.M., Lloyd, J., Arneth, A., Byers, J.N., McSeveny, T.M., Milukova, I., Grigoriev, S., Schulze, E.-D., Evaporation from a central Siberian pine forest (1998) J. Hydrol., 205, pp. 279-296
27. Kienitz, G., Milly, P.C.D., Van Genuchten, M.Th., Rosbjerg, D., Shuttleworth, W.J., Hydrological interactions between atmosphere, soil and vegetation (1991) International Association of Hydrological Sciences Publication No. 204, 204. , IAHS Press, Wallingford, UK
28. Klaassen, W., Average fluxes from heterogeneous vegetated regions (1992) Boundary-Layer Meteorol., 58, pp. 329-354
29. Klaassen, W., Lankreijer, H.J.M., Veen, A.W.L., Rainfall interception near a forest edge (1996) J. Hydrol., 185, pp. 349-361
30. Kruijt, B., Klaassen, W., Hutjes, R.W.A., Veen, A.W.L., Heat and momentum fluxes near a forest edge (1991) International Association of Hydrological Sciences Publication No. 204, 204, pp. 107-116. , Kienitz, G., et al. (Eds.), Hydrological Interactions Between Atmosphere, Soil and Vegetation. IAHS Press, Wallingford, UK
31. Laurance, W.F., Bierregaard R.O., Jr., A crisis in the making (1997) Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities, , Preface to Laurance, W.F., Bierregaard, R.O. Jr. (Eds.). University of Chicago Press, Chicago, USA
32. Laurance, W.F., Ferreira, L.V., Rankin-De Merona, J.M., Laurance, S.G., Rain forest fragmentation and the dynamics of

Amazonian tree communities (1998) Ecology, 79, pp. 2032-2040

33. Lean, J., Warrilow, D.A., Simulation of the regional climatic impact of Amazon deforestation (1989) Nature, 342, pp. 411-413
34. Liang, X., Lettenmaier, D.P., Wood, E.F., Burges, S.J., A simple hydrologically based model of land surface water and energy fluxes for general circulation models (1994) J. Geophys. Res., 99, pp. 14415-14428
35. Matlack, G.R., Microenvironment variation within and among forest edge sites in the eastern United States (1993) Biol. Conserv., 66, pp. 185-194
36. McGuffie, K., Henderson-Sellers, A., Zhang, H., Durbridge, T.B., Pitman, A.J., Global sensitivity to tropical deforestation (1995) Global Planet. Change, 10, pp. 97-128
37. Meinzer, F.C., Goldstein, G., Andrade, J.L., Regulation of water flux through tropical forest camopy trees: Do universal rules apply? (2001) Tree Physiol., 21, pp. 19-26
38. Monteith, J.L., (1973) Principles of Environmental Physics, , Elsevier, New York
39. Murcia, C., Edge effects in fragmented forests: Implications for conservation (1995) TREE, 10, pp. 58-62
40. Neal, C., Robson, A.J., Bhardwaj, C.L., Conway, T., Jeffery, H.A., Neal, M., Ryland, G.P., Walls, J., Relationships between precipitation, stemflow and throughfall for a lowland beech plantation, Black Wood, Hampshire, southern England: Findings on interception at a forest edge and the effects of storm damage (1993) J. Hydrol., 146, pp. 221-233
41. Nobre, C.A., Sellers, P.J., Shukla, J., Amazonian deforestation and regional climate change (1991) J. Climate, 4, pp. 957-988
42. Polcher, J., Laval, K., The impact of African and Amazonian deforestation on tropical climate (1994) J. Hydrol., 155, pp. 389-405
43. Schaeffer, S.M., Williams, D.G., Goodrich, D.C., Transpiration of cottonwood/willow forest estimated from sap flux (2000) Agric. For. Meteorol., 105, pp. 257-270
44. Shukla, J., Nobre, C., Sellers, P.J., Amazon deforestation and climatic change (1990) Science, 247, pp. 1322-1325
45. Stewart, J.B., Engman, E.T., Feddes, R.A., Kerr, Y., (1996) Scaling up in Hydrology Using Remote Sensing, , Wiley, Chichester, UK
46. Turton, S.M., Freiburger, H.J., Edge and aspect effects on the microclimate of a small tropical forest remnant on the Atherton Tableland, northeastern Australia (1997) Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities, pp. 45-54. , Laurance, W.F., Bierregaard, R.O. Jr. (Eds.). University of Chicago Press, Chicago, USA
47. Veen, A.W.L., Hutjes, R.W.A., Klaassen, W., Kruijt, B., Lankreijer, H.J.M., Evaporative conditions across a grass-forest boundary: A comment on the strategy for regionalizing evaporation (1991) International Association of Hydrological Sciences Publication No. 204, 204. , Kienitz, G., et al. (Eds.), Hydrological Interactions Between Atmosphere, Soil and Vegetation. IAHS Press, Wallingford, UK
48. Veen, A.W.L., Klaassen, W., Kruijt, B., Hutjes, R.W.A., Forest edges and the soil-vegetation-atmosphere interaction at the landscape scale: The state of affairs (1996) Prog. Phys. Geogr., 20, pp. 292-310
49. Whitmore, T.C., Tropical forest disturbance, disappearance, and species loss (1997) Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities, , Laurance, W.F., Bierregaard, R.O. Jr. (Eds.). University of Chicago Press, Chicago, USA
50. Willschleger, S.D., Hanson, P.J., Todd, D.E., Transpiration from a multi-species deciduous forest as estimated by xylem sap flow techniques (2001) For. Ecol. Manage., 143, pp. 205-213
51. Wright, I.R., Gash, J.H.C., Da Rocha, H.R., Shuttleworth, W.J., Nobre, C.A., Maitelli, G.T., Zamparoni, C.A.G.P., Carvalho, P.R.A., Dry season micrometeorology of central Amazonian ranchland (1992) Q. J. R. Meteorol. Soc., 188, pp. 1083-1099
52. Xue, Y., Bastable, H.G., Dirmeyer, P.A., Seller, P.J., Sensitivity of simulated surface fluxes to changes in land surface

parameterizations - A study using ABRACOS data (1996) J. Appl. Meteorol., 35, pp. 386-400

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