C      REMOTE SENSING/VEGETATION CLASSIFICATION

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## Hierarchical Linkage Model - CALVEG

Multi-level remote sensing is a cost effective tool for assessment of
our natural resource base. In order to most effectively utilize the
present and future tools of remote sensing technology, a hierarchical
classification system for identification of vegetation units is needed.
The CALVEG classification system has been developed, tested and deter-
mined to be an economically efficient tool for classification of both
existing and potential vegetation.

Once the Resource Manager has answered the basic questions concerning
what level of vegetation description is required, and how that level
of vegetation description can best be communicated to others concerned,
the appropriate level of classification is available in the CALVEG
classification model.

## Introduction

Remote sensing has been utilized in the western hemisphere since the
time of the Aztec civilization of eastern Mexico. Today, we have
certainly more sophisticated technology, however, prior to the utiliza-
tion of any remote sensing technology, a basic set of questions must
be answered.

- What entity are we trying to describe?
- What level of description is pertinent to our needs?
- How will the accuracy of the description be assessed?
- What level of accuracy of interpretation is acceptable?
- How can we best communicate to others the entity we wish
  to describe?

The CALVEG classification system - a classification system applicable
to both existing and potential vegetation - was developed upon the
aforementioned questions. This classification system is hierarchical,
thus responding to the requirements of classification and interpreta-
tion of vegetation at various levels of description, from site descrip-
tions (field application), to broad idientification levels (national
and international application). A major strength of the system is the
flexibility in application of remote sensing technology to assess, des-
cribe and communicate data relative to vegetative resource (See Figure 1).

# REMOTE SENSING

TECHNOLOGY

SATELLITE

HIGH ELEV PHOTO

LOW ELEV PHOTO

FIELD RECON

FORMATION CLASS

LEVELS

SUBFORMATION

OF

SERIES

CLASSIFICATION
INTERPRETATION

ASSOCIATION

NATIONAL

REGIONAL

LOCAL

PROJECT

MANAGEMENT NEEDS

CLASSIFICATION

GROUND LEVEL

Figure 1   Remote Sensing & Vegetation Classification (Linkage Model)

## Discussion

The CALVEG classification system is based on four levels of description. The system is aggregative, that is, the basic unit of description identifies a site specific vegetation community. All other levels of description are aggregates of this basic unit. The following describes these four levels and the application of each level to remote sensing technology for use by resource managers.

Association — The Association is the basic unit and the most detailed level of classification. This level of description identifies three separate vegetation strata and is site specific (on-the-ground). The three identified levels of vegetation stratum are: the tree overstory, shrub understory and herbaceous ground cover. Identification is based upon species dominance (canopy cover) within each stratum. Remote sensing technology can be useful in identification of Associations providing overstory canopy cover is less than 60%. This level of vegetation description is most applicable to field managers and specific resource projects that require on-site description of vegetation.

Series — The Series level of classification identifies the dominant species or group of species. This level of classification is an aggregate of Associations with identical overstory species and different understory species. Series are usually designated by a single dominant species (such as Ponderosa Pine or Greenleaf Manzanita). When two species codominate, a dual species designator is used (Redwood, Douglas Fir or Tanoak-Madrone Series). Remote sensing scales of 1:10,000 to 1:60,000, usually color or color IR photography are most applicable to this level of description. The Series level of classification is most applicable to resource managers planning 50,000 to 1,000,000 acres of land.

Subformation — Subformations are aggregates of physiognomically similar Series. As an example, three or four distinct shrub Series may be aggregated into a "Mixed Montane Shrub" Subformation. The publication "CALVEG - Mosaic of Existing Vegetation of California, 1979, describes existing vegetation based upon this level of description. Satellite imagery at the scales of 1:100,000 to 1:250,000 are most applicable to this level of vegetation identification and interpretation. Both visual interpretation methodology and computer assisted spectral analysis technology are applicable to this level of assessment. Subformations are most useful to resource managers at the statewide planning level.

Formation Class — This level of classification aggregates Subformations into units of similar physiognomy in the broad sense.

Eight Formation Classes have been identified:   Conifer Forest-
Woodland, Hardwood Forest/Woodland, Chaparral, Soft Chaparral,
Sagebrush Shrub, Desert Shrub, Dwarf Scrub (Alpine) and Herbaceous.
Remote sensing technology at scales of 1:250,000 to 1:1,000,000
are best suited for interpretation at this level.  This level of
classification is best suited for national/international classifi-
cation of vegetation.


A unique feature of the CALVEG classification system is the development
of "phases".  Phases are additional descriptors assigned to any of the
above 4 levels of classification.  Herein are identified the various age
classes, cover classes, or decadence classes within the existing hierarchy
of classification.  As an example, one might classify a sapling phase
within the Douglas Fir Series, or a moderately dense, overmature phase of
the Basin Sagebrush/Squirreltail Association.  A complete explanation of
phases and the use is contained in "CALVEG - A Classification of Californian
Vegetation, 1981.


## Application/Testing

The first application of the CALVEG system was development of a statewide
map and description of vegetation Series.  This endeavor was based on the
standard USGS 1:250,000 quad base (42 Quads) and utilized visual interpre-
tation of Landsat imagery of the same scale.  Approximately 125 Series
were mapped and described for the 102 million acres in California.  Ac-
curacy throughout this assessment was maintained at 80 - 90%.  This
accuracy was based upon approximately 10,000 miles of field verification
and referencing of current vegetation maps.  The effort required a total
of 4 months, including field verification time and cost approximately
$ 0.0040 per acre.  This cost equates to about 40¢ per one thousand acres
of land area.  This level of mapping is presently being used to determine
vegetation types within existing ranges of wildlife species on a statewide
basis.


A further application of the CALVEG system was development of a statewide
vegetation map at a scale of 1:1,000,000.  This application utilized the
Subformation level of classification, and was derived by aggregating the
previously developed, Series maps and vegetation descriptions.  Forty one
vegetation Subformations were identified, described and mapped.  A com-
posite of this mappin g endeavor was created and published.  This com-
posite map, with corresponding descriptions of each Subformation, is cur-
rently being used by many resource agencies throughout California as the
basis for statewide assessment of existing vegetation.  Agencies include
the US Forest Service, State of California - Department of Resources, and
the US Fish & Wildlife Service.

Response during the past year fully supports the conclusion that this type of hierarchical classification is fully responsive to application of remote sensing technology and requirements of resource managers.

## Economic Use of Remote Sensing Technology

Many applications of remote sensing technology are available. Maps have been compiled, reports developed and plans initiated based upon application of current remote sensing tools. One problem inherent to many of these remote sensing applications has become all too apparent - the lack of statistical verification of assessments utilizing remote sensing (Landsat) technology.

During this period of inflationary costs and reduced budget appropriations, remote sensing technology has found a viable place in economic assessment of natural resources. To fully utilize present and future remote sensing technology, and simultaneously verify any level of assessment, a multi-level strategy of assessment should be initiated. This proposed strategy encompasses two major concerns —

- Economy of assessment procedures
- Statistical verification (Data Elements Expand Capability) within the assessment.

This approach requires on-the-ground review of only a small percentage of the total area being assessed and achieves a considerable cost reduction over total field analysis.

## Summary

Multi-level remote sensing is a cost effective tool for assessment of our natural resource base. In order to most effectively utilize the present and future tools of remote sensing technology, a hierarchical classification system for identification of vegetation units is needed. The CALVEG classification system has been developed, tested and determined to be an economically efficient tool for classification of both existing and potential vegetation.

Once the Resource Manager has answered the basic questions concerning what level of vegetation description is required, and how that level of vegetation description can best be communicated to others concerned, the appropriate level of classification is available in the CALVEG classification model.

## References

1    CALVEG – A classification of Californian Vegetation, Regional
     Ecology Group, US Forest Service, Department of Agriculture,
     January 1981.

2    CALVEG – Mosaic of Existing Vegetation of California, 1979,
     Matyas, W.J. and Parker, I., Regional Ecology Group, Forest
     Service, US Department of Agriculture.