EXPLORING THE REMOTE SENSING OF FOLIAR BIOCHEMICAL CONCENTRATIONS WITH AVIRIS DATA

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1. INTRODUCTION

AVIRIS data shows promise for the estimation of foliar biochemical concentrations at the scale of the canopy (Committee on Earth Science 1989, Wessman *et al.* 1988, Curran 1989). There are, however, several problems associated with the use of AVIRIS data in this way and these are detailed in a recent Plant Biochemical Workshop Report (Peterson 1991). The research reported here has concentrated upon three of these problems: field sampling of forest canopies, wet laboratory assay of foliar chemicals and the visualisation of AVIRIS data.

2. STUDY SITES

Two study sites were used in this research. The first is north east of Gainesville, Florida, is NSF funded and is maintained by the University of Florida (UF). This site is covered by a slash pine (*Pinus elliottii*) plantation and contains 8 fertilised and 8 control plots, each 50m x 50m in size. These were overflown by AVIRIS in March and September 1990, with multiple overpasses on each date (Curran *et al.* 1991). The second study site is around Llyn Brianne in Wales, UK. The upland site is covered by a Sitka spruce (*Picea sitchensis*) plantation with small areas of other plantation species (japanese larch, *Larix kaempferi*; lodgepole pine, *Pinus contorta var. latifolia*) and contains 51, 50m x 50m plots. These were overflown twice by AVIRIS in July 1991 as part of the NASA MAC Europe (Curran and Plummer 1992).

3. PROBLEMS

3.1. Field sampling of forest canopies

The five main stages were: choosing the study site, choosing the study plots, locating the plots, collecting forest mensuration data and finally sampling the foliage. These will be discussed in turn.

The two study sites have a history of environmental research. The site in Florida has a homogeneous canopy on a flat site and the site in Wales has a heterogeneous canopy on a rugged site.

The Florida study site contained established plots. At the Welsh study site the establishment of plots was made difficult by windthrow and drains. In addition, flat areas were seasonally waterlogged and suffered from large variations in tree growth over small distances. Collecting ground data in such

areas would mean sampling virtually every tree within the plot. Therefore, the range of plots chosen to represent relative levels of tree vigour were all on drained, slightly sloping land where neighbouring trees were similar. Sitka spruce plantations afford limited access to their interior and so a network of access paths had to be cut, by the removal of lower branches.

The Global Positioning System (GPS) was to be used to locate the plots. Unfortunately, hand-held systems when used within the forest could not pick up the signals from the GPS transmitters. Any future use of GPS for plot location within forest stands would require an external aerial that could be placed above the canopy. Classical surveying techniques were therefore used to locate the plots on both study sites.

UF collected forest mensuration data for each plot at the Florida study site (Gholz *et al.* 1991). During NASA MAC Europe, a wide range of forest mensuration data (diameter at breast height, leaf area index, tree height) were collected for each plot at the Welsh study site.

The open canopy and lack of low level branches at the Florida study site meant the canopy could be sampled by shooting small branches from the canopy which then fell to the ground. The Sitka spruce at the Welsh study site had a very dense canopy and retains its dead branches on lower whorls preventing sample branches from reaching the ground. Two methods were used to sample this canopy. At some points within the plots the lower dead branches from the tree were cleared until the live canopy was reached. A ladder and pruning pole were then used to remove the selected live branches from the canopy. At other points within the plots a tree was felled. Once the tree was horizontal hand pruners could be used to remove the required parts of the canopy. In total 539 foliage samples were collected, 384 for the study site in Florida and 155 from the study site in Wales.

3.2. Wet laboratory analysis of foliar chemicals

The sampled foliage was bagged by age class and frozen for return to the University College of Swansea (UCS). The samples were then analyzed using standard wet laboratory techniques for chlorophyll, moisture, lignin, cellulose, nitrogen and carbon, with replication. So far the chlorophyll and moisture analyses have been completed and these show statistically significant differences between the fertilised and control plots at the Florida site and the relative level of tree vigour at the Welsh site.

3.3. Visualisation of AVIRIS data

The Department of Geography at UCS was oriented towards the analysis of broad band remote sensing data and so initial analysis of the AVIRIS data cube was slow and relatively unproductive. This early processing was divided into two sections: spatial analysis and spectral analysis. The original data cube remained on a VAX 8820 and the required data were displayed spatially on a GEMS image processing system, running GEMSTONE software and spectrally on a 386PC, running in-house software. This separation of the data made it hard to link images and spectra together. Effective processing was achieved using SUN SPARC stations running PV-Wave software which is designed for the visualisation of multi-dimensional data sets. A set of routines is being

developed in the PV-Wave Command Language to perform the necessary processing associated with AVIRIS data.

4. FUTURE RESEARCH

The work described above continues in an effort to better understand the relationships between foliar biochemical concentrations and remotely sensed spectra. The NASA MAC Europe involved other sensors. Broad band multispectral scanners provide estimates of the foliar biomass and the AIRSAR provides estimates of the amount of wood within forest stands. These data sets will be integrated and applied to ecosystem simulation models to derive estimates of net primary productivity at a regional scale.

5. CONCLUSIONS

The remote sensing of foliar biochemical concentrations is an important contribution to the development of ecosystem models on regional to global scales. Field campaigns are vital if it is to be demonstrated that the AVIRIS can provide such information. This paper has emphasised the complexity of such campaigns, in particular the need for meticulous site preparation and a large number of foliar samples, backed up by the facilities necessary for wet laboratory assay and the visualisation of AVIRIS data.

6. REFERENCES

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