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An economic analysis of the use of satellite imagery in mapping tree cover across Victoria

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The objective in this paper is to identify and quantify some of the current and potential social benefits from using Landsat TM based tree cover data sets to make natural resource management decisions. In most cases these benefits were able to be identified. In some cases benefits could be quantified on the basis of cost savings. From these cost savings it was found that the use of the data sets would accrue a positive net benefit to society.

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ABARE project 30.008

Introduction

Concern over the extent of land clearing in Victoria dates back many years. Woodgate and Black (1988) estimated that between 1869 and 1987 tree cover over the state of Victoria declined from at least 20 million hectares (88 per cent of the state) to 8 million hectares (35 per cent of the state). Tree cover was defined in that study as 'all woody vegetation with a height greater than two metres and a density (foliar cover) greater than ten per cent'. Therefore, the range of vegetation identified included sparse tall shrublands through to tall closed forests, native and non-native, including orchards, urban parks and mallee shrublands.

The Government of Victoria (1987) identified tree cover loss on privately owned land as being an issue of particular concern. Scientists believe that the loss of approximately 12 million hectares of tree cover has contributed to the land degradation problems prevalent in the state at the moment (Office of the Commissioner for the Environment 1991). These problems include wind and water erosion, dryland and irrigation salinity and various other forms of environmental problems such as loss of habitats and biodiversity. However, this is not to deny that much of the state's economic development has depended on the clearing and use of its timber resource and resultant use of the land for agriculture.

While assessments of forest cover can readily be obtained by aerial photography on a regional basis, the cost of obtaining this information on the status of tree cover statewide was prohibitive prior to the mapping project outlined in this paper. Ground census was not a feasible alternative because of the excessive cost involved, while ground sampling was not acceptable because of the need to monitor the change in vegetation for specific locations anywhere in Victoria. Satellite imagery was identified as potentially useful for mapping the current status of tree cover in Victoria and also for monitoring change in tree cover over time.

The objective in this paper is to identify and quantify some of the current and potential social benefits from using Landsat Thematic Mapper (TM) based tree cover data sets to make natural resource management decisions.

The Australian Space Office has funded this economic research because it is interested in the return to society that investment in remote sensing is making.

Tree cover mapping

To coordinate and re-establish tree cover across the state the Tree Victoria program was established within the Department of Conservation and Natural Resources (DCNR) in 1989. Part of its objective was to map tree cover for the state to provide baseline information as at the commencement of clearing controls in late 1989. In particular, a project was established, through the Remote Sensing Section of the DCNR, to achieve this goal. The ensuing data set of tree cover in Victoria for 1990 was based on Landsat TM imagery and was completed in late 1992.

The objectives of the Goodson, Gilbee, Choma and Frazier (1992) study, which established the data set, were as follows:

- to develop a largely computer controlled mapping technique that could routinely generate accurate digital information on the location and extent of tree cover across Victoria for the purposes of tree cover monitoring;
- to provide baseline data sets of actual tree cover as at summer 1989-90 with a minimum mapped area of one hectare, and incorporate these data sets into DCNR's corporate Geographical Information System (GIS); and
- to produce area statements of summer 1989-90 tree cover, by land tenure.

Algorithms were developed in order to identify areas of tree cover greater than one hectare. The results are presented in the draft report (Goodson et al. 1992).

The final output comprised 126 individual 1:100 000 map sheet files. The amalgamation of these in a digital form has become known as the 1990 tree cover data set. Work is currently underway to produce a subsequent data set, hereafter called the 1993 data set, and also a tree cover difference data set which will identify tree cover changes between the two mapping periods.

These data sets contain information on the presence and absence of tree cover on both private and public land. They also contain major roads, waterways and regional boundaries.

A benefit-cost evaluation

A review of the available literature both within Australia and internationally revealed that there appears to have been no economic analyses of projects which have used satellite remote sensing to map forest cover. Similarly, ABARE is not aware of any comprehensive economic analyses of other remote sensing applications in general.

There have been a number of partial economic assessments of remote sensing applications. These have been mainly costings and/or cost comparisons of particular applications. There have also been some qualitative type assessments of the nature of benefits accruing to applications but there have been very few attempts to quantify these benefits.

The evaluation criterion used to assess the social value of the application was net present value:

$$(1) \quad \text{Net present value} = \sum_{t=0}^T [B_t - C_t] / (1+r)^t$$

where:

B_t = benefits in year t in real terms

C_t = costs in year t in real terms

T = number of years being discounted

r = the real annual discount rate.

The benefit-cost ratio was used as an additional evaluation criterion:

$$(2) \quad \text{Benefit-cost ratio} = \frac{\sum_{t=0}^T B_t / (1+r)^t}{\sum_{t=0}^T C_t / (1+r)^t}$$

where:

B_t = benefits in year t in real terms

C_t = costs in year t in real terms

T = number of years being discounted

r = the real discount rate.

The time frame chosen for the study was ten years. The costs incurred for the creation of the 1990 and 1993 data sets and the benefits related to one full cycle of monitoring are assumed to occur over this period. This time profile was also used because the mapping technique using Landsat TM data is likely to be superseded due to developments in satellite

and computer technology that are likely to occur within the next decade. However, any subsequent processing techniques are likely to be compatible with current technology.

The real discount rate used in the study was set at 8 per cent as recommended by the Victorian Treasury for project appraisals in that state. The Victorian Treasury has estimated that an 8 per cent rate presently represents the margin above the real cost of debt to the Victorian government but does not incorporate risk premiums which require separate considerations and which are inherent in all capital commitments (Department of the Treasury 1993).

Costs of tree mapping using Landsat TM

The costs involved in mapping tree cover using Landsat TM data were collected in close consultation with the DCNR officers administering the project. The costs were validated and confirmed by the DCNR to be accurate representations of the actual costs incurred for the 1990 Landsat TM based data set and of those expected to be incurred for the 1993 Landsat TM based and tree cover change data sets.

Only the direct costs of mapping tree cover such as data processing and the cost of purchasing the satellite imagery were measured. No attempt was made to measure the real cost to the United States government, the owners of the Landsat satellite, of providing that information. This type of measurement was deemed to be outside the scope of the study.

The costs incurred in tree mapping were either capital or recurrent in nature. Capital expenditure was defined as expenditure on items that provided services over more than one year and was incurred for the equipment required for data set production and for the required floor space of the tree mapping project. Recurrent expenditure was defined as expenditure that varied from year to year and included costs which were incurred in conjunction with using the capital items. For example, these were the purchasing of data, the staff resources required to undertake data set production, and for materials, administration, energy, postage and telephone.

The 1990 Landsat TM based tree cover data set was created during the period 1990-91 to 1992-93, while the 1993 Landsat TM based data set is being created during 1993-94. Therefore, the 1990 Landsat TM based data set took approximately 27 months to complete while the 1993 data set is expected to take only 12 months to complete. The 1993 data set will comprise a tree cover difference data set that will highlight any tree cover lost since

the 1990 mapping exercise. From this tree cover data set it will also be possible to create a revised 1990 tree cover data set and a 1993 data set.

To simplify the analysis it was assumed that both the 1990 and 1993 Landsat TM based data sets were commenced at the beginning of the 1990-91 and 1993-94 financial years respectively. Hence, the 1990 Landsat TM based data set was assumed to be completed in October 1992, while the 1993 Landsat TM based data set was assumed to be completed in June 1994.

The steps involved in mapping tree cover using Landsat TM data are by nature complex, involving the use of various computerised data processing procedures. Broadly these procedures are: image analysis, processing of data within the DCNR corporate GIS, ground truthing of results against information obtained from field surveys and aerial photographs, and final production of data sets.

An important difference between the 1990 and 1993 mapping procedure is that the DCNR will be using more advanced computing equipment and software in the 1993 data set, allowing faster processing of information. These technological advances have contributed, in part, to revisions to the actual mapping procedures, leading to many data processing steps that were included in the 1990 Landsat TM based data set to be either integrated processes or no longer necessary for the 1993 Landsat TM based data set.

A summary of the costs of producing the Landsat TM based data sets over the life of the project are contained in table 1.

The costs in each of the years of production were converted to 1990-91 dollars by the consumer price index (CPI) as recorded by the Australian Bureau of Statistics (ABS) for 1990-91 and 1991-92 and estimated by ABARE for 1992-93 to 1993-94. The indexed costs are shown in table 1.

The present value based on a real discount rate of 8 per cent for the indexed cost profile in table 1 was about \$394 000.

Benefits of tree mapping

There are many users and uses of the Landsat TM based tree cover data sets. Only the four principal uses and users, as shown in table 2, are described in this paper.

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Table 1: Summary of costs for the Landsat TM based data sets

	1990-91	1991-92	1992-93	1993-94
Capital expenditure	\$	\$	\$	\$
Equipment and building space requirements	60 110	11 491	3 049	35 371
Recurrent expenditure				
Data acquisition	23 135	24 875	47 200	0
Data processing	38 248	41 292	11 512	37 587
Ground truthing	6 387	6 714	1 839	17 108
Project materials	4 356	4 396	1 099	5 396
Administration costs of project	17 436	17 714	4 493	17 773
Energy	1 081	1 175	294	1 269
Post and phone	594	694	174	732
Total costs	151 347	108 351	69 660	115 236
ABARE index	100	101.8	103.1	106.3
Indexed costs 1990	151 347	106 435	67 565	108 406
Discounted indexed costs	151 347	98 551	57 926	86 056
Present value of indexed costs in 1990-91 dollars	393 880			

Following is an individual background and description for each of the uses in table 2 and a discussion of the valuation of that use. In some instances it was possible to provide surrogates or proxies for the benefits. In other situations it was only feasible to determine the possible nature of benefits.

Where this technology replaced another means of collecting the information, the benefits were in the form of potential cost savings and any additional benefits, such as improved accuracy. The fact that the 1990 tree cover data set is barely operational and the 1993 and tree cover change data sets were not completed at the time of writing this paper complicated the valuation process.

Table 2: Selected uses and users of Landsat TM based tree cover data sets

Use	User
• Input into old growth forests project	DCNR - Remote Sensing Section
• Input into bush fire management	Country Fire Authority
• Monitoring tree cover change	DCNR - Office of the Environment
• Monitoring vegetation	DCNR - Tree Victoria

Old growth forests project

Background and description

In 1992, the Remote Sensing Section of the DCNR received funding from the Department of Primary Industries and Energy for a project titled 'Classification and assessment of old growth forests in the East Gippsland Forest Management Area'. This became known as the old growth forests project. The aim was to construct an objective and scientifically credible set of map based data describing the characteristics and values of the range and age classes of forests in East Gippsland with a major focus on the older age classes.

The old growth forest project essentially involves the manual interpretation of aerial photographs of regions where old growth forests are present to provide area maps of old growth. Old growth forests may be defined subjectively on the basis of fulfilling several criteria. These include location, growth stage of forest, fire history, presence of forest diseases and previous logging history. The fulfilment of all these criteria can best be determined through visually interpreting aerial photographs and researching historic records. In East Gippsland it is estimated that there are about 7 million cubic metres of sawlogs and about 29 million cubic metres of pulpwood in old growth forest areas (Streeting and Hamilton 1991).

Currently the old growth forests of East Gippsland and the Central Highlands are being mapped. It is also planned to map the Central Gippsland, North East and Colac Regions over coming years. Each region can take up to several person years to complete.

Identifying and valuing associated benefits

The main benefit of using the 1990 tree cover data set is that it reduces the time required to map old growth areas. The tree cover information contained in the data set allows for the targeting of aerial photographs which require interpretation

One option to value the benefit was to determine how much more it may have cost to complete the old growth forest project for East Gippsland in the absence of the 1990 tree cover data set. The original application to the Department of Primary Industries and Energy for funding for the area was \$325 000 based on the expectation that the tree cover data set would be used. The costings in the application were then reworked assuming that the data set was not available. Under this scenario the funding required was estimated to be 5 per cent higher at \$341 250 (Peter Woodgate, DCNR, personal communication, 1993).

This implies that the use of the tree cover data set may have provided a \$16 250 saving in costs.

If East Gippsland is a representative region and each of the other four Forest Management Area's receive funding (not necessarily all by the Commonwealth), the discounted net benefit accruing to the use of the tree cover data sets could be in the order of \$60 075. This is assuming that one area is completed each year from 1993-94 to 1996-97 and the cost savings accruing from using tree cover data sets for these regions are similar to those for East Gippsland.

There are potential social benefits accruing from protecting old growth forests, and the associated conservation of biodiversity. However, the amount of the benefit of preserving this resource directly attributable to the tree cover data set would be difficult to estimate with any degree of accuracy.

Bushfire management

Background and description

Bushfires throughout Australia are a major source of risk to lives and property. For example, the Ash Wednesday bushfires on 16 February 1983 burnt over 335 000 ha of land, claimed 73 lives and caused property losses estimated at \$450 million (Cheney 1993). This damage occurred in a period of less than 12 hours.

The Country Fire Authority of Victoria is responsible for the prevention and suppression of fire and the provision of rescue services to the people of rural Victoria in the event of fire. Under the Country Fire Authority Act of 1958, the agency is obliged to make decisions related to fire prevention and suppression based on the best information available and to provide the best possible advice to rural Victorians in bushfire prone areas (Garvey, Stephenson and Whelan 1992).

In recent years the Authority has adopted GIS technology and related models to improve its bushfire management capability. The overall GIS system used by the Authority is known as the Operation Management System which can model and predict the likely impact of fire. This system can also facilitate the effective planning and responses to bushfires by the Authority to minimise the loss of life and property.

Within the Operation Management System there are four principal system components. These are the Remote Automatic Weather Station System, the curing index for crops and pastures, the Dynamic Fire Spread model, and bushfire threat mapping components (Garvey et al. 1992). The 1990 tree cover data set is an input into the curing index system.

Identifying and valuing associated benefits

Timely and more accurate information (including tree cover information) has the potential to improve management decisions. Improved bushfire management decisions, both tactically in the field and strategically in planning centres, have the potential to save lives and minimise damage to property.

In 1983 the Ash Wednesday bushfires destroyed \$9.8 million an hour per fire on average (Mark Garvey, personal communication, 1993). If the tree cover data set could contribute to the more efficient control of bushfires then there are benefits which are attributable to the data set. For example, better information may have reduced the damage estimate from the Ash Wednesday bushfires to a figure somewhat below the \$450 million as stated by Cheney (1993). Unfortunately, there is no information on the value of potential savings available and the potential benefits cannot be apportioned directly to the use of tree cover data sets. The tree cover information is just one small segment/input into an intricate system of bushfire management systems and decision making processes.

The most direct use of the tree cover data set will be in the delineation of tree cover and grasslands/cropping areas. The 1990 tree cover data set and subsequent updates will provide more accurate delineation of these areas than the previous data set (Mark Garvey, personal communication, 1993). It is important that tree cover be excluded from a curing index rating because this index is designed to measure fire fuel status of grassland and is not relevant for areas of tree cover (Barber 1992).

Strategic monitoring of tree cover change

Background and description

Perhaps the most important use of tree cover mapping is the role that the tree cover data sets will play in monitoring tree cover change. This potential monitoring role was one of the principal reasons for the mapping project being originally undertaken. Consequently, the DCNR – Office of the Environment were the major sponsors of the original project and are continuing with significant financial support.

The DCNR has information on the applications for permit clearing since the introduction of clearing controls in late 1989. However, it is perceived that there also is a certain amount of illegal (non-permit) clearing taking place as well as those with permits failing to clear. The DCNR requires a relatively inexpensive, accurate and readily repeatable means of monitoring the change in statewide tree cover over time. The tree cover data sets have the potential to provide this information under the given constraints.

The 1990 tree cover data set provides the baseline data on tree cover as at the introduction of the tree clearing controls in 1989. Production of a 1993 tree cover data set and the subsequent identification of changes in tree cover has the potential to provide the DCNR with key information required for strategic monitoring of tree cover changes over time, and consequently measure the effectiveness of current approaches to native vegetation retention as well as providing a basis for assessing alternative approaches.

Identifying and valuing associated benefits

The tree cover data sets and associated tree cover change data set provide the initial targeting and monitoring upon which the DCNR can take appropriate action.

Tree cover data sets have the potential (especially when combined with on the ground information) to provide information on the following issues relevant to DCNR.

- Determining whether or not clearing is taking place within the prescribed time after permits have been issued.
- The extent of illegal clearing.
- The amount of revegetation taking place. This could be where clearing had occurred but the area has since been left to revegetate.

Monitoring of vegetation cover change will allow appropriate advice to be presented to the government and will facilitate the targeted allocation of resources for education, replanting and habitat protection effort to those areas of greatest need and where greatest benefit will result.

The Victorian government is currently developing draft Catchment and Land Protection Legislation. Monitoring of change and the setting of clear statewide and regional targets

will be an essential requirement in formulating effective integrated catchment management arrangements in Victoria.

Details of the actual valuation of monitoring tree cover change is presented in the following section in conjunction with information on the valuation of monitoring revegetation.

Strategic monitoring of revegetation

Background and description

While the Office of the Environment is primarily interested in monitoring tree cover which is being lost, Tree Victoria is interested in determining where tree cover is being restored, especially on private land.

Tree Victoria is the state agency, established in 1989, principally involved with revegetation. Its goal is to plant 100 million trees by the year 2010 (Department of Conservation and Environment 1990). It coordinates work with other government bodies undertaking revegetation (such as the Victorian Roads Department) and also works closely with Landcare.

Tree Victoria is mainly interested in tree cover changes since 1990. Therefore, the tree cover change data set of 1993 will be particularly relevant. This highlights the strategic nature of the potential use of the tree cover data sets by Tree Victoria. Tree Victoria has a mandate to monitor areas of revegetation on a statewide basis and it is proposed to do this via remote sensing (Department of Conservation and Environment 1990).

This use is very similar to monitoring tree cover losses as outlined in the previous subsection. However, there are some interesting differences as compared with the former application which relate mainly to the definition of tree cover. Because of the definition of tree cover, it can take up to eight years for revegetation to appear as tree cover on the data sets. Therefore, the 1993 data set may only be able to identify areas of revegetation planted pre-1985. This lag has implications for the use of the tree cover data sets by Tree Victoria. As with most other cases, it would have to be linked in with other sources of information to maximise its effectiveness.

The major use for the tree cover data sets will be in monitoring the amount of revegetation occurring on private land. This will be especially important for monitoring tree planting

outside the auspices of Tree Victoria. Production of the 1993 tree cover data set and identification of areas of revegetation will be able to supplement various surveys of revegetation which have taken place (for example, the Natural Resources Conservation League recently surveyed revegetation in Victoria).

An example of what could happen once the 1993 change data set is completed is as follows. Tree Victoria may be able to identify areas of revegetation which it or other agencies have funded on public and private land. It may also be possible to identify areas where tree planting has occurred on private land without public funding and of which Tree Victoria was not previously aware. This information could provide the basis for reallocating education, extension, and revegetation funds in order to maximise efficiency in a manner similar to that outlined for the tree permit monitoring system.

Identifying and valuing associated benefits

Directly valuing the benefits which will potentially accrue from strategic monitoring is not possible. Hence, in order to obtain some indication as to the possible extent of benefits accruing to groups like Tree Victoria and the Office of the Environment, it is necessary to undertake less direct means of valuation.

One way of valuing the benefit of using Landsat TM imagery for producing tree cover data sets is based on the concept of opportunity cost. This involves assessing the cost of the next best alternative which in this case was aerial photography. This assumes that willingness to pay is at least equal to the cost of the next best alternative. A comprehensive assessment of using aerial photography has been estimated to cost \$2 564 947 (ABARE work in progress)

Therefore, the benefit of not having had to use aerial photography is the difference between the costs of that and using Landsat TM. This benefit equates to \$2 171 067. The actual cost incurred by the funding organisations, Tree Victoria and Office of the Environment, (\$343 050) of supporting the project is subtracted from this figure to obtain a resultant net benefit of \$1 828 017. This is one way of attempting to value the benefit to organisations which use the tree cover data sets.

Results and conclusions

This project did not set out to assess the merits of revegetation programs or the permit system. The decision to create a tree cover data set for Victoria had already been made at

a political level. Hence, this project has only determined that there are net benefits to the funding agencies in undertaking to create a tree cover data set using Landsat TM data.

Table 3 gives a summary of the benefits identified as accruing to the funding agencies for the old growth forest project and from using the data set for strategic monitoring. The combination of these benefits at a real discount rate of 8 per cent is estimated to be about \$1.89 million

Despite only valuing benefits from a few applications and being in the early stages of its development, using Landsat TM tree cover data sets has a positive net present value of around \$1.49 million and a benefit-cost ratio of 4.79 at a discount rate of 8 per cent. The key assumption made in the study was that the cost savings realised through the use of satellite imagery versus the next best technology yields a direct benefit to society. On this basis the use of the data sets appear to have a substantial net positive benefit to society.

Sensitivity tests were carried out on key parameters such as the discount rate, and major costs and benefits. For example, from table 3, alternative discount rates of 4 per cent and 12 per cent were used. From the magnitude of the net present values and the benefit cost ratios, these values were insensitive to changes in the main parameters.

Only the four main uses of the data sets were identified and described in this paper. There are many other current and potential uses of the tree cover data sets but an analysis of these was outside the scope of this paper.

Table 3 Summary of results

	Discount rate		
	4%	8%	12%
Present value of benefits of data sets	\$	\$	\$
Old growth forest project	69 560	60 075	52 301
Strategic monitoring	2 003 093	1 828 017	1 677 166
Total	2 073 553	1 888 092	1 729 467
Present value of costs of data sets	412 528	393 880	377 402
Net present value	1 661 025	1 494 212	1 352 065
Benefit-cost ratio	5.03	4.79	4.58

No attempt was made to value the benefits accruing from other uses of the Landsat TM imagery acquired for the tree cover project. These uses were identified as being potentially important and therefore could influence the opportunity cost proxy which was used to value the use of the tree cover data sets for strategic monitoring. Similarly, no attempt was made at valuing alternative uses of the mapping technique which has been developed and is highly likely to be a major input into other mapping applications such as that for the Murray-Darling Basin vegetation mapping exercise (Ritman 1993).

If it was possible to value these and other uses it is highly likely that the net present value and benefit-cost ratios would be significantly more favourable. One of the main reasons the valuation of the tree cover data sets was so difficult was the fact that the data sets are only an intermediate good and therefore an input into other decision making systems. As methods of valuing environmental and information resources are improved and refined, it may be possible to provide more accurate estimates of the value of tree cover data sets and similar goods. It may also be possible to provide a more comprehensive assessment of the uses and users of these data sets in the future as use of the tree cover data set expands.

References

- Barber, J. 1992, 'Monitoring grassland fire fuels with satellites', *Agricultural Science: the Journal of the Australian Institute of Agricultural Science*, vol. 5, no. 1, January, pp. 44-7.
- Cheney, P. 1993, 'Future blazes may be far worse', *Weekend Australian*, 13-14 February, p. 6.
- Department of Conservation and Environment 1990, *Tree Victoria Action Plan*, Land Protection Division, Melbourne, August.
- Department of the Treasury 1993, *Project Appraisal Guidelines (draft)*, Melbourne, April.
- Garvey, M., Stephenson, K. and Whelan, M. 1992, *The Use of Geographic Information Systems at the Country Fire Authority*, Country Fire Authority of Victoria, Fire Management Department, Melbourne.
- Goodson, P., Gilbee, A., Choma, A. and Frazier, P. 1992, *Tree Cover Mapping in Victoria A New Data Set for Monitoring Change (draft)*, Remote Sensing Section, Natural

Resources Systems Branch, Department of Conservation and Environment, Melbourne, September.

Government of Victoria 1987, *Protecting the Environment: A Conservation Strategy for Victoria*, VGPO, Melbourne.

Office of the Commissioner for the Environment 1991, *Agriculture and Victoria's Environment*, 1991 State of the Environment Report, Melbourne.

Ritman, K. 1993. Basincare: mapping vegetation in the Murray Darling Basin with Landsat TM, Paper presented at the Advanced Remote Sensing Conference, Sydney, 19-23 July.

Streeting, M. and Hamilton, C. 1991, *An Economic Analysis of the Forests of South-Eastern Australia*, Resource Assessment Commission Research Paper no. 5, Canberra, December.

Tree Victoria 1993, *Value of Native Vegetation Controls and Landsat Monitoring*, Land Protection Division, Department of Conservation and Environment, Melbourne.

Woodgate, P. and Black, P. 1988, *Forest Cover Changes in Victoria 1869-1987: A Report and Map Describing the Extent of Forest Cover in Victoria in 1987, the Change in Forest Cover since 1869, and the Change in Forest Cover over the Period 1972-1987*, Remote Sensing Group, Lands and Forests Division, Department of Conservation, Forests and Lands, Melbourne, October.