Big Brother and The Law of the Land: The Role of Satellite Surveillance and GIS in the Regulation of Land Clearance

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ABSTRACT

Land clearance regulations aim to reduce the loss of native vegetation and therefore also reduce land degradation, the enhanced greenhouse effect and threats to biodiversity. An assessment of the success of such laws is long overdue, if the aims of the regulations are to be ultimately achieved. Insufficient monitoring and enforcement are problems frequently encountered in the regulatory field in general, perhaps because of administrative reluctance to interfere with behaviour which is otherwise beneficial (such as clearance for agriculture) and electorally sensitive. Remote sensing is presently employed in the monitoring of land cover change for data collection purposes but is under-utilised in the regulatory field, particularly in the forensic realm. Preliminary investigations suggest:

1) a lack of systematic monitoring or at least data-sharing between agencies mapping landcover change and those responsible for enforcing land management regulations; and
2) an agency reluctance to refuse permits, to prosecute, and/or to prefer counter-productive revegetation works to preservation.

More effective utilisation of satellite remote sensing and geographic information systems could treat the first and exposure of the second would at least highlight the nature of the problem for policy-makers.

Keywords and phrases**:** Land Clearance, Land Clearance Regulations, Remote Sensing, Satellite, Geographic Information Systems, Land Management, Land Degradation, Biodiversity, Greenhouse

1.0 INTRODUCTION

Reducing the loss of native vegetation has been identified by scientific and government bodies as one of the most important factors in ensuring our environmental security (Glanznig, 1995; Graetz *et al.*, 1992). The link between declining natural cover and the enhanced greenhouse effect, loss of biodiversity and land degradation is well documented (see for example DEST, 1994; Saunders *et al.*, 1996). The first Greenhouse Gas Inventory estimated that land clearance in Australia totaled 500,000 ha per year and contributed a third of Australia's total carbon dioxide (and a quarter of the total greenhouse gas) emissions (DEST, 1994; SEAC, 1996). Even using the more recent rate estimate of 381,000 ha/yr (Barson *et al*., 2000), Australia would rank in the top ten clearing nations (FAO, 1997), six of which (including Australia) are classified as mega-diverse (Saunders *et al.*, 1996: 30). The government reaction has been to enact permit-based regulations in an attempt to attenuate the risk, the first in South Australia in 1983. Most of the land cleared privately in Australia is converted to cropping or pasture (Barson *et al*., 2000a). There has been an unfortunate historic connection between agriculture and desertification (Dregne, 1986) but the liberal and capitalist notions of property ownership which underpin western society mean that there is often considerable political resistance to fettering the traditionally untramelled rights of land use (see for example Dodds, 1994; Young *et al.*, 1996). Frequent transgressions of environmental laws have been historically observed (Rosenbaum, 1991), the criticism leveled that regulations are poorly enforced and ineffective (Gunningham, 1974: 56; Hawkins, 1984). Previous workers have concluded that the effectiveness of pollution regulations has been hampered by administrative discretion exercised in favour of the regulated industries (an interpretation known as capture theory) (Grabosky and Braithwaite, 1986; Hawkins, 1984). In the land management field satellite remote sensing and geographic information systems (GIS) could be employed as a watchdog of both the regulated and the regulators. While it has been suggested (Danaher *et al.*, 1998) that satellite-derived information could be used to base administrative decision making at the permit application stage this would still limit the field of agency view to those already attempting to comply, leaving the “cowboys” unattended. This is one of the first examinations attempted of the success of land clearance regulations. An increased role for satellite remote sensing and GIS is proposed, following an overview of the regulatory approach to land clearance. Current agency practice, particularly the dearth of monitoring and the apparent reluctance to refuse permits and to prosecute, is criticised.

2.0 DISCUSSION

2.1 The Regulatory Approach to Land Clearance

Regulations are usually imposed in areas where the behaviour is not considered so morally repugnant that it is banned outright, but is instead controlled, often so as not to hamper an otherwise legal enterprise (Barker, 1984). The most common regulatory approach introduced has been the permit system, where clearance of native cover can not legally proceed without an application to an administering body that grants permission according to ecological and economic criteria. The offences created are ones of strict liability, meaning that proof of action itself is sufficient to prove the offence and evidence of “evil intent” is not required.

2.1.1 The Australian Regulatory Landscape

Although the National Government has international obligations to discharge by its participation in international treaties on Biodiversity and Greenhouse, in the Australian Federal system it is the States who are, by the omission of the Constitution, chiefly responsible for matters concerning the environment (see for example ANZECC, 1996; Crommelin, 1987). South Australia was the first government in Australia to seek to control land clearance through regulation (see Table 1).

Table 1: Key government responses to land clearance.

International	National	State
	GREENHOUSE	
Framework Convention on Climate Change 1992 (UNFCC) Kyoto Protocol 8% increase by 2008-12	National Greenhouse Response Strategy, Bush for Greenhouse, Plantations 2020	
	BIODIVERSITY	
Convention on Biological Diversity 1992	Biodiversity Strategy 1996, Reserves System (CAR) 1997	
	LAND DEGRADATION	
	Landcare	Landcare
	LAND CLEARANCE	
	National Vegetation Initiative (including Bushcare 1987) Save the Bush 1989, One Billion Trees 1989	SA: Native Vegetation Act 1991 (earlier since 1983) VIC: State Planning, 1989 Planning and Environment Act 1987 WA: Soil and Land Conservation Act 1945, amended 1986, amended 1995 NSW: SEPP 46 Aug 1995; Native Vegetation Conservation Act 1997 Qld: Lands Act 1994 amended 1997 (for leasehold); yet to be extended to freehold

There is usually considerable administrative discretion allowed, and permits are generally not required for the clearing of smallholdings, or for farm, mine, residential or fire prevention purposes. Those who apply for a permit in South Australia and New South Wales may be required to undertake a certain amount of revegetation and restoration, a legislative requirement known as the "shadow project" approach (Pearce and Turner, 1990: 21).

2.1.2 Regulatory Failure

Assessing success

There are a number of methods of assessing whether a law has been successful (see for example Hawkins, 1984). One test, assuming the aim is the retention of native vegetation, is to see whether rates and extents of vegetation loss have been reduced since the introduction of the legislation. While a measurement of the rates and extent of land clearance may appear to be the most useful guide, rates and extents of land clearance are affected by factors other that the existence of regulations. Land may not be cleared because it is uneconomic to do so, or the land is marginal to agriculture. The figures may fall on paper simply because there is no land left to clear. The rate of clearance is lowest in South Australia (see Table 2 below) but arguably such success is as much attributable to the lack of treed arable land remaining as to the introduction of regulations. Rates in Queensland may be said to have increased because of regulations due to panic clearance preceding their introduction.

Table 2: Land clearance rates in eastern Australia.

STATE	PERIOD	RATE (ha/yr)	SOURCE
Queensland	1997-1999	408,000	State Landcover and Trees Study (SLATS) using Landsat TM
		2 million	Farmer survey (ABARE, 2000)
	1995-1997	340,000	State Landcover and Trees Study (SLATS) using Landsat TM (DNR, 1999)
	1991-1995	289,000	State Landcover and Trees Study (SLATS) using Landsat TM (DNR, 1997) (SLATS figures include all woodland)
	1989-1990	450,000	Extrapolated figure from clearing contractor surveys and herbicide use records (Glanznig, 1995)
New South Wales	1994-1995	30,000	Environmental Research and Information Consortium report to the Department of Land and Water Conservation using Landsat TM (in NGGIC, 2000)
	1991-1995	16,400	Bureau of Rural Sciences Landcover Change project using Landsat TM (Barson *et al.,* 2000a) (forest woodland only)
	1989-1990	150,000	Extrapolated from regional studies (Glanznig, 1995)
Victoria	1990-1995	2,450	Bureau of Rural Sciences Landcover Change project using Landsat TM (Barson *et al.,* 2000a) (forest woodland only)
	1989-1990	6,157	Land clearance permits (Glanznig, 1995)
South Australia	1997-1998	1,144	Land clearance permits (unpublished reports of Native Vegetation Council)
	1990-1995	1,370	Bureau of Rural Sciences Landcover Change project using Landsat TM (Barson *et al.,* 2000a) (forest woodland only)
	1981-1990	28,797	NGGI project report to the Department of Environment Sport and Territories using Landsat TM (in NGGIC, 2000)
	1989-1990	4,471	Land clearance permits (Glanznig, 1995)
AUSTRALIA TOTAL	1997-1998	381,282 ha	Cumulative estimate (NGCIC, 2000)
	1983-1993	500,000 ha	Cumulative estimate (DEST,1994)

Another test is one of compliance: whether only those areas permitted to be cleared are cleared, and nothing more. Traditionally, the success of law has been measured according to arrests or convictions, i.e. the processing rates of criminals (Hawkins, 1984). However the picture is more complex in the area of regulation: success may be affected by administrative reluctance to refuse permits, police and/or prosecute transgression and judicial discretion in penalising the guilty. Table 3 below shows that the overwhelming majority of permit applications made in New South Wales and South Australia are awarded.

Table 3: Examples of administrative and judicial regard of land clearance regulations by State.

STATE	% OF PERMITS GRANTED	NO OF PROSECUTIONS	MAXIMUM PENALTY AVAILABLE	MAXIMUM PENALTY ACTUALLY AWARDED (not including costs)
South Australia	80-90% since 1994	approx 10 per year since 1995	$40,000	$40,000 (an outlier, usually only several thousand dollars in fines per year)
New South Wales	80-95% since 1997	0 under Native Vegetation Conservation Act, 11 under SEPP 46 (since 1995)	$110,000	$20,000 (plus $40,000 costs) for 275 ha (maximum expressed as price per hectare is $286 ($10,000 for 35 ha))

Enforcement a necessary evil

Observance of regulations may be generated by their status as law, by the educative aspects of their enactment (see for example Hedman, 1991: 890-1), or, it is suggested principally, generated by the deterrence effect of the threat of punishment contained within. For such a threat to operate as a disincentive the probability of detection, capture and prosecution must be high (see for example Farrier, 1992). However it has been observed that "(I)n the enforcement of regulation, a distinct aversion is noticeable to sanctioning rule-breaking with punishment" (Hawkins, 1984: 3). Detection may be the greater problem in the land management field. In Victoria prosecutions are rare and resources inadequate (Miller, 1999). Environment Victoria, The Victorian Local Governance Association and Environs Australia have called for an increase in penalties and monitoring and enforcement resources (Miller and Baker, 2000). Enforcement is considered necessary, even by those who oppose the regulatory approach, to deal with the recalcitrant, and while lack of monitoring may not be fatal to the approach, monitoring is required, at the very least, to assess the ultimate effectiveness of the regulations themselves (see Figure 1 below) (Hawkins, 1984; Young *et al.*, 1996).

Law in practice

The intended consequence of laws when drafted doesn't always translate to practice in the real world. Under earlier incarnations of the South Australian regime landholders applied to clear, expecting to be refused and be therefore granted compensation (ANZECC, 1996). Compensation remains an issue: new legislation to stop the high rate of clearance in Queensland remains deadlocked over compensation funds between the Commonwealth and State governments. Bradsen (1994) alleges that in South Australia "enforcement has not been a significant issue". While a South Australian prosecution for illegal grazing of grassy woodlands failed, in Davies' (1998) opinion, due to lack of appreciation of conservation principles by the judiciary, this does not seem to be a widespread problem, certainly not from the maximum penalty handed down in South Australia (see Table 3 above). However, that case was unique, and in a sense all cases that reach a court are: they are those which the agency has pursued, while generally preferring remedial orders and negotiation to prosecution (see for example Skinner, 2000). In New South Wales in *Director-General of Land and Water Conservation v Ramke* [1999] NSWLEC 22) Justice Talbot referred to the seriousness of the offence, as evidenced by the maximum penalty, but went on to make a remedial order in lieu of a fine (see also *Director-General of Land and Water Conservation v Robson* [1998] NSWLEC 174, *Director-General of Land and Water Conservation v Ashenden* [1998] NSWLEC 283). In most cases judges require specific evidence of deleterious effects occurring as a result of clearance and often reduce the maximum penalty after taking in to account mitigation factors such as co-operation, contrition, and agreements to pay costs and undertake remedial orders. Remedial orders rarely require the reinstatement of the vegetation illegally cleared.

The greater scheme of things

Other factors which are thought to affect the achievement of the aims of clearance legislation is the legislation itself and its place within the greater policy framework: the concentration on tree clearance, perhaps at the expense of habitats requiring greater protection, such as native grasslands, and the methods of clearance allowed. Minimum retention strategies referred to in several policies may be viewed as maximum reduction strategies (see for example Bradsen, 1994: 151). Another issue is the extent to which revegetation, agroforestry or orchard production, that have favourable greenhouse, land degradation and economic outcomes, are promoted by governments. Such land uses may be just as deleterious for biodiversity as conversion to cropping or pastoralism. Trading-off revegetation for clearance is a problem because the ecological integrity of the new plantings is unlikely to attain the status of the destroyed remnants. Due to rapid growth, replanting may have beneficial greenhouse and land degradation outcomes (at least in the short term) but the biodiversity outcome is negative: it can never be regained, can not act as a corridor or refugia or as a future source of seed. The importance of remnants in an evolutionary sense has been given extra weight in a recent examination of primary succession (Fuller and del Moral, 2000). In any case revegetation works are not matching the quanta of clearance and there remains a net loss of native vegetation (Bradsen *et al.,* 2000a). In South Australia the clearance/revegetation ratio is 10: 1 (ANZECC, 1996).

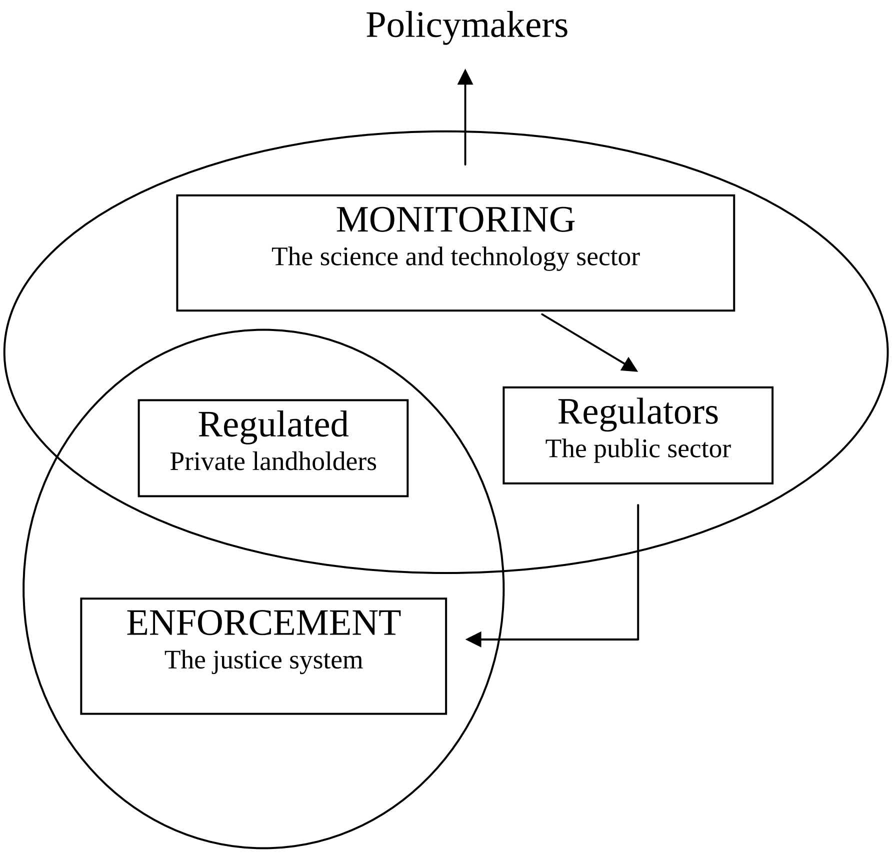

Figure 1: Diagrammatic representation of the essential factors within the regulatory environment and the possible role of remote sensing and GIS as watchdogs of both the regulated and the regulators and as providers of forensic evidence. Arrows indicate the flow of information derived from remote sensing and GIS.

2.2 The Role of Remote Sensing and Geographic Information Systems

Mapping large areas using remote sensing allows for uniform analysis of large areas without the need for expensive and time-consuming on-ground survey. One advantage of this field of view is that all landholders are brought within it, not just those who bring attention to themselves by applying for a permit. Another advantage is the ability to monitor the regulators themselves. An advantage of employing GIS is that one can include administrative data, especially property boundaries and property holder information (as is currently available for Victoria on the Giconnections website). Combining information from several sources could be incorporated into the decision-making process at the permit application stage (see Figure 2).

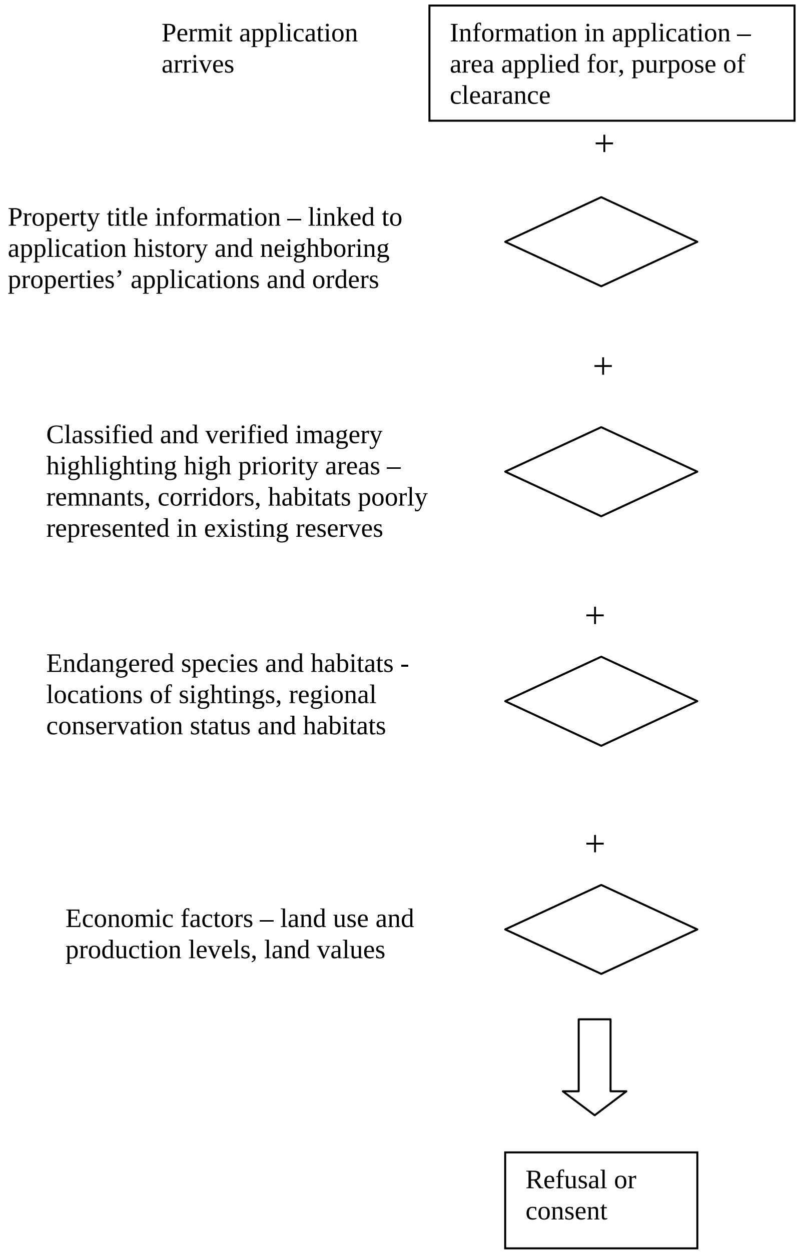

Figure 2: Schematic representation of possible inputs into a GIS to aid the decision-making process of agencies responsible for administering land clearance legislation at the permit application stage.

2.2.1 A Monitoring Role

Existing government agencies, primarily those responsible for natural resource management, have performed some monitoring of land cover change using Landsat and similar satellites. A lack of knowledge, at base data level, has been an impediment to both scientific study and the setting of government agenda. In several States, permit data is still used as a surrogate for clearance data without any independent corroboration (see Table 2 above). Monitoring by Queensland’s State Landcover and Trees Study (SLATS) and by the Bureau of Rural Sciences nationwide (see for example Barson *et al.*, 2000a; Cameron and Hart, 1998; Danaher *et al.*, 1998) has been primarily directed toward assessing the contribution to Australia’s carbon dioxide emissions (DEST, 1994). These studies could be extended to assess the extent of illegal clearance (and test compliance) by matching permit data with land cover change over time. The present separation of existing monitoring from enforcement agencies however may not be a bad thing: it would be easier for politics to hijack or co-opt an in-house system (see Figure 3).

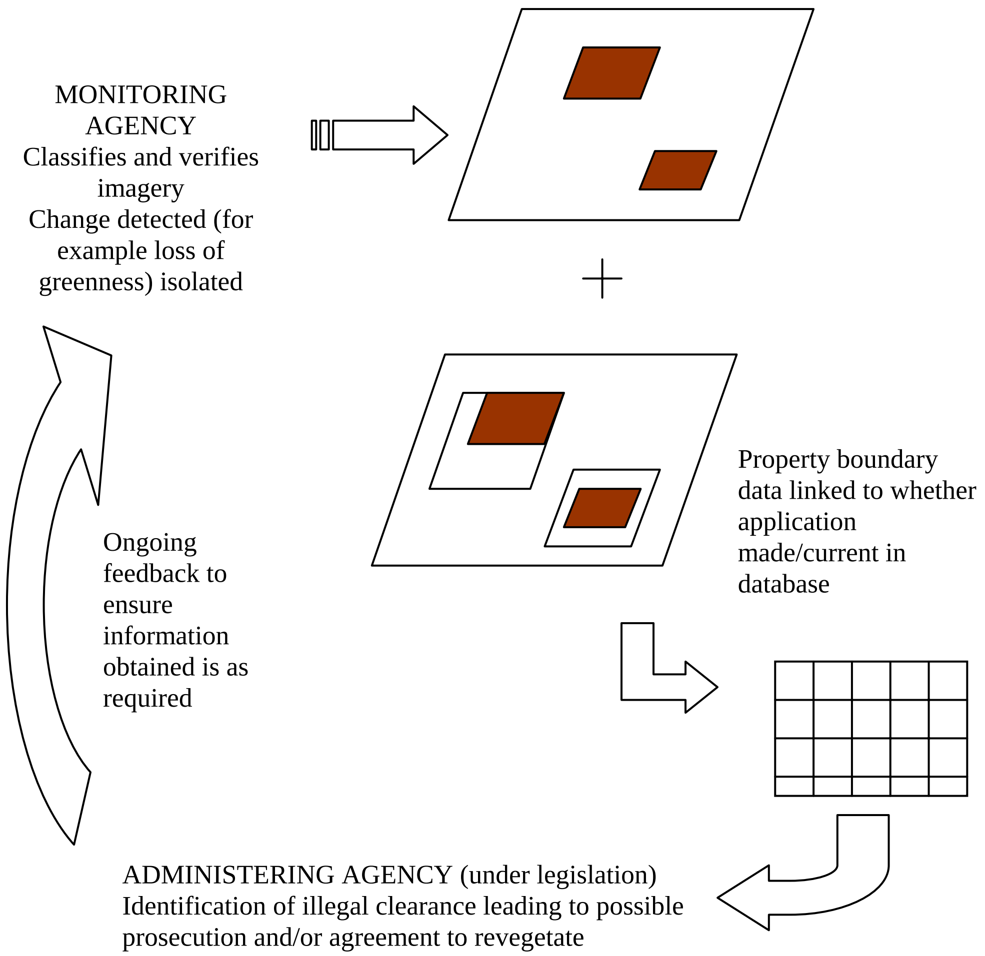

Figure 3: Schematic representation of the provision of data by monitoring agencies and its utilisation by agencies responsible for administering land clearance legislation.

2.2.2 A Forensic Role

Remote sensing could be employed to strengthen deterrence by raising the probability of detection. It could also be used as evidence to base a prosecution (see Figure 1 above). Recent cases reported in New South Wales demonstrate that the methods used to expose transgression have been ad-hoc. In one case illegal clearance was reported by a neighbour (*Director-General of Land and Water Conservation v Robson* [1998] NSWLEC 174) and in another clearing was occurring adjacent to a major highway upon which a Departmental officer happened to be travelling (*Director-General of Land and Water Conservation v Greentree* [1998] NSWLEC 30). It appears therefore that remote sensing and GIS have much to offer, although sufficient spatial and attribute accuracy must be demonstrated. The degree of spatial and attribute accuracy needed to demonstrate compliance and sufficient to base a prosecution may vary according to:

- evidentiary requirements
- parcel size and ecosystem/agrosystem heterogeneity (region-specific methods may have to be developed)
- the requirements of legislation (for example individual trees)
- whether a pragmatic standard is adopted (for example whether the defendant can afford expert witnesses)
- whether courtcraft is adopted (i.e. the use of “hired gun” expert witnesses).

Although land clearance legislation protects all native vegetation, including heath, shrublands, native grasses and even marine, land clearance figures derived from remote sensing have mainly looked at gross changes over time between woody and non-woody (forest/non-forest) vegetation. At present it appears that even these basic clearance figures are unreliable, the Forest and Grassland Conversion (Land Clearing) Sector was entirely omitted from the most recent main Greenhouse Gas Inventory for this very reason (NGGIC, 2000). The NGGIC categorised rates of land clearing as having been highly uncertain (defined as greater than 60% uncertainty) from before 1980 up until 1998 (the last inventory), with a brief period (1991-1995) of medium (20-60%) uncertainty (the period of the BRS study) (NGCIC, 2000). Comparative studies of change detection techniques have found the most accurate to be post-classification image differencing using NDVI and even these struggle to attain 70 % accuracy (Michener and Houhoulis, 1996; Muchoney and Haack, 1994). One recent study using NDVI found it could confuse vegetation with agricultural crops (Apan *et al.*, 2000). Confusion may also arise due to the effect of undergrowth green flushes, black soils, wetlands, irrigation and drought (Barson *et al.*, 2000a). Although several regional studies have been successful in differentiating structure and the effects of specific disturbances in several types of forest (see for example Foody and Curran, 1994 re tropical forests; Walker *et al.*, 1986a and b re clearing of semi-arid woodlands; Michener and Houhoulis, 1996 re flooding and Worsley *et al.*, 2000 re fire) greater difficulties exist in differentiating classes and identifying change over larger heterogeneous landscapes (Barson *et al.*, 2000b; Behn *et al.*, 2000; Foody and Curran, 1994; Michener and Houhoulis, 1996; Walker *et al.*, 1986a). Carterra is the only commercially available data with the ability to track the fate of individual trees, the subject of the South Australian legislation and local planning laws elsewhere. The 14-day repeat cycle of Carterra however is still too slow to catch perpetrators in the act. Improving resolution and accuracy may raise issues of privacy: a recent newspaper article entitled “Exposed: our 800km eye in the sky” likened Ikonos2 to Big Brother and portrayed (or reflected) a public largely unaware of ubiquitous satellite surveillance (Mascall and Dare, 2000).

3.0 CONCLUSIONS

Deficiencies exist in both the monitoring and enforcement side of regulations. An improved utilisation for remote sensing and GIS will be able to treat the problem of detection, so that agencies will no longer have to rely on nosy neighbours and chance discovery. Of course, this will only help if agencies are committed to the legislation and do not wish to “turn a blind-eye”. Remote sensing and GIS can not treat systemic problems such as the over-granting of permits and the trading of clearance for revegetation projects but could expose them and show whether rates and extents of clearance are being reduced (and not just by default), whether permit data is an accurate surrogate for actual land cleared and whether orders requiring revegetation are being complied with. Such information will be useful to policymakers in shaping future policy. This role is integral even if there is a shift, for example, to market mechanisms to control land clearance (see for example Young *et al.*, 1996).

In summation, there is evidence that serious institutional deficiencies exist in the administration of permit-based land clearance regulations. It may not be said at this stage whether this is due to “capture” or a lack of political support more generally. Given sub-standard monitoring, the most committed administration may fail, and the deployment of even the most ideal monitoring methods will have little impact on systemic problems. Ultimately, the utility of satellite-derived information will be affected by the willingness of the administration to adopt it.

4.0 FUTURE WORK

Further examination of agency practice is required and practical effectiveness of remote sensing deployment demonstrated. In the future a GIS specifically tailored to enforcement could be created, in which satellite data, classified using regional requirements, could be examined close to real-time. The findings may also assist those working with similar land use restrictions in the forestry, mining and planning sectors.

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