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**USES OF REMOTE SENSING IN FOREST  
PEST DAMAGE APPRAISAL:  
SUMMARY AND DISCUSSION**

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**ABSTRACT**

Presentations on the fundamentals of remote sensing interpretation for damage appraisal, the practical aspects of forest pest damage assessment, and information needs resulted in a well-rounded seminar. A synopsis of those presentations is provided. Additionally, a summation is presented of the major points and recommendations that arose from the presented papers and the discussion session.

**INTRODUCTION**

One of the 1981 project goals of the damage appraisal program at the Northern Forest Research Centre (NoFRC) was to assess the feasibility of using remote sensing techniques for forest pest detection and damage assessment. To assess this need, a seminar was organized on behalf of the Forest Insect and Disease Survey (FIDS) to acquire an information base from which to develop a program plan. The seminar was conducted in a logical sequence, starting with aspects of damage interpretation, followed by the success or failures of case studies, and ending with a description of informational requirements. The term damage as used here includes both dead and infected vegetation.

Three primary aspects of remote sensing were addressed by the seminar. These included the capabilities of remote sensing for the detection, assessment, monitoring, and mapping of pest conditions; the capability to identify damage-causing agents; and the concept of previsual detection and its use to acquire advance knowledge of pest conditions. It is the purpose of this paper to merge the major findings of the seminar.

**SYNOPSIS OF PRESENTATIONS**

Dr. P A. Murtha presented a paper on the theory of detection and analysis of vegetation stresses using aerial photographs. Among the important points mentioned were four associated subject areas an interpreter must be aware of in

interpreting vegetation stress from remote sensing data. In addition, in using remote sensing to assess damage it is necessary to understand not only the effects of stress on vegetation but also the film reactions to spectral reflectance changes in the vegetation caused by the stress.

A conceptual problem that was outlined and is supported by Fox (1978) is the use of the term previsual detection. This term is correct only when the interpreted symptom eventually becomes visible. Previsual detection implies that near-infrared changes are always followed by visual reflectance changes; however, alterations in the near-infrared are not necessarily followed by visual changes and, some previsual symptoms may never become visual because of vegetation recovery. Consequently, the term extra-visual detection is proposed (Murtha 1978, 1981).

A strong recommendation was that the scale and film type must be related to the objective of interpretation. There is a direct relation between the scale of the photo and the amount of detail available. For example, a small-scale photo affords a broad view of the terrain but is useless for interpreting damage on individual trees. A suggestion was also made to first identify the information that would be useful and then to develop keys or lists of what to look for. Additionally, use of interpretation keys such as that outlined by Murtha (1972) can be valuable.

The second presentation was by E. Winqvist and J.H. Vandenbrink of the Alberta Forest Service (AFS) on their experiences with color and color infrared photography for monitoring the mountain pine beetle (Dendroctonus ponderosae Hopkins) infestation in southern Alberta. A main concern has been to salvage as much of the beetle-killed timber as possible before it degrades and to reduce the fire hazard. They expressed a preference for color film because of the difficulty they had in distinguishing mountain pine beetle-infested stands from overmature white spruce (Picea glauca (Moench) Voss.) and balsam fir (Abies balsamea (L.) Mill.). Color film also permitted better shadow penetration in the mountainous areas, but there was a problem with haze penetration at the higher altitudes.

A.P. Jano of the Ontario Centre for Remote Sensing discussed the practical considerations of using remote sensing for forest pest damage assessment. The major benefits of using aerial photographs include an overview of large forested areas, a reduction of ground work, and a permanent record of forest conditions at a specific time. This permits monitoring and mapping by photo comparison if photos are acquired in successive years. Additionally, interpretation can be performed in a comfortable office with the benefits of three-dimensional viewing using a stereoscope.

For practical operational use, some criteria need to be developed to judge how and when to apply remote sensing for assessment. This is an important point, because the assessment objectives determine the informational requirements and therefore the appropriate remote sensing techniques. With regard to cost effectiveness, assuming aerial photography is used for both detection and mapping, Mr. Jano recommended prestratification using forest cover maps or

photos to identify areas that have a higher potential for damage. This would reduce the total amount of photo coverage otherwise required. He also emphasized that remote sensing is actually better suited for accurate mapping of known damaged areas than for detection of unsurveyed areas.

Two additional concerns that can affect the ease of remote sensing application are the equipment available for both photo acquisition and interpretation and the staff expertise. It is difficult to be committed to using remote sensing imagery if you cannot get a continuously high-quality product. This is especially true for color infrared film with its narrow exposure latitude. It was therefore recommended that a private firm be contracted to facilitate receiving good results.

Support was given to the critical selection of photo scale since it must be in relation to the detail that is required. It was also noted that, although aerial sketch mapping is fast and efficient, it is only good if the terrain features are easily related to the map or photo.

A discussion of the general information needs, functions, and pest problems of the Forest Insect and Disease Survey unit at NoFRC was given by Dr. B. Moody. Federal and provincial agencies require detection and monitoring of damage conditions for their pest management programs, and this information is primarily acquired through aerial surveys that may be augmented by ground surveys. Of particular importance is the regional contribution to the national overview of forest pest conditions. Annual reports such as those by Hiratsuka et al. (1981) and Sterner and Davidson (1981) are produced to describe current conditions and to provide predictions. The regional data currently consist of numbers of trees, areas affected, and volume loss estimates when available; however, the trend is for more-accurate estimates of volume loss for inventory purposes.

No presentation was made by the Pacific Forest Research Centre (PFRC), but a written contribution was provided briefly describing the current PFRC-FIDS program position. Planning is under way for expansion of the remote sensing damage appraisal program.

## DISCUSSION

### Role of Remote Sensing

An important point that was not emphasized at the seminar is that remote sensing is a tool with which to acquire information for some end purpose. As such, remote sensing must be viewed in terms of what it can and cannot provide. For example, several damage causing agents will result in the same morphological damage on a tree or forest stand. Does this mean that we rule out the use of remote sensing because we cannot readily identify the causal agent? I would like to think not. Using remote sensing could tell us that something is wrong and would provide some idea of the pattern of damage. It is, then, the essential use of other information--maps, photos, historical data, ground information, air-photo interpretation keys, and a priori knowledge--that will provide the basis for the identification of the causal agent.

### Aerial Sketch Mapping vs. Photography

Sketch mapping involves flying over preplanned flight lines with an aerial observer sketching the damaged areas onto maps. This is the principal technique used in the prairie region and in British Columbia (Harris and Dawson 1979). Two of the major problems are that accuracy is hard to assess and that single and small groups of trees are hard to distinguish. Furthermore, the success of aerial sketch mapping is highly dependent on the observer's abilities and experience (Harris and Dawson 1978). An additional problem for the aircraft observer is that there is little time for verification, except by recircling the area.

The use of aerial imagery is also not without problems. Knowledge and experience are required to specify the correct aerial photo parameters to facilitate successful acquisition of photography. Failure to specify optimum parameters can result in high interpretation error, loss of needed data, and inefficiency (Ciesla 1978). One of the major considerations is selection of the correct time of year during which to survey the damage-causing agent of interest. Additionally, the selection of photo scale and aerial film must be in relation to the information to be interpreted from the photos. In retrospect, the best approach appears to be a combination whereby aerial photos are used to supplement sketch mapping. Possibly, a double sampling scheme providing a means for correction could then be employed, with minimal ground sampling constituting the secondary sample. Murtha advocated aerial surveying for detection, not sketch mapping. He also encouraged the use of multistage sampling utilizing remote sensing techniques for the actual assessment. Along the same line, an excellent documentation of a double sampling approach utilizing aerial photographic techniques for estimating damage by insects is given by Wear *et al.* (1966). In summary, Safranyik *et al.* (1974) conclude that an efficient appraisal method based upon aerial photography and limited ground sampling can considerably reduce the cost of a survey and increase its precision.

### Interpretation and Identification of Damage

Photo interpretation of forest damage requires knowledge from several subject areas. One must also realize that an interpreter can only interpret symptoms or manifestations of damage (Murtha 1978). These manifestations are changes in morphology or physiology of the vegetation or a combination of both. A knowledge of the morphological and physiological characteristics of normal healthy plants and their alterations with stress is therefore essential to the proper understanding and interpretation of reflectance characteristics (Puritch 1981).

It is also critical that an interpreter have a knowledge of interpretation elements and know what to look for. Too often the emphasis has been on detecting changes in the color or tone of the vegetation alone. Here, the use of *a priori* knowledge in the interpretation process cannot be underemphasized. This is especially true if one of the objectives is to identify the possible causal agent(s).

There is a common misconception in expecting the capabilities of remote sensing to include the means for identifying the damage agent. This problem

would be compounded in stands of mixed conifers, where different mortality causing agents produce the same result (Ciesla 1978). One should remember that a dead tree is a dead tree, and even on the ground further analysis is often necessary to determine the cause. Here again, the use of a priori knowledge cannot be underemphasized.

### Survey

Greater significance needs to be placed on the intensity of a survey. Accuracy requirements and budgetary limitations play key roles in survey design. Most important is that different intensities of surveys are required for different information needs. Where appropriate, sampling and statistical considerations should be input variables in planning the survey.

Interest was expressed in performing surveys to acquire advance lead time for mountain pine beetle control. Dry foliage is highly reflective of near-infrared, however, and it is for this reason that bark beetle-infested trees are so difficult to interpret on aerial photographs before the foliage turns red brown (Murtha 1978). At this time, then, the best use of remote sensing may be limited to the monitoring and mapping of the infestations and in determining the pattern of damage. This is, of course, no small feat in itself. There are encouraging studies at the University of B.C. comparing optical density values of the images of healthy and attacked trees, which may warrant consideration for feasibility in an operationally oriented program. In the future, as more knowledge is obtained about the sequence of physiological changes that occur in the host tree after infestation it will be possible to focus remote sensing techniques more precisely on what to sense and when to sense it (Puritch 1981).

## CONCLUSIONS AND RECOMMENDATIONS

The theoretical and practical considerations of using remote sensing for forest pest damage appraisal were presented in the seminar, with the major points summarized in this paper. The need for qualification of terminology was outlined, with emphasis on uniform usage of the term previsual detection.

With regard to photo acquisition, it was stressed that selection of photo scale and film type must be in relation to the objective of the aerial survey. Knowledge of the terrain and photographic conditions is also valuable in facilitating achievement of the objectives of the photography. Prestratification is recommended to guide flight-line location for improved efficiency. Aerial photography was recommended as a supplement to an aerial sketch-mapping program. Murtha subsequently recommended the use of remote sensing wherever possible with surveys using traditional techniques.

Emphasis was placed on remote sensing as an information tool, and that information could best be derived with the essential use of a priori knowledge in photo interpretation. Additionally, one must be familiar with the elements of interpretation and know what to look for on an aerial photograph. As well, interpretation requires a knowledge of host plants and the effects of stress.

Greater care in survey planning is also recommended, particularly if statistical procedures are to be employed. One final note is to encourage literature searches and/or use of a bibliography such as that by Henniger and Hildebrandt (1980), as they can be of tremendous value in the preparatory stages of a project when developing methodology.

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