# Validation of ASTER and MODIS Surface-temperature and Vegetation Products with Surface Flux Applications

Progress Report, June 20000

Stith T. Gower, John M. Norman, and George R. Diak
University of Wisconsin

Kenneth Davis
Pennsylvania State University
(formerly from University of Minnesota)

---

## Vegetation Parameters: Land cover, LAI and NPP

*Land Cover*

The three hundred plots were established successfully in 1998 and basic mensurational data (e.g. species, tree diameter) were recorded for each variable radius plot. We used the plot data and spatial statistics to derive a land cover map for the EOS validation region surrounding the tall tower (Figure 1). We are in the process of using the plot data and existing Landsat TM data and MODIS data to compare empirically derived land cover maps and remotely sensed land cover maps.

*Leaf Area Index (LAI)*

Leaf area index was estimated in 1999 using the direct approach of allometry and the optical approach involving seven Li-Cor LAI-2000 Plant Canopy Analyzers (Gower et al. 1999). The average LAI ranges from a low of < 1 for the grass ecosystem beneath the tall tower to 3.5 to 4.2 for the dominant forest types (Figure 2). LAI was highly variable within each of the forest cover types.

We used the spatial sampling design to examine spatial patterns of LAI for the tall tower region. Semi-variograms uncorrected for vegetation cover and corrected for vegetation cover for the tall tower region are presented in Figure 3. Spatial correlation of LAI occurs at the spatial scale of approximately 150 m, and the scale is slightly reduced if the LAI data are corrected for vegetation cover. We are currently in the processing of using soils data, specifically water holding capacity, to determine if these data can be used to further explain spatial patterns of LAI. These relationships can be extremely useful in understanding abiotic and biotic controls on LAI, and implications of scaling remotely sensed estimates of LAI to larger scales.

One objective of the proposed study was to further evaluate the potential of remote sensing to indirectly estimate leaf area index of forests in the Lake States region (Fassnacht et al. 1997). All of the analyses presented in Appendix 1 are based on Landsat TM5 imagery that most closely corresponds to field-based measurements of LAI. Normalized difference vegetation index (NDVI) was the best predictor of LAI for needle-leaf evergreen conifer forests and tasseled cap greenness was the best vegetation index for broad-leaf deciduous forests. Only study plots with homogeneous stands for a minimum of 3 x 3 pixels were included in the analysis; poorer relationships were observed when all plots were included, illustrating the difficulties of estimating LAI for heterogeneous landscapes.

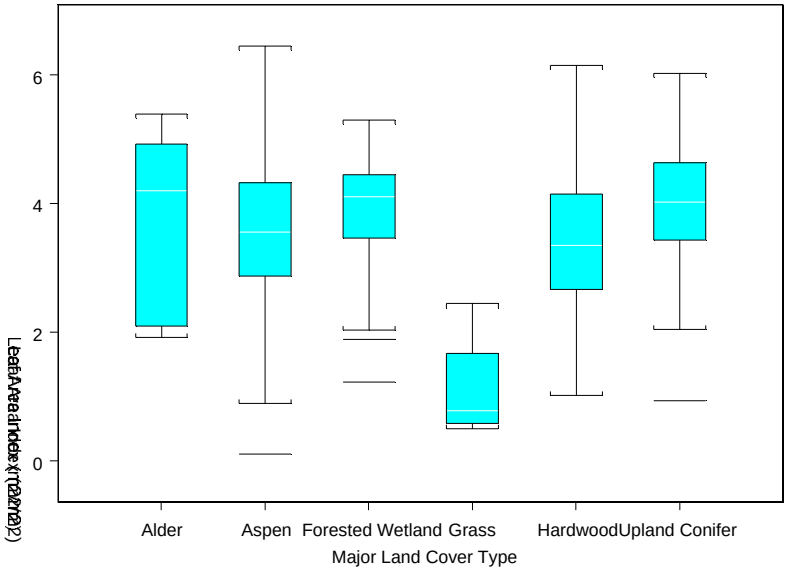



Figure 2. Average and + 1 standard error leaf area index for the dominant vegetation cover types for the Park Falls, Wisconsin EOS validation site. LAI values presented are based on the optical measurements using the Li-Cor LAI-2000 Plant Canopy Analyzer.

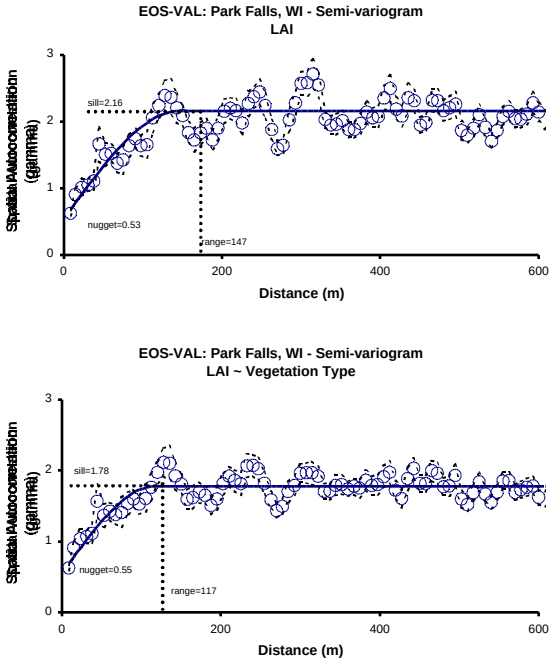



Figure 3. Leaf area index semi-variograms (a) uncorrected for vegetation cover and (b) corrected for vegetation cover. Accounting for vegetation cover reduced the spatial autocorrelation or range among study plots.

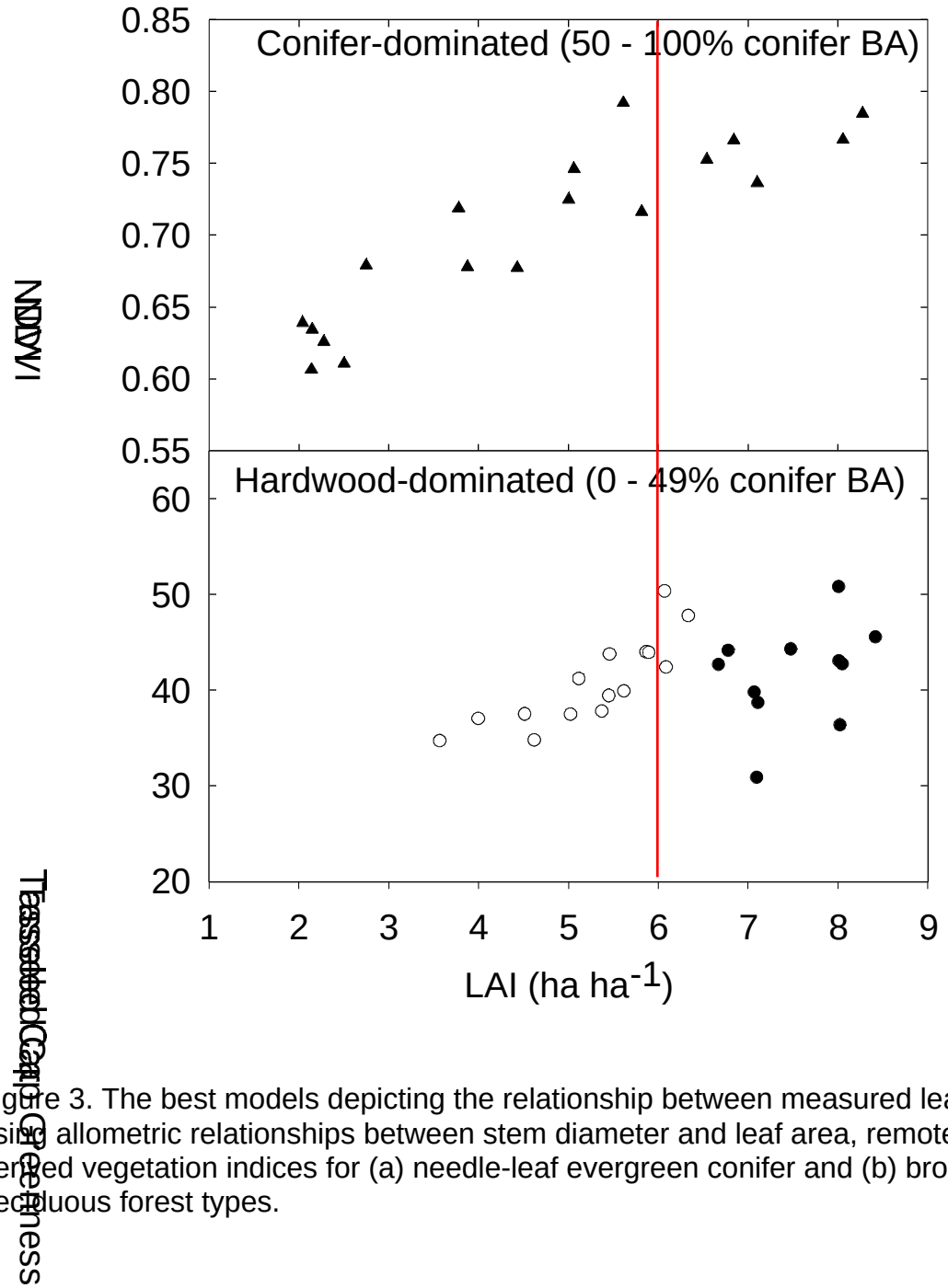



Figure 3. The best models depicting the relationship between measured leaf area index, using allometric relationships between stem diameter and leaf area, remotely sensed derived vegetation indices for (a) needle-leaf evergreen conifer and (b) broad-leaf deciduous forest types.

Aboveground Net Primary Production

Leaf litterfall, a proxy for foliage production, has been measured on a subset of plots for the past two years. Litterfall has been sorted by species, weighed, and we are in the process of analyzing the data. The second component of tree net primary production is woody increment, and requires accurate measurements of annual stemwood radial increment. Because of the delay in the TERRA launch, we delayed the comprehensive coring activity.

ANPP data for a subset of the EOS-VAL plots (Figure 1) and additional plots that include a broad range of forest types and stand structure have been collected and analyzed. Fassnacht et al. (1997) compared ANPP-LAI relationships for deciduous and conifer forests and suggested production efficiency (ANPP/LAI) was greater for deciduous than evergreen forests; however a strong conclusion could not be reached because of inadequate sampling of both forest types over the wide range leaf area. Based on a more comprehensive sampling scheme, the production efficiency (ANPP/LAI) was greater for deciduous than evergreen forests (Figure 5).

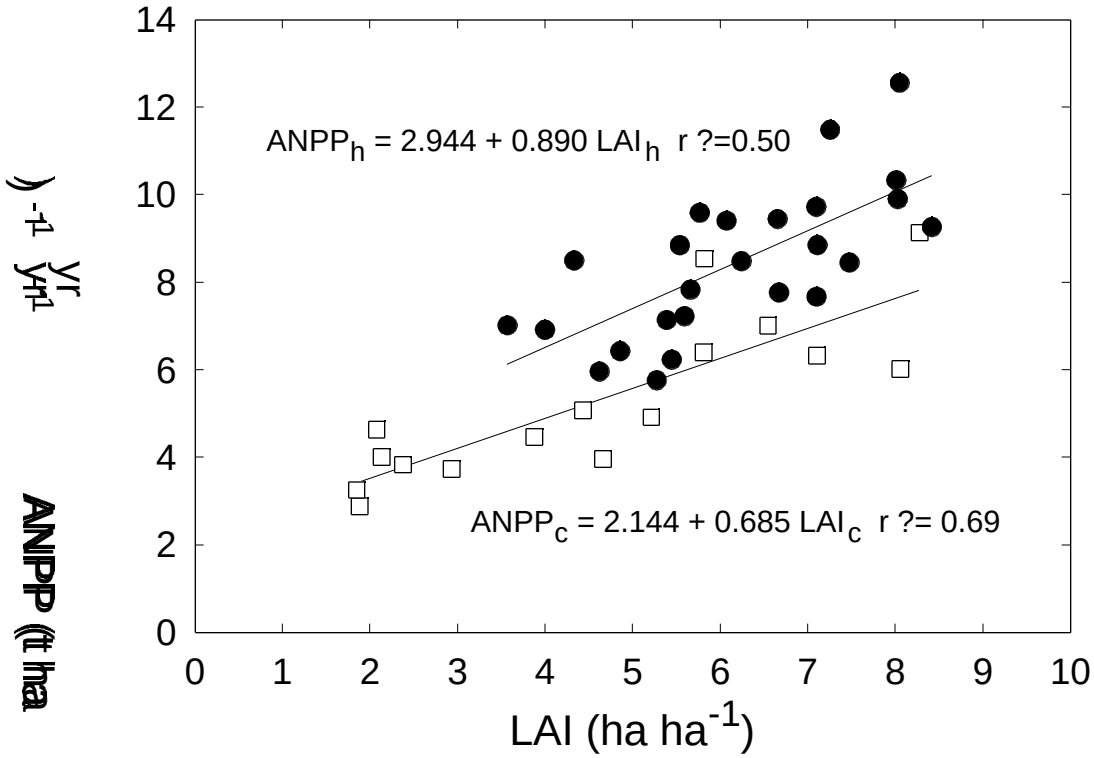
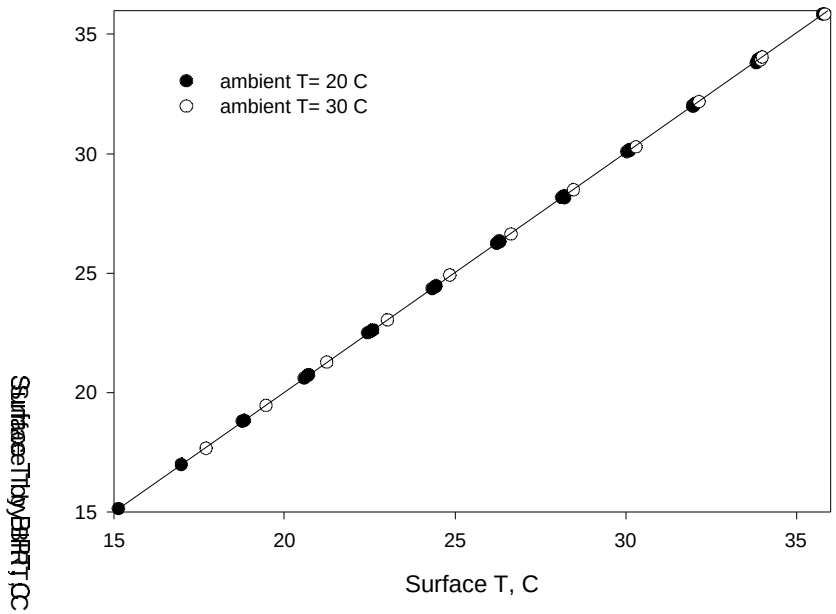



Figure 5. Relationship between aboveground net primary production (ANPP) and one-half total leaf area for broad-leaf deciduous hardwood (filled circles) and needle-leaf evergreen conifer forests (open squares).

**Vegetation Temperature**

Although we had designed an accurate differential infrared thermometer for mounting on the Tall Tower, it required a controller electronics board available from LICOR, Inc. that was designed for laboratory conditions and not the wide range of temperatures that the unit might experience year around on top of the tower. In addition, the unit was quite large, approaching a cubic foot in volume, and thus difficult to mount on the Tall Tower. Because of these issues we have embarked on a different design using a miniature Dexter, Inc. thermopile with our own control circuit that should work over the wide range of temperatures experienced on the Tall Tower. We have had a special software instruction created by Campbell Scientific, Inc. for the CR-23x data logger to operate a servo to move the thermopile detector between the target and the black body. We are in the final stages of construction of the null-balance infrared thermometer.




Calibration of Differential Infrared Thermometer (DIRT) against a black body under laboratory conditions showing an absolute accuracy that is better than 0.1C at two different ambient temperatures.

Without Terra last year, there was not a whole lot to do, however. We did make a couple of trial runs up to the tower with our infrared interferometer to get down the techniques for measuring the emissivity of the grass circle. We will also have to get a measurement of the black top road coming in and establish the proportion of the circle that it represents, and of course, of the ASTER data when they start coming in. Any indication of when we might expect to get this ASTER data would help us schedule the same interferometer

trips for this year. We expect to start in mid to late May, when there is green up and the snow is for sure gone and hope to catch both the green-up and senesence of the circle. This will be worked out in the next couple of weeks, hopefully with some info from you and Sean as to when these events occur. Other than that the reception facility here at SSEC is ready to suck down the appropriate data and level 1-b products for our comparisons. We've started gathering insolation data for the region and have modified the routine to produce PAR from the same GOES data base, which should be in operation by the time that we need it. You might check with JN about his progress with Minnesota in getting the tower radiometers mounted for temperature verification. In the next few weeks I will be acquiring some standard radiative transfer software to make the atmospheric corrections for these tower data, necessary even at the relatively modest 400-m height of the units.

**Data Archival and Collaboration with MODIS Scientists**

We have attended many of the MODIS readiness review meetings in D.C. over the past year and worked closely with Jeff Morisette on image acquisition issues. WE are particularly pleased to announce that all of the data collected to date have been processed and made available to the scientific community by placing it on the MERCURY system on the DACC at Oak Ridge National Laboratory, Oak Ridge, Tennessee. Current files include plot-level data for plot location, vegetation cover/ species composition, leaf area index, biomass, and basal area. In addition, we have encouraged other scientists working at the WLEF tall tower site in northern Wisconsin to place their data on the MERCURY system and most science teams have agreed to do so as well.

The PI’s and their respective students attended several national meetings in 1999 and presented preliminary results. Sean Burrows and Doug Ahl, two graduate students working with the EOS-VAL data but funded from different projects, made oral presentations at the 1999 AGU meetings in San Fransico, CA in December 1999.

Statement of Work in the Final Year

*Leaf Area Index*

Leaf area index will be measured three times (mid-June, late July, and early September) using the Li-Cor LAI-2000 Plant Canopy Analyzer. We will also estimate LAI of the overstory and understory using allometry and understory clip plots, respectively. Filed measurements will be correlated to various vegetation indices calculated from different sensors (ETM+, ATLAS, and possibly AVRIS). We are particularly interested in determining if the apparent sensor saturation problem observed for the broad-leaf deciduous forests (fig. X) can be improved upon using the new data sources.

*Aboveground Net Primary Production*

Trees have not been cored to estimate aboveground net primary production because of the delayed launch of TERRA. It is cost prohibitive to core the trees several times. Moreover, we feared that coring the trees multiple times may adversely affect the growth of the trees. Consequently, we will core all trees in

the fall of 2000 and we will use these data to back-calculate annual growth of trees for the entire funding period.

*Temperature*
The new null-balance IRT (NBIRT) should be ready for installing on the Tall Tower near the end of May, 2000. It will have a field of view of 25 degrees instead of the original 15 degrees (double angle) in order to maintain the output of the thermopile detector. The NBIRT should have an absolute accuracy of 0.1 C. The NBIRT will be installed at the 176-m height on the tower and view only the grass area near the tower. The ASTER sensor will be compared with the NBIRT on the grass area and then MODIS will be compared to ASTER in the surrounding forest to calibrate the MODIS thermal sensors.

**Presentations and Publications**

Gower, S.T., K.S. Fassnacht, D.G. Mladenoff, S.E. Burrows. 2000. Spatial patterns of leaf area index and aboveground net primary production of forests in northern Wisconsin. Remote Sensing of Environment (in preparation).

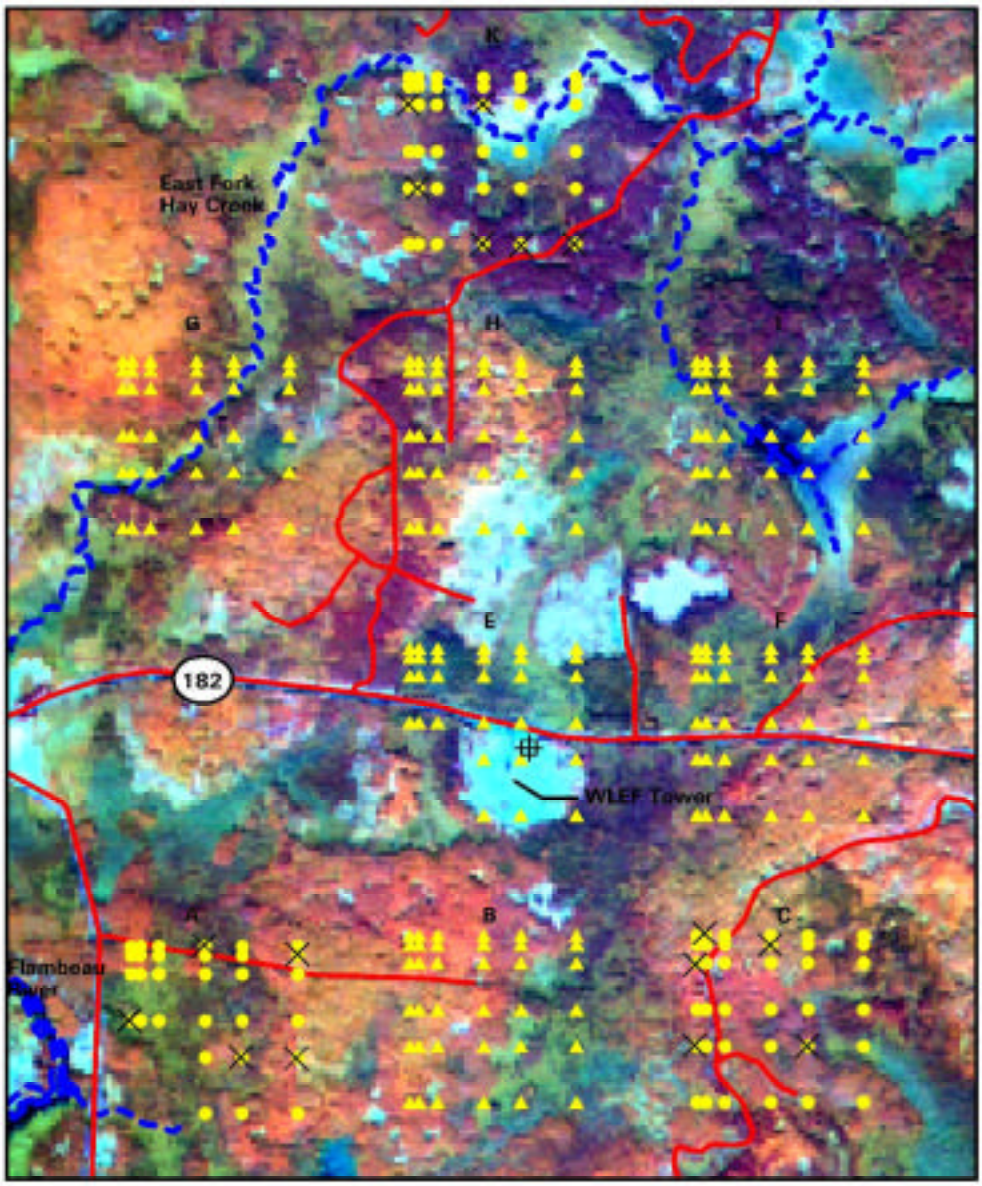
Burrows, S., S.T. Gower, and M. Clayton. Using spatial statistics to examine leaf area index spatial patterns in contrasting terrestrial ecosystems. Ecosystems (in preparation).

Ahl, D.E., S.N. Burrows, D.S. Mackay, and S.T. Gower (2000). Implementation of a sampling design in a forested environment using current satellite positioning technology. *Canadian Journal of Forest Research*. (Submitted).

Ahl, D.E., S.N. Burrows, D.S. Mackay, and S.T. Gower. (1999). Comparison of Statistical Methods Used to Derive LAI: Implications for Using Process Models. *American Geophysical Union Fall Meeting*, San Francisco, CA, December 13-17, 1999. Presentation

Ahl, D.E., D.S. Mackay, S. Burrows, and S.T. Gower. (1999). Remote Sensing, Sampling, and Ecological Modeling Techniques for Scaling Temperate Forest Ecosystem Processes. *Annual Meeting of American Society for Photogrammetry and Remote Sensing, Portland, Oregon.*

# EOS VALIDATION PARK FALLS, WI CORE SITE
# EQUIPMENT AND PLOT LOCATIONS
# UNIVERSITY OF WISCONSIN - MADISON





Contact:
Dr. Tom Gower 608-262-0532
stgower@facstaff.wisc.edu
Dept. of Forest Ecology and Management
120 Russell Laboratories
1630 Linden Drive
Madison, WI 53706


Scale
500 Meters 0

ATLAS 15m Imagery 9/10/98
NIR,MIR,Red-RGB

Streams
Roads
Plot Stakes
Plot Stakes with Litter Baskets
Root Tubes

GPS Survey Marker
45:56:45.16148N
90:16:20.29606W