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Published

2014

Journal Title

Conservation and Society

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## Forest Conservation Policy Implementation Gaps: Consequences for the Management of Hollow-bearing Trees in Australia

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### Abstract

Hollow-bearing trees in native forests and woodlands are significant habitat resources for many Australian fauna but habitat removal, commercial timber harvesting and urban development continue to threaten these ecosystems. Protection for these habitats and their species is purportedly provided for in legislation, policy, and strategic management plans. However, public debate and disagreement surrounding forest management has resulted in the disintegration of national plans as interpreted by states and territories as well as individual stakeholders, resulting in gaps in policy implementation. This paper presents a hierarchical review of the current legislation and policy mechanisms underpinning forest conservation in Australia, with specific attention paid to important habitat features such as hollow-bearing trees. Apart from federal and state legislation acknowledging the importance of hollow-bearing trees to biodiversity, sufficient mechanisms to halt the ongoing loss of this resource from Australian landscapes at the local level appear to be lacking. Hollow-bearing tree conservation strategies from 46 local councils in Victoria, New South Wales, Tasmania, and Queensland were reviewed. Very few (<5%) respondents from local councils across all states indicated that they have specific plans for the conservation and management of hollow-bearing trees, highlighting policy implementation gaps at the local level. Furthermore, apparent environmental management strategies and actions rank relatively low on local council priorities. Therefore, a stronger focus on conservation actions towards management of critical habitat features across the landscape supported by robust local, national, and international policy is needed.

**Keywords:** policy implementation gaps, hollow-bearing trees, critical habitats, Australia

### INTRODUCTION

Sound environmental policy is the cornerstone of global conservation efforts, directing action at local, regional, national, and international levels (Thomas 2007). Over the past five decades, however, environmental policy decisions in Australia have caused considerable conflict within all

levels of government. Consequently, national plans as interpreted by states and territories as well as individual stakeholders have collapsed, resulting in far reaching gaps in policy implementation, particularly for forest management (Musselwhite and Herath 2007). The inability to resolve conflicts nationally has led to a number of environmental assets, important for the retention of biodiversity, being at risk. The national attention given to forestry and forest management within Australia (McAlpine et al. 2007) underpins the conservation of these natural resources, particularly large hollow-bearing trees. This in turn provides a useful platform for the analysis of the potential consequences of policy implementation gaps at the local level.

Living or dead, hollow-bearing trees are important features of forests (Spies et al. 1988; Newton 1994), providing structural heterogeneity in natural, cultural, and recently

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10.4103/0972-4923.132122

modified landscapes. Hollow-bearing trees are also globally acknowledged for their value in conserving wildlife (Mawson and Long 1994; Ball et al. 1999; Wormington et al. 2002; Aitken and Martin 2004; Beaven and Tongayi 2012). They provide essential wildlife habitat by offering protection from predators; are used as roosting and breeding sites; are used for feeding (Holloway et al. 2007); and offer a stable micro-environment that ameliorates ambient weather conditions (Gibbons and Lindenmayer 2002). Within Australia, the use of this resource by native fauna has received considerable research attention (Comport et al. 1996; Lamb et al. 1998; Gibbons et al. 2000; Lumsden et al. 2002; Eyre 2005; van der Ree et al. 2006), with many of these studies focusing on the dependence of threatened species on hollow-bearing trees. Consequently, the continued loss of these habitat features from the landscape is an important conservation management problem (Gibbons and Lindenmayer 1996; Eyre 2007; Goldingay 2009).

The retention and longevity of hollow-bearing trees within the landscape depends on the synergistic effects of multiple factors. These not only include natural ecological processes contributing to hollow formation and the extent to which hollow-bearing trees are threatened by anthropogenic activities but also the manner in which forests are conserved and managed. Hollow formation is influenced by a variety of environmental factors related to tree damage and decay forming agents such as termites and fungi (Gibbons and Lindenmayer 2002; Adkins 2006), along with tree characteristics such as age and size (Lindenmayer et al. 2000). Thus, Australian eucalypts require at least 150 years before hollows are likely to be suitable for occupation by vertebrate fauna (Ross 1998). Threatening processes facing hollow-bearing trees include agriculture (Cogger et al. 2003), firewood collection (Driscoll et al. 2000), urban development (Garden et al. 2007), altered fire regimes (Ross 1999), as well as forestry and timber harvesting (Gibbons and Lindenmayer 1996; Lamb et al. 1998; Adkins 2006). Correspondingly, political inertia in the translation of forest management policy to management actions (Riley et al. 2003; Prest 2004; Musselwhite and Herath 2007) also potentially threaten the conservation of hollow-bearing trees. Therefore, an understanding of the strategic frameworks and policies in place to protect hollow-bearing trees at the local level is required to demonstrate how these achieve regional, state, and national biodiversity conservation objectives.

Australia's natural forest estate is made up of a variety of forest types and land tenures with a corresponding array of management practices (Aenishaenslin et al. 2007). Forestry practices and interests can vary immensely amongst federal, state, and local private landholders, with divergent ideologies resulting in ad hoc programs with no long-term planning or direction. This creates difficulty in formalising conservation objectives that are often incompatible with other potentially competing land uses such as timber harvesting, urban development, or agriculture (Dovers 2003). The diversity of historical, cultural, political, and physical circumstances within Australia's states and territories contributes to decentralised, confusing, and often overlapping commercial

versus conservation forestry initiatives. However, some consistency arising from the development of 'best practice' policies among the states has been achieved, giving rise to five basic forestry conservation initiatives. These initiatives allow for 1) afforestation, 2) the creation of wildlife habitats, 3) prevention or reversal of land degradation, 4) establishment of shelter for crops and wildlife, and 5) general amenity (Herbohn et al. 2000). While some attention has been directed towards retaining habitat features in natural production forests within Australia (Lamb et al. 1998), there is relatively little information available on the implementation of federal conservation policies at the local government level. This failure to amalgamate policies across the nation is also found at the state level. For example, a previous review of stakeholder involvement in Victorian forest policy (Musselwhite and Herath 2007) revealed that local governments were not included in the survey, thus highlighting the lack of commitment to include local government agencies.

As hollow-bearing trees are essential habitat features, managing landscapes for their persistence should be considered an important measure of the success of conservation initiatives. How such conservation actions are implemented, however, depends on the interpretation of policies at various levels of government, but particularly at the local level. This paper provides an overview of the current 'best practice' policies and guidelines for forest management in eastern Australia. It compares the relative importance of environmental management at the local level among regional councils, and then examines the scalar translation of policy to implementation. It does so by investigating specific actions to conserve hollow-bearing trees and/or habitat trees as essential habitat features within the landscape.

## METHODS

The degree to which the conservation of hollow-bearing trees within Australia is captured within existing legislative frameworks was assessed by reviewing available scientific literature as well as forestry and nature conservation related legislation, to document the current status of the forest management hierarchy. This process summarised the hierarchy of federal and state legislation, reviewed 'best practice' forestry policies and ascertained the extent of forest conservation provisions made in local government policy and planning guidelines. These documents were then searched for any mention of hollow-bearing or habitat trees.

The transfer of guiding policies and recommendations from higher levels of government that inform the strategies at local level are imperative. With this in mind, a two-stage process was followed to assess local level environmental management objectives, and specifically how these translate into the protection of hollow-bearing trees. Information was accessed at the local council level by contacting 86 randomly selected local council areas throughout eastern Australia (Tasmania, Victoria, New South Wales, and Queensland). These local councils were categorised at the broad level

as ‘urban’, ‘regional’, or ‘rural’ based on the classification system used by the Department of Infrastructure and Regional Development (Australian Government 2001). In the first stage, webpages of local councils were assessed to determine their environmental emphasis within a broader social responsibility context. This was undertaken across three hierarchical levels. Level 1 entailed enumerating the number of primary council strategies and objectives listed on their respective webpages. This was then taken to a finer scale by searching for any strategies pertaining to the importance of environmental assets and biodiversity and thus hollow-bearing trees by association. Level 2 calculated the relative importance of environmental actions. We first counted the total number of menu tabs on each primary council webpage and then determined the placement of ‘environment’ within this menu structure by recording its order within the tabs. The relative importance was then calculated by dividing the order of the ‘environment’ tab by the total of all menu tabs for each council and these figures were normalised by the maximum number of tabs across all councils ( $n=18$ ). Theoretical minima and maxima for the relative importance of ‘environment’ ranged between 1 (lowest rank) and 324 (highest rank). Finally, Level 3 analyses compared the number of sub-categories within each ‘environment’ tab to those within all other menu tabs on the primary webpage. Collectively, these results give an overall representation of how councils place themselves in a socio-environmental context. Comparisons of the number of environmental strategies among councils based on their location category were made using a one-way ANOVA.

For the second stage, copies of any policies and/or strategies that captured the conservation of hollow-bearing trees as one of their management actions were requested from council representatives. Documents received from council representatives were then ranked based on the nature of the conservation and management frameworks and actions that councils have in place to conserve hollow-bearing trees. Three broad categories were recognised: 1) council policies that rely upon the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and other federal and state legislation, with no specific reference to hollow-bearing trees; 2) council policies that rely on the EPBC Act and other federal and state legislation, with specific reference to the importance of hollow-bearing trees, but with no specific protection offered; 3) council nature conservation strategies and management plans with specific mention of the retention/protection of hollow-bearing trees and actions to achieve these objectives. The implications of these findings are discussed in the context of forest conservation and management in Australia with specific reference to the threats facing hollow-bearing trees.

## RESULTS

### Legislation and the conservation of Australian forests and hollow-bearing trees

At the Rio Earth Summit in 1992, the use and management of forests received considerable attention globally, culminating

in the production of a number of agreements including the ‘Global Statement of Principles of Forests’ (GSPF) and ‘Agenda 21’. The GSPF made several recommendations for the management, conservation, and sustainable development of all forest types globally. Australia endorsed the GSPF and signed a number of conventions relating to biological diversity and climate change in order to achieve the full range of benefits available from forests (Commonwealth of Australia 1992). Furthermore, Agenda 21 called for global action regarding sustainable development and was considered by many as the centrepiece of the Rio accords (Prado-Lorenzo and Sanchez-Garcia 2007). From Agenda 21 emerged ‘Local Agenda 21’, that offers support for environmental issues at the local level (Thomas 2007). Local Agenda 21 systems aimed to achieve sustainability through the integration of planning and policy, by focusing on long-term outcomes and involving all sectors of the community (Stenhouse 2004; Thomas 2007).

Australian federal strategies and objectives were then outlined in the ‘National Forests Policy Statement 1992’ (NFPS) which lay the foundations for forest management in Australia for the next century. The NFPS, signed by the federal government, states, territories, and local governments, provides the framework recognising the need to initiate processes required for changes to occur in order to protect Australia’s forests for ecologically sustainable growth and management (Commonwealth of Australia 1992). At this level however, there are no explicit provisions made that stipulate the management interventions or actions required to protect specific habitat features such as hollow-bearing trees.

Following the endorsement of the NFPS, the federal and state governments established the framework for Regional Forestry Agreements (RFAs). Twelve RFAs were progressively signed by the federal and state governments between 1997 and 2001 (Mobbs 2003). Each RFA is a 20 year intergovernmental agreement concerning the security of forests resources, as well as the conservation of environmental heritage and social values (Lane 1999; Aenishaenslin et al. 2007). The key outcomes of RFAs are the allocation of approximately 30% of publicly-owned commercial native forests to an expanded reserve system, the strengthening of the codes of practice, and increased resource management for the timber industry (McAlpine et al. 2007). Despite the provisions for increasing the extent of native forests within the national reserve system, the RFAs do not highlight any measures required to conserve specific structural features within these forests. Furthermore, there has not been widespread adoption of the RFAs by state governments, exacerbating inconsistencies in forest management practices among states and territories. For example, Queensland did not initially sign an agreement and developed its own Queensland Forest Agreement outside of the federal government’s RFA guidelines. This was done in conjunction with the Australian Rainforest Conservation Society, the Queensland Conservation Council, The Wilderness Society, and the Queensland Timber Board (Mobbs 2003). This alternative agreement initiated in 1999, failed to fully encompass all forest types in south-east Queensland, favouring rainforest and wet sclerophyll forests

in the conservation reserve system (McAlpine et al. 2007). Virtually no allowance was made for the protection of dry eucalypt forests, thereby failing to preserve the ecosystems and species with the highest vulnerability to land clearing (Norman et al. 2004; McAlpine et al. 2007). Similarly dry sclerophyll forests in New South Wales received little or no recognition and are poorly represented in the New South Wales RFA (Flint et al. 2004). Nevertheless, it has been suggested that RFAs under the NFPS have achieved some positive outcomes, if only for native forests within the national reserves system following the implementation of a higher level of sustainable forestry practices aimed at conservation (Meek 2004).

Nationally, RFAs require that within individual public forest estates a minimum of 15% of each forest type, 60% of remaining old growth forest, and at least 90% of high quality wilderness is reserved (Aenishaenslin et al. 2007). Therefore, while the RFA process has seen a significant reduction in the volumes of timber harvested from within public forest estates, in some states this has led to an increase in the importance of private native forests as a source of saw logs (Norman et al. 2004). Private forests are therefore potentially under greater threat as a consequence of the implementation of the RFAs in various states. This highlights that further engagement at the local level is needed as the current system only ‘encouraged’ land owners of private forests to participate in the policy. Local authorities such as councils are also not readily included in national reserve system planning or management (Lunney 2004).

Private forests have typically been placed in the ‘too hard’ basket by policy makers, legislators, conservationists, and foresters, as being of low conservation and economic value. Therein, the management of private forests has been formed by a combination of public ignorance and political and agency inertia (Prest 2004). Furthermore, forest policies within private native forests in eastern Australia remain highly controversial as each state has differing forestry codes of practice, all of which are governed by overarching state and federal legislation. For example, the forestry code of New South Wales is highly restrictive in terms of forest harvesting, and management is heavily focused on environmental objectives, with little importance placed on the contribution of private native forests. In Queensland and Victoria codes are commercially driven, while Tasmania attempts to achieve a balance between environmental and commercial objectives (Aenishaenslin et al. 2007). Equally, small remnant forest patches isolated by fragmentation through urbanisation have been abandoned, and considered to be of low conservation value (Alvey 2006; Harper et al. 2008). However, small and often isolated landscapes are valuable to conservation as they are representative of the former habitat that was once common to any given area (van der Ree et al. 2003), and also serve to connect habitats within a larger landscape matrix (Lindenmayer and Fischer 2006). Ongoing land conversion will increase the value of private and urban forests (Alvey 2006), as there is a clear link between the condition of private land and biodiversity conservation in Australia (Fitzsimons

and Wescott 2001). The importance of local councils in directing conservation efforts on private land is paramount, as these agencies already administer a number of private conservation initiatives like the Land for Wildlife schemes in Victoria, New South Wales, and Queensland (Fitzsimons and Wescott 2001). Local councils, therefore, act as the interface in providing private landholders with clear policy directions on the conservation and management of forest features such as hollow-bearing trees. Despite these objectives, conflicts continue to plague the industry and both public and private native forests continue to shrink. This emphasises the urgent need for sustainable management of all forests to conserve biodiversity (McAlpine et al. 2007).

Despite their long-standing recognition as important forest features, the loss of hollow-bearing trees due to forestry practices was nominated for listing as a key threatening process in 2005 under the federal Environment Protection and Biodiversity Conservation Act 1999. The nomination recognised two parts to the process—activities which remove or destroy hollow-bearing trees, and processes which affect tree and seedling recruitment. However, the Endangered Species Scientific Subcommittee found that, where a RFA was in place, a nationally co-ordinated threat abatement plan was neither feasible nor an effective and efficient way to limit the loss of hollow-bearing trees. For regions where no RFA is in place, a range of state forestry management prescriptions, nature conservation and threatened species legislation, vegetation clearance controls, and voluntary measures apply. This suggests, therefore, that RFAs and other legislation have explicit details and plans in place for the conservation of hollow-bearing trees. However, this is not the case. These documents largely comprise broad sweeping terminologies that cover conservation issues in general, with no specific references to hollow-bearing trees or other important forest structures. Thus, hollow-bearing trees are not specifically protected under the federal Environment Protection and Biodiversity Conservation Act 1999 due to the belief that sufficient mechanisms exist within individual state legislation to address their conservation requirements. As the RFAs under the NFPS draw to a close in 2017, so do the opportunities for management and system reform under these policies. The direction of forestry reform and conservation in Australia thereafter should be closely monitored. This does also provide an opportunity for local councils to put policy measures in place that will ensure the ongoing conservation of hollow-bearing trees.

Forestry practices within Australia generally identify hollow-bearing trees as being of low commercial value, while also suppressing forest regeneration (Gibbons and Lindenmayer 2002). In spite of this they continue to be harvested primarily as saw logs or at a later stage for fire wood or fence posts (Lamb et al. 1998). In some regions, provisions for the retention of hollow-bearing trees under certain land uses are in place. For example, in Queensland the Habitat Tree Technical Advisory Group (HTTAG) was formed by the Environmental Protection Agency to assist in the development of guidelines for the management of hollow-bearing trees

as habitat for wildlife in relation to silviculture (Lamb et al. 1998). Under these guidelines, habitat and recruitment trees are identified as those requiring retention for the purpose of wildlife conservation and may be of either merchantable or non-merchantable value (Queensland Government 2007). Habitat trees are defined as those having one or more hollows >10 cm in entrance diameter, while recruitment trees are suitable trees within a 40 cm diameter at breast height class (Lamb et al. 1998). Recommendations from the HTTAG have also been incorporated into the Code of Practice for Native Timber Production on State Lands (Eyre 2005; Queensland Government 2007). Of those recommendations, the retention of a minimum of six live habitat trees and two recruitment trees per hectare is mandatory throughout harvesting areas (Eyre 2005). Under standard harvesting practice, where habitat trees occur uniformly in an area subject to clearing, additional recruitment trees must be retained where >50% of the basal stand area is to be removed (Lamb et al. 1998). However, these recommendations and guidelines are not applicable outside of production forests, again highlighting the need for local government bodies to establish and implement conservation programs aimed at the maintenance and recruitment of hollow-bearing trees on commercial, public, and private lands.

The preceding review highlights that all acts, codes, agreements, and policies at the federal and state level within Australia strive for ecological sustainability and the retention of certain vegetation communities at a national scale. However, apart from the HTTAG in Queensland there appears to be little documentation regarding the specific management and retention of hollow-bearing trees as a habitat resource to be conserved within the landscape. Therefore, while federal and state legislation acknowledges the importance of hollow-bearing trees to biodiversity, sufficient mechanisms to halt the ongoing loss of this valuable habitat resource from Australian landscapes appear to be lacking. Without adequate legislation at the national or state levels, there is little hope for achieving conservation objectives for hollow-bearing trees at the local level. This study therefore assessed the nature of hollow-bearing tree management strategies at the local level to determine if national level policies are implemented at this scale.

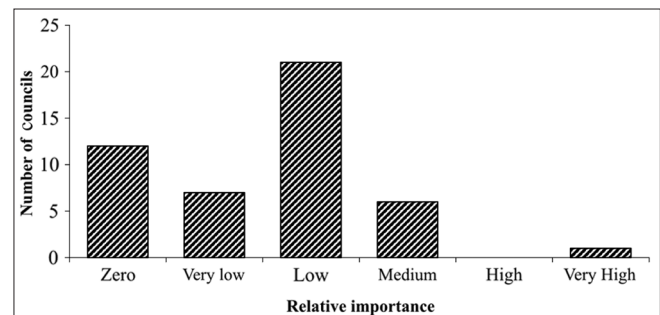
### Local level ranking of the importance of biodiversity assets, in particular hollow-bearing trees

Of the 86 councils contacted, only 46 (53.4%) responded to calls for information on their environmental strategies and plans for the conservation of hollow-bearing trees. These councils were subsequently used in the analysis of broader council social responsibility and how ‘environment’ placed within this operational framework. Of the 46 respondents, 12 were classified as being ‘urban’, 23 ‘regional’ and 11 ‘rural’ (Table 1).

Level 1 searches of council webpages revealed that only 46.7% of councils had overarching strategies and guiding principles relating to environmental protection and the

importance of biodiversity assets. The relative importance of ‘environment’ among councils was also highly variable with ranked importance values ranging between 2.3 and 108. Overall, 85% of councils ranked ‘environment’ low, very low, or not at all. Only 2.1% of councils ranked ‘environment’ highly and 13% placed a medium emphasis on ‘environment’ (Figure 1). Finally, Level 3 analyses revealed that the number of environmental programs run by councils in general were significantly less than the mean numbers captured across all other programs run by the council ( $t=4.5$ ;  $d.f.=45$ ;  $P<0.001$ ) (Table 1). However, there was no difference in the emphasis placed on ‘environment’ among ‘urban’, ‘regional’, or ‘rural’ locations ( $F=2.32$ ;  $d.f.=2,43$ ;  $P=0.11$ ).

Information on the management strategies for hollow-bearing trees at the local level provided by 46 councils provided the basis for assessing the degree to which higher level policies are taken up by implementing agencies. Local councils providing information were spread along the south-eastern seaboard of Australia and were represented by Queensland (30.4%), New South Wales (36.9%), Victoria (26.1%), and Tasmania (6.5%) (Table 2). Surprisingly, 95.6% of councils reported that they had no specific conservation management policies or guidelines in place for hollow-bearing trees, and that they relied primarily on either state or federal acts and legislation to protect vegetation communities within their shires. Only two councils (4.4%), one each from New South Wales and Queensland, had specific measures in place to protect hollow-bearing trees, while a further seven councils (15.2%) mentioned the ecological importance of hollow-bearing trees but did not have any specific conservation measures in place. In case of the New South Wales council, these guidelines were embedded within development control measures along with a significant tree registry. By comparison, the council in Queensland had a series of guidelines targeted at hollow-bearing tree retention. The guidelines implemented by the Queensland local council are from a comprehensive document that is entirely committed to the identification, conservation, retention, and management of hollow-bearing trees within its boundaries with reference to the Integrated Planning Act 1974 (Table 3). The guidelines offer ecological recognition and value to habitat trees within the landscape, supported by the ability to undertake on-



**Figure 1**  
The relative importance placed on the environment by local councils based on the ranking of the ‘environment’ tab in relation to all other menu tabs on primary council webpages

**Table 1**  
*Data from the webpages of local councils in relation to how they place themselves environmentally in a social context*

Council by state	Council classification*	No. of tabs	Placement of the 'Environment' tab on webpage	Mean n tabs (excluding environment)	No. of environmental strategies
NSW 1	Rg	8	4	7.4	1
NSW 2	U	9	4	12.6	28
NSW 3	Rg	6	4	5.6	9
NSW 4	R	5	0	14.5	0
NSW 5	R	13	9	5.3	10
NSW 6	Rg	7	7	11.8	3
NSW 7	U	8	8	9.0	0
NSW 8	R	8	4	5.1	0
NSW 9	Rg	7	1	8.5	1
NSW 10	Rg	5	3	10.8	1
NSW 11	R	8	5	9.6	0
NSW 12	U	3	3	29.0	14
NSW 13	Rg	8	5	11.6	5
NSW 14	Rg	7	3	12.0	8
NSW 15	Rg	5	5	9.5	0
NSW 16	U	7	7	10.2	0
NSW 17	R	9	7	21.9	8
QLD 1	U	8	4	30.3	0
QLD 2	U	7	3	38.8	6
QLD 3	U	8	5	14.4	5
QLD 4	U	7	0	32.5	10
QLD 5	U	6	0	11.2	0
QLD 6	U	9	4	9.3	0
QLD 7	R	7	4	13.3	1
QLD 8	Rg	8	4	9.0	0
QLD 9	Rg	8	4	9.6	3
QLD 10	Rg	8	5	12.9	1
QLD 11	Rg	7	5	23.5	0
QLD 12	Rg	8	0	5.1	1
QLD 13	R	5	0	9.5	3
QLD 14	U	6	0	12.2	4
TAS 1	Rg	5	4	6.5	0
TAS 2	R	9	0	7.1	1
TAS 3	R	7	0	5.8	1
VIC 1	Rg	8	8	22.7	3
VIC 2	Rg	6	2	12.2	3
VIC 3	U	17	0	8.0	0
VIC 4	U	7	4	8.3	13
VIC 5	Rg	8	0	24.7	5
VIC 6	U	18	9	10.2	14
VIC 7	Rg	6	0	15.2	2
VIC 8	U	6	3	13.2	8
VIC 9	Rg	14	9	7.2	1
VIC 10	R	5	0	26.0	16
VIC 11	Rg	18	11	7.2	3
VIC 12	R	7	4	9.2	20

\*U=urban; Rg=regional; R=rural

Note: The number of environmental strategies for each council were found from those listed within each primary 'Environment' tab on council webpages. Council classification data was obtained from the Australian Government: Department of Regional Australia Local Government, Arts and Sport.

**Table 2**  
*Number of councils contacted to request information of strategies and policies targeted at hollow-bearing trees at the local level, and number of respondents by state*

Councils\MEDKNOW\State	Queensland	New South Wales	Victoria	Tasmania
No. contacted	25	26	25	10
No. responded	14	17	12	3

ground implementation, including measures that consider the implications of the removal of hollow-bearing trees.

## DISCUSSION

Within Australia, amnesia and ad hoc policy formulation is considered to be an ongoing problem at the institutional and organisational foundations of forest policy and management (Dovers 2003). This presents a significant problem for land managers concerning the implementation of natural resource policy and legislation. The difficulties arise when translating the intentions and aspirations of parliamentary statutes, which are intended to protect the environment, into meaningful on-ground actions (Shepherd and Martin 2011). Our results revealed how some councils appear to give little consideration to environmental issues within the broader socio-environmental context, while few gave specific attention to hollow-bearing trees. This is demonstrated by the fact that eight of the 46 councils surveyed appeared to have no information relating to the environment and/or the importance of biodiversity assets displayed on their public websites. Furthermore, when councils did provide information about the environment, this information is often hidden or nested under larger programs or objectives. Nevertheless, results from our three tiered investigation into council webpages suggest that approximately 50% of local councils generally considered the environment and biodiversity as being of some importance. To interpret these results further, they need to be understood in context with the information pertaining to hollow-bearing trees supplied to us by councils. In doing so, we reveal an overwhelming lack of translation of overarching national and regional policy and legislation into local conservation action. This also appears to be an ongoing and pervasive problem within the Australian administrative system, as similar concerns were noted by Humphries (1989). This lack of local

policy implementation is highlighted by the fact that only two councils (4%), both of which were classified as being 'urban', had dedicated measures in place to protect hollow-bearing trees. The majority of local councils rely heavily on existing state and federal legislation, despite these being vague in their provisions for the preservation of hollow-bearing trees. Thus, the dependence on overarching policies may not ultimately achieve conservation objectives simply because these policies frequently do not have the level of support and detail required to implement targeted conservation strategies.

In the years following the introduction of Local Agenda 21, 117 of Australia's then 750 councils had either established or were developing local sustainability strategies (McDonald 1998). While this national trend saw the transfer of power and responsibility from federal government to local authorities, by November 1999, local council involvement had dropped to 75 (Mercer and Jotkowitz 2000). Whittaker (1997) obtained a deeper insight into why Australian councils were slow or reluctant to embrace Local Agenda 21, reporting that many had difficulty in deciding whether they were in fact developing a Local Agenda 21 or not, and if their management plans could be incorporated into a Local Agenda 21. Ultimately, Local Agenda 21 requires changes to values and patterns of consumption both from within local councils and the community. However, many councils stated that they had great difficulty in raising awareness of Local Agenda 21 and getting the community involved at the time (Whittaker 1997). Furthermore, the apparent lack of support offered to conservation strategies within local councils (as recorded in this study) is further exacerbated by the limited transfer of scientific findings to policy makers or the general public (Pitman et al. 2007). Ecologists generally convey their findings to a limited audience (e.g., other academics), often resulting in key decisions relating to the management of biodiversity and conservation being made without the full benefit of science (Shanley and López 2009). Ironically, the rapid loss of biodiversity continues despite the plethora of information available and the considerable financial investment in research, highlighting the breakdown in communication between science and policy makers. Based on our findings, even where research may have informed the development of higher level conservation policy, these policies are not being enacted at a local level. This demonstrates the cascading effects of limited information flow pathways.

Our study demonstrates this policy implementation breakdown by using hollow-bearing trees as an example, and suggests that the problem itself is more deep-seated, compromising the effectiveness of a myriad of conservation programs at the local level. Conservation managers at the local level need to make conscious efforts to address ongoing threats to natural habitats and their associated fauna and flora through the development of targeted action plans, along with the implementation of hollow-bearing tree protection legislation (e.g., development control measures). The extent to which these problems are entrenched more broadly within other Australian local councils remains to be seen, as only 53% of councils responded to this survey. Nonetheless, it is troubling

**Table 3**  
*Specific measures implemented by two 'urban' local councils to protect and preserve hollow-bearing trees on public and private land in Queensland and New South Wales*

<b>Queensland Council: Guidelines for the Retention of Hollow-bearing Trees</b>	<b>New South Wales Council: Development Control Plan</b>
1. Tree Management Report <ul style="list-style-type: none"> <li>1.1 Ecological Assessment Report</li> <li>1.2 Risk assessment</li> <li>1.3 Hollow-bearing tree assessment</li> <li>1.4 Selection criteria: hollows, tree health and DBH</li> </ul>	1. To protect old growth and significant hollow-bearing trees.
2. Annual Management Report <ul style="list-style-type: none"> <li>2.1 Maintenance of hollow-bearing trees</li> <li>2.2 Data reporting and recording</li> </ul>	2. Significant Tree Register: Trees of high ecological value as well as other social values.
3. Tree Removal Plan <ul style="list-style-type: none"> <li>3.1 Removal of wildlife</li> <li>3.2 Compensatory actions</li> </ul>	

that our initial review may be indicative of a prevailing status quo, particularly in urban regions.

This investigation generated considerable interest amongst councils, with some council respondents expressing their frustration at the lack of protection they felt they were able to provide to hollow-bearing trees and remnant vegetation in general. This is perhaps due to the variable land uses that occur within council jurisdictions such as public parks, bushland, reserve networks, and recreational reserves, as well as the range of environmental and social values operating across the landscape (Snep and Opdam 2010). For example, in urban areas a tree is also considered to be hazardous if there is potential for harm to people and property. Accordingly, trees containing hollows that are readily detectable are judged as 'hazardous trees' and are therefore removed (Terho 2009). However, an underlying cause perpetuating inaction appears to be linked to the hesitant transition to adaptive management paradigms by local councils. Active adaptive management balances the requirements of management with the need to learn about the system being managed, thus leading to better decision-making (McCarthy and Possingham 2007). For crisis disciplines such as conservation (Burgman et al. 1993), conservation managers must deal with direct environmental threats in dynamic socio-political environments. The broader social responsibility targets being pursued by local councils, as demonstrated by our study, can be captured within contemporary active adaptive management paradigms to improve management (Cundill and Fabricius 2010). Fostering an adaptive management approach for the conservation of hollow-bearing trees at the local level is dependent on a number of factors. These include an understanding of the conservation development objectives of multiple stakeholders (e.g., councils, landowners, NGOs, traditional landowners), knowledge of the status of the resource, and the identification of defined approaches to achieve these objectives. Calls for conservation planners to develop strategies enabling them to engage with decision makers in order to integrate biodiversity conservation initiatives into land-use planning (Lagabrielle et al. 2010), are supported by our study.

### Conservation challenges and the way forward

Australian urban forests contain hollow-bearing trees providing critical refugia for a variety of native fauna (Goldingay and Sharpe 2004; Harper et al. 2005). However, given the lengthy time to hollow formation, significant time spans may separate the current hollow-bearing trees from possible recruitment trees that allow for the continuous replacement of hollows (Gibbons and Lindenmayer 2002). Therefore, prioritising forest management policies to preserve a suitable age-structure supply of hollow-bearing trees is required, if the biodiversity values of these urban habitats are to be retained in the long-term. This can be achieved through a number of actions that would arguably form the basis of future hollow-bearing tree conservation strategies, particularly for those councils where

these are currently lacking. The following strategies and actions are recommended:

1. Definition of clear management objectives and conservation targets at the outset that will inform future adaptive monitoring efforts;
2. Compiling an inventory of hollow-bearing trees at the local level, to establish a baseline for identifying potential interventions required to meet predefined objectives. These data can then be incorporated with other known data sets on the urbanisation process, such as land clearing, land use, population density, etc., to inform holistic land use planning and policy development for the retention of hollow-bearing trees; and
3. Most importantly, there is a need to facilitate on-ground action plans for the retention, recruitment, and management of hollow-bearing trees at the local level, and particularly within rapidly urbanising regions.

Such actions will, in turn, maintain forest structure and faunal communities as well as increasing their value at the landscape level. Activities include those that manage the residual natural resources (e.g., minimising fire impacts on large dead hollow-bearing trees), but also those that propose active facilitation to enhance or improve habitat conditions (e.g., supplementation, accelerated hollow formation). While short-term supplementation (e.g., erection of nest boxes) can assist species conservation efforts in some situations (Beyer and Goldingay 2006; Durant et al. 2009), they cannot replace naturally occurring hollows. Moreover, their usefulness has been vigorously debated (Spring et al. 2001; Lindenmayer et al. 2002). For hollow-bearing trees, any mitigation action should be implemented with a complete understanding of the current status and availability of this resource within the landscape.

Artificial hollow formation has been suggested as an alternative to the use of nest-boxes (Gibbons and Lindenmayer 1996). Accelerating the formation of hollows could be achieved by the deliberate attempts to kill or injure a tree (Bull and Partridge 1986), the injection of growth hormones and inoculation with fungi (Connor et al. 1981), tree girdling (Connor et al. 1981), the use of explosives (Smith and Lindenmayer 1988), fire (Adkins 2006), and the combination of these techniques with natural decay agents associated with hollow formation (Lindenmayer et al. 1993). As Goldingay (2009) points out, there are currently no published studies from Australia that describe experiments to promote or create natural hollows in trees, or indeed whether these are successful. Furthermore, the time to accelerated hollow formation in Australian hardwood forests may also be longer than the 3 to 5 years reported from North American softwood forests (Bull and Partridge 1986; Arnett et al. 2010).

### CONCLUSION

There are a number of implications for the ongoing management of natural resources at the local level arising from this work, particularly for hollow-bearing trees. Firstly, we

provide empirical evidence of a gap in policy implementation in connection with the management of hollow-bearing trees in Australia. Despite the national emphasis placed on the value of these habitat features within native forests, there is little on-ground implementation of conservation actions aimed at their persistence within the landscape. Higher level policy is poorly translated into on-ground action, and this requires a shift in current management strategies to adopt a more proactive adaptive approach.

Secondly, a review of, and change in, environmental policy is required in order to amalgamate the varying, convoluted, and disjointed policies currently in place, to provide greater focus to the management of forest resources at various scales. Continuing under current legislative frameworks will be insufficient in preventing the further loss of key resources such as hollow-bearing trees. Furthermore, the potential implications of such largely inadequate and ineffective efforts extend beyond that of hollow-bearing trees and could compromise a number of other forest assets, which is of particular concern in rapidly developing regions.

Thirdly, the role of local government in biodiversity conservation operates at both a regulatory and advisory level, in that local councils direct both short- and long-term influences on land management and development processes across varied land tenures. As such, a review of existing policies is also necessary to acknowledge and guide the conservation contribution within the private sector.

In closing, this review of local council policies provides new evidence demonstrating the lack of connectivity between federal policy and local implementation. While existing legislation identifies the need to retain 'forests', 'regional ecosystems', 'remnant habitat' or 'vegetation communities', it masks the fact that it is largely ineffective in delivering real on-ground conservation actions for finer scale habitat features such as hollow-bearing trees, particularly for those found within urban landscapes and non-protected forests.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge the contributions made by the various councils that supplied information on the management strategies that they employed for the retention of hollow-bearing trees at the local level. The research was funded by Griffith University and the Gold Coast City Council. An earlier version of this manuscript benefited from the comments from anonymous reviewers.

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Received: March 2012; Accepted: March 2013

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