1-1-2013

Changes to land tenure and pastoral lease ownership in Western Australia's central rangelands: Implications for co-operative, landscape-scale management

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10.1071/RJ11088

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Abstract. The majority of arid and semi-arid land in the Western Australian pastoral zone has a long history of livestock grazing within an extensive network of predominantly family-held pastoral leases. A variety of different groups have purchased pastoral leases in the last five decades and, for many, making a profit from pastoralism is no longer a priority. For the central rangelands of Western Australia, these groups have included: government agencies, who have purchased some 9 % of pastoral leases by area; private conservation organisations (<1 % purchased); aboriginal communities and groups (*c.* 7 %); and mining companies (*c.* 13 %). The purchases of pastoral leases by government agencies was designed to improve the conservation status of arid-zone ecosystems, and is the first step in a process of changing land tenure to a conservation reserve. This paper summarises the extent and other characteristics of these changes in land tenure and ownership of pastoral leases, and explores the implications for land management and conservation, stemming from these changes. It demonstrates that large areas of contiguous land with no or reduced domestic stocking can now be found in many parts of these rangelands, particularly in the Coolgardie, Yalgoo and Pilbara bio-regions, with some leaseholders actively

managing land for the conservation of biodiversity and restoring sites degraded through past over-grazing. In some bio-regions, such land covers considerable proportions of sub-catchments, suggesting that broad-scale conservation management and restoration objectives may be realised. It is argued that to fully realise these objectives requires effective communication and co-ordination between land managers, including sharing of ideas, view-points and resources. In particular, mining companies, now major holders of pastoral leases in Western Australia, can play an important role in contributing to and even facilitating such objectives.

Additional keywords: land-use change, mining, pastoralism, grazing management, property rights, multi-functional transition**,** landscape ecology, ecosystem management, catchment management

Introduction

The various types of land tenure, and their spatial extent and configuration, can have a profound effect on rangeland condition. This is because land tenure legally mandates the permissible uses of land, constraints to such uses and specific property rights, as well as influencing the objectives of rangeland management (Holmes 1997, 2006; Homewood and Thompson 2010). Differences in rangeland condition have been regularly noted across types of land tenure (Homewood *et al*. 2001; Vetter *et al*. 2006; Williams *et al*. 2009) and, indeed change of tenure, such as from a pastoral lease to a conservation lease, has resulted in improvements in rangeland condition (Cheal 2009). Quantification of changes in land tenure over time is, therefore, likely to be of interest to managers of rangelands and policy-makers more generally. Common types of rangeland tenure are lease systems (the long-term rental of government or Crown land by third parties for grazing and/or other activities), freehold and various types of traditional land tenure, such as through long-term association with land by indigenous people.

The characteristics of the landholder can have an equally persuasive effect on rangeland condition through their influence on such things as overall land management ethos, management priorities and economic imperatives (Huntsinger *et al.* 2010). Type of landholder can cut across types of land tenure; for instance, in Australia, indigenous people may hold rangelands through freehold title (mostly non-transferable), common-law native title or ownership of a pastoral lease (Holmes 2010). Quantification of spatial changes in land, based on landholder type, is also likely to be of interest to those responsible for rangeland policy and management.

There has been a long history of pastoralism in the arid and semi-arid lands of Western Australia. European settlers first began grazing domestic livestock in the

64 southern Murchison region in the 1860s and, by 1910, most of the land suitable for
65 grazing along the Murchison and Gascoyne Rivers, and their major tributaries, had
66 been allocated to pastoralists (Burnside 1979; Curry *et al*. 1994). Initially, pastoralists
67 in these areas made use of existing surface waters and shallow wells nearby, thereby
68 concentrating impacts on river frontages and around wells. Generally, higher and
69 more persistent stocking rates of livestock were achieved from the 1920s onwards as
70 technology became available for constructing deeper earthen dams and bores (Pearson
71 and Lennon 2010). The establishment of these permanent or otherwise long-term
72 watering points facilitated the spread of leases away from major river systems. By the
73 1930s almost all of the semi-arid and arid woodland and shrublands in the western
74 half of Western Australia and south of the Tropic of Capricorn were under pastoral
75 lease and subject to grazing by livestock, mainly sheep and cattle (Curry *et al*. 1994).
76 By 1955, close to 90 % of the Murchison, Gascoyne and Carnarvon bio-regions were
77 covered in more-or-less spatially continuous pastoral leases. Most of these leases have
78 been held and run as small family operations, many of whom lived permanently on
79 the stations, a tradition which is now less common. For most of the period from 1910
80 to 1990, with the notable exceptions of prolonged drought periods, such as 1935-1941
81 and the late 1970s, the pastoral industry in these regions has been financially
82 profitable (Brandis 2008).

83 The impacts of widespread and sustained grazing pressure, not only from
84 domestic livestock but also kangaroos and feral animals, such as goats, have been
85 substantial in these rangelands and include loss of vegetation and microbial crusts
86 with subsequent soil erosion, as well as changes in the composition of plant species
87 towards less preferred plant species, particularly around water-points (Wilcox and
88 McKinnon 1972; Curry *et al*. 1994; Landsberg *et al.* 1997; Ludwig *et al*. 1997).

Regional rangeland surveys have indicated that 25 % of the rangelands of Western Australia are in poor condition, with the Murchison bio-region having the highest proportion of land in poor range condition (42 %) and the Pilbara bio-region the lowest (12 %; EPA, 2004), although there is evidence of improving range condition away from major drainage systems (Watson *et al.* 2007). Much of the impact of pastoralism in these regions can be attributed to the persistence of very high stocking rates, built up through runs of wet years, into a succeeding period of severe drought (Stafford Smith *et al*. 2007). Pastoralism is also implicated in the loss of biodiversity; for instance, it is often cited as one of the primary reasons for the loss of small- to medium-sized mammals throughout arid and semi-arid Australia (Letnic 2007).

Following decades of stability, noteworthy changes to land tenure and the type of holder of pastoral leases have occurred in Western Australia's rangelands in recent years. Some of these are reasonably well-documented, such as the holding of pastoral leases by the Western Australian Department of Environment and Conservation (WADEC) for the purposes of conservation (Brandis 2008). Under this process, pastoral leases were systematically evaluated, based on specific selection criteria, and, if suitable and available, purchased from the holder by the government and reverted to Unallocated Crown Land as an interim measure before changing to a conservation land tenure at a later date (Brandis 2008; Economics and Industry Standing Committee 2010). Less well-publicised are the holding of pastoral leases by mining companies, indigenous groups and various conservation and scientific organisations for whom pastoralism is usually not the main priority or activity.

To date, no overview of these changes in land tenure and of the holders of pastoral leases, in terms of spatial area and configuration, has been published, nor has an exploration of the broader ecological and conservation implications of these

changes been undertaken. This paper seeks to quantify changes to Western Australian pastoral leases from the 1950s to recent times, chiefly in terms of amendments to land tenure and the types of lease holders, and evaluates the potential for such changes to realise outcomes for nature conservation and the restoration of degraded landscapes. It is particularly focussed on exploring the implications of land tenure and landholder changes on landscape- to regional-scale ecosystem patterns and processes. The study area is the main rangeland belt across central Western Australia, which are arid and semi-arid lands consisting predominantly of *Acacia* shrublands/woodlands, and is delineated by six bio-regions (Pilbara, Gascoyne, Carnarvon, Yalgoo, Murchison and Coolgardie), covering some 76 m ha in total (Fig. 1). It excludes the Nullarbor and the three Kimberley rangeland bio-regions as these are distinct in terms of pastoral lease ownership, vegetation and climate, as well as being spatially separate from the main rangeland belt of Western Australia. Bio-regions are broad-scale geographic classifications of land based on biophysical characteristics as determined by the interim Biogeographic Regionalisation for Australia (Thackway and Cresswell 1997) and are commonly used for conservation planning and assessment purposes.

Definitions, data and spatial analyses

Although pastoral lands and their resources are owned by the Crown in Western Australia, leases may be bought or sold on the open market and, hence, for the purposes of this paper, a person or organisation can be holder of a pastoral lease which gives them rights to graze that land and sell livestock from it. The holder of a pastoral lease is also referred to as the lessee or leaseholder. Three types of holders of pastoral leases are recognised in this paper: 1) individual, family or company, referred to as private leases in this paper, for whom pastoralism (grazing of livestock) is the

139 main objective and means of livelihood; 2) mining company, who may maintain some
140 livestock but whose main objective is typically not pastoralism but rather mineral
141 extraction, exploration and/or access; and 3) aboriginal group where pastoralism may
142 be an objective, but not always the only one (e.g. traditional land uses may also be
143 practised; Eringa and Wittber 2010) - these are referred to as indigenous pastoral
144 leases in this paper. Two additional categories of ownership are recognised for
145 pastoral leases acquired between 1998 and 2008 for the purpose of conservation: 1)
146 'WADEC' for those many pastoral leases purchased by WADEC in this period; and
147 2) 'non-government conservation' which represents pastoral lease purchases by
148 private conservation organisations. The WADEC-held leases are planned to be
149 converted to conservation reserves, the first step of which has involved
150 relinquishment of the lease which results in automatic but interim reversion of land to
151 the Unallocated Crown Land category. The proposed next step is formal change of
152 tenure to conservation reserve which requires approval by the Western Australian
153 State Parliament which has yet to occur. Most of the WADEC-held leases, therefore,
154 are no longer pastoral leases in terms of land tenure but are maintained as a separate
155 entity in this paper to highlight recent trends in conversions of leases and the fact that
156 this transition in tenure to conservation reserve is likely to take some time and is not
157 guaranteed.

158 Spatial and temporal data on land tenure and lease ownership within the study
159 area was obtained from a number of sources (Table 1). Data on land tenure was
160 obtained from the National Land and Water Resources Audit of Australian
161 rangelands, which includes detailed land tenure maps for 1955, 1965, 1975, 1985,
162 1995 and 1999. This data was then updated using other government spatial databases
163 (Table 1) and statistics (e.g. land tenure statistics of the WADEC and the

Collaborative Australian Protected Area Database to provide statistics on land tenure for 2008). Spatial data on the holders of pastoral leases was obtained from a GIS coverage of pastoral leases (with categories based on audit of lease holders conducted in late 2008) maintained by Department of Agriculture and Food, Western Australia (Table 1).

GIS coverages on land tenure and lease ownership were intersected with catchment and region coverages from the interim Biogeographic Regionalisation for Australia database (Table 1) using the Spatial Analysis extension in ESRI ArcGIS v.9 (ESRI, Redlands, California, US) to generate statistics on the spatial extent of various types of land tenure and the holders of leases by region and major catchment. All coverages were rendered consistent in terms of map projection, datum (GDA94), UTM zone (50) and unit of measure before spatial analyses.

Changes in land tenure and the holders of pastoral leases in central Western Australian rangelands

Although the vast majority of land in the study area remains as pastoral lease tenure (~ 65 %; Table 2), the area and number of pastoral leases has declined since 1955, especially those held by families and/or companies (non-indigenous leases in Fig. 2). Between 1955 and 2008, the area of non-indigenous leases declined by 8.9 m ha, which represents about 12 % of the study area (Fig. 2). The bulk of this change has occurred since 1995 and is mostly attributable to pastoral leases being purchased by the WADEC and aboriginal organisations. Pastoral leases owned by aboriginal groups have increased gradually over the last few decades (Fig. 2) and now occupy almost 5 % of the study area (Table 2).

188 Many of the WADEC-held pastoral leases were acquired under the Gascoyne-
189 Murchison Strategy between 1998 and 2004 with some 4 m ha across 37 pastoral
190 leases (including 19 part leases) being purchased in this period (Brandis 2008; Hughes
191 and Jones 2010). The Gascoyne-Murchison Strategy was implemented to improve
192 ecological, social and economic sustainability across these regions. With inclusion of
193 these and more recent conversions of pastoral leases, conservation reserves now
194 occupy some 11.5 % of the study area (up from <1 % in 1955; Table 2 & Fig. 2).
195 Although almost all of these WADEC-held pastoral leases are presently Unallocated
196 Crown Land, this is a temporary measure as previously noted. During this transition
197 period, they are managed for conservation by the WADEC under a Memorandum of
198 Understanding between the WADEC and Department of Regional Lands and
199 Development (Economics and Industry Standing Committee 2010).
200 The contribution of these pastoral leases held by the WADEC to improving the
201 network of conservation reserves has been assessed in detail (Brandis 2008). Other
202 changes in the holders of pastoral leases have also occurred, especially since the late
203 1990s. Non-government conservation organisations have recently purchased leases in
204 and around the Yalgoo bio-region, namely Mt Gibson and Faure stations by the
205 Australian Wildlife Conservancy, and White Wells and Eurardy stations by Bush
206 Heritage Australia. Pastoral leases managed for conservation by Non-government
207 conservation organisations now cover some 48 800 ha of the study area (Fig. 3),
208 although the total area of these reserves is 231 000 ha. This is because these reserves
209 straddle the study area boundary, i.e. they extend into the Avon and Geraldton
210 Sandplain regions to the south. Another example of a new type of owner is the CSIRO
211 who purchased the Boolardy lease (357 000 ha) in 2009, primarily to facilitate
212 astronomical research including the proposed Square Kilometre Array. Aboriginal-

213 controlled pastoral leases have also increased, including land set aside as Indigenous
214 Protected Areas such as a section of Ninghan station in the Yalgoo bio-region, to
215 around 4.4 m ha. Lastly, as of 2008, 43 pastoral leases covering 8.4 m ha were
216 controlled by mining companies or their subsidiary interests (Fig. 3). Typically
217 mining companies have purchased pastoral leases where they have considerable
218 mining leases and/or activity. Mining companies, for instance, hold some 24 % of
219 pastoral leases in the Coolgardie bio-region and some 44 % of leases in the Fortescue
220 River catchment in the Pilbara bio-region (Table 2). Although leases are regularly
221 changing their holder, and are sometimes held indirectly by mining companies
222 through their ownership of pastoral companies, the data demonstrates that mining
223 companies now have at least as much current or former pastoral land under their
224 management as conservation agencies and aboriginal groups combined (Fig. 3).
225 Furthermore, the holding by mining companies of pastoral leases is likely to increase
226 over coming years in line with major expansions in mining activity predicted
227 throughout the study area. Pastoral leases are currently of up to 50 years duration in
228 Western Australia and will next expire in 2015; 95 exclusions on 75 leases across the
229 state are planned for 2015, mostly for areas deemed to be of conservation significance
230 (some 1.4 m ha in total; Karel Enringa, pers. comm.).

231 The outcome of these recent purchases of pastoral leases is that some 71 % of
232 leases, including the recent WADEC acquisitions, by both area and number, are
233 privately held, mostly by families but also by some pastoral companies, whilst the
234 other 29 % is being managed by groups for whom making a profit from pastoralism is
235 not necessarily a priority (Fig. 3). This percentage of leases and ex-leases managed by
236 non-private owners varies from region to region (e.g. high in Coolgardie, Pilbara and
237 Yalgoo bio-regions and low for the Carnarvon bio-region; Table 2). For some owners

(WADEC, Bush Heritage Australia and Australian Wildlife Conservancy), these leases (or ex-leases) are managed solely for the purposes of nature conservation, with de-stocking and varying degrees of de-watering (i.e. closing artificial water-points) being practised, which has generated some controversy (Economics and Industry Standing Committee, 2010). Many mining companies have adopted more conservative stocking regimes on their pastoral leases, with some practicing, at least temporarily, de-stocking. Although some mining companies, especially in the Pilbara bio-region, have appointed station managers and continue to obtain profits from pastoralism, for most it is of secondary or minor importance as the main reasons for the holding of the lease are to allow unfettered access to mineral resources and reduce risks and liabilities such as those associated with straying stock.

Leaseholders need to demonstrate some pastoral practice on their lands and are not permitted to use land for non-pastoral purposes under the conditions of the *Land Administration Act 1997* (Western Australia) except where a diversification permit has been granted to enable an alternative use. Temporary de-stocking, or spelling, is allowed under this Act to facilitate recovery of severely degraded land. Section 108 of the *Land Administration Act 1997* states that "the lessee must use methods of best pastoral and environmental practice, appropriate to the area where the land is situated, for the management of stock and the management, conservation and regeneration of pasture for grazing". There is, therefore, considerable scope to adjust stocking regimes in accordance with more long-term sustainability objectives. A pertinent example of how mining companies may strive to improve conservation values of their pastoral leases, whilst maintaining conservative pastoralism, is Mt Weld station which is working to a sustainability and biodiversity management plan (James *et al*. 2001).

In 2011, an amendment to the *Land Administration Act 1997* to allow for different types of pastoral lease, including a 'rangeland lease' which permits a greater diversity of uses, such as conservation, tourism and indigenous uses, was proposed as part of the Rangeland Reform Process in Western Australia (RDL 2011). Such an amendment, if passed, will allow Non-government conservation organisations, mining companies and other owners more scope to adjust stocking and generally manage land in line with their chosen objectives and ethos. In Western Australia, changing patterns of rangeland holders, in combination with changes in socio-economic conditions both locally and more broadly, are driving changes to land tenure arrangements and legislation, and can be seen as important steps in the shift from production-only livestock systems to that of multiple values and land uses (Hughes and Jones 2010). This multi-functional transition has been reported in rangelands elsewhere in Australia (Holmes 2002, 2010) and other affluent countries (Huntsinger *et al*. 2010).

Although the WADEC aimed in part to disperse their purchases of pastoral leases under the Gascoyne-Murchison Strategy to improve representation and coverage of poorly reserved ecosystem/vegetation types (Brandis 2008), the more random and opportunistic nature of the availability of pastoral leases for sale, as well as the concentration of pastoral leases held by mining companies in the main mining belts, means that large contiguous areas of these non-private pastoral leases now occur (DAWA 2002; Fig. 1). Nine such areas have been identified and many of these have adjoining or intervening formal conservation reserves further expanding the area of land no longer managed for traditional pastoralism (numbers cross-reference to Fig. 1): 1) Hamersley Ranges and Upper Fortescue Valley; 2) West Pilbara: Onslow - Pannawonica-Karratha; 3) Meekatharra – Kumarina; 4) Sandstone – Lake Mason; 5) Northern Goldfields: Leinster to Wiluna; 6) Northern Goldfields: Laverton to Lenora;

7) North of Perenjori to Koolyanobbing; 8) Northern Geraldton Sandplains to Shark Bay; and 9) Southern Goldfields - Kalgoorlie area.

The unevenness in the spatial distribution of pastoral lease holders is evident when comparing bio-region to catchment statistics: e.g. some 72 % of the Murchison River and Gascoyne River catchments are covered in private pastoral leases, whereas the broader Murchison and Gascoyne IBRA regions have 60 – 63 % of the land surface covered in such leases (Table 2; Fig. 1). Such discrepancies reflect the large number of pastoral leases held by mining companies in areas of active mining to the east of these catchments where drainage occurs to the inland of the continent, but also may reflect greater profitability of pastoralism towards the west, which translates into fewer properties being available for purchase, especially along the floodplains of the major river systems. There are relatively few areas set aside for conservation or not under pastoral management along the major river floodplains, such as the Murchison and Gascoyne Rivers, where degradation is widespread and often severe (Wilcox and McKinnon 1974; Curry *et al*. 1994; Pringle *et al*. 2006). This has important implications for broad-scale land management and restoration, which are explored below.

Management of rangelands at landscape to regional scales

Through the relatively new disciplines of landscape ecology and ecosystem management, there is now a greater appreciation of ecological processes and other ecological phenomena operating over broad spatial scales (Christensen *et al*. 1996; Lindenmeyer *et al*. 2008; Stafford Smith and McAllister 2008). Some examples of such processes relevant to rangelands of the study area are summarised in Table 3. Although individual pastoral leases in Western Australia typically cover >100 000 ha,

312 the subdued topography, ancient and well-sorted soils and landforms, and the sparse
313 nature of the vegetation, mean many of these processes need to be managed over a
314 number of contiguous leases.

315 A prime example of a broad-scale process operating in arid rangelands is
316 surface water flow and subsequent redistribution of alluvial soil and other resources
317 (Pringle and Tinley, 2003). Typically this process has been monitored and managed at
318 within-landscape scales through the quantification and, where necessary, restoration
319 of vegetation patch to inter-patch soil fluxes (Tongway and Ludwig 2010). However,
320 much remedial action directed locally is likely to be of short-term benefit if base
321 levels downslope have been incised and thereby lowered due to erosion within
322 watercourses which may follow overgrazing, for instance. Incision causes faster, more
323 confined flows which results in further gullying and lateral erosion, and increased
324 sedimentation downstream, as well as increasing and expanding desiccation upstream
325 (Pringle and Tinley, 2003; Pringle *et al.* 2006). Thus a sequential process of land
326 degradation can be set in place, gradually moving to upper parts of the catchment
327 (Pringle and Tinley 2003). In other words, dysfunction at the catchment scale may
328 take precedence over that at local and landscape scales and, furthermore, management
329 actions may have impacts considerable distance away, both upstream and
330 downstream. This suggests that leaseholders must co-operate at the broad scales of
331 catchments or sub-catchments to be effective in restoration.

332 Another key process operating at broader spatial scales is the movement of
333 fauna, particularly emus and kangaroos. Many of these are nomadic or semi-nomadic
334 and may move over large distances as they seek food resources generally available
335 following large episodic rain events (Davies 1984); some fences, e.g. barrier fences,
336 and other structures can impede such movements resulting in increased grazing and

337 trampling impacts where animals accumulate. Such vertebrates are also dispersers of
338 seed over long distances thus facilitating regional gene flow (Calvino-Cancela *et al*.
339 2006, 2007). Similarly, control of exotic vertebrates, such as foxes, wild dogs and
340 goats, is likely to be more effective when practiced at a regional scale compared to
341 lease or paddock scale.

342 Fire is another key ecological factor operating at broader spatial scales (Table
343 3). Most rangelands within the study area can potentially experience fire although
344 mostly only following abundant rain and/or sustained low grazing pressures (Nano *et*
345 *al*. 2012). Vegetation types, dominating around the margins of the study area, e.g.
346 shrublands on sandplains and hummock grasslands, however, tend to experience
347 widespread wildfires which may burn unchecked for days or even weeks, often
348 crossing lease and land tenure boundaries. Such wildfires homogenise landscapes in
349 terms of fuel age and habitat characteristics (Burrows *et al*. 2006). Management
350 strategies to deal with such large fires include improving suppression capabilities
351 and/or introducing a patch burning scheme to lower fuel levels and create landscape-
352 scale mosaics of different burn ages; both approaches require co-operation across
353 properties/leases given the expanses of land involved (Legge *et al*. 2011).

354 The establishment of conservation reserves on pastoral leases as part of the
355 Gascoyne-Murchison Strategy increased the proportion of vegetation associations
356 represented in reserves from ~ 29 % to ~ 58 %, and the proportion well represented in
357 reserves (those with > 10 % of their spatial extent in reserves) from ~ 7 % to about a
358 third (Brandis 2008). Therefore despite the planned nature of lease acquisitions under
359 the Gascoyne-Murchison Strategy, many vegetation associations are not represented
360 in reserves, which is not unexpected given that many have restricted distributions
361 (<50 000 ha). Nor could they be expected to protect the majority of species given high

spatial turnover of species within some ecosystems (Gove *et al*. 2008; Gibson *et al.* 2011). The responsibility for stewardship for many of these unreserved and poorly-reserved vegetation types and species, therefore, falls to leaseholders and emphasises the need for off-reserve conservation strategies.

Co-operative rangeland management across pastoral leases

It has been argued that co-ordination and co-operation across adjoining pastoral leases is required to effectively manage certain ecological and threatening/degradation processes. Impairment of certain processes is resulting in catchment-scale dysfunction and requires a joint approach over whole catchments or sub-catchments as appropriate (Pringle and Tinley 2003). Although the need to manage such processes across broad spatial scales is not new, this need is not always recognised by agencies with responsibilities for rangeland management. The shift towards multiple ownership types and land use in the study area presents both additional challenges and opportunities to fulfil such management objectives (Hughes and Jones 2010). Achieving integrated, community-driven catchment management can be difficult in any region but there is now a huge amount of experience gained from broad-acre agricultural regions (Curtis and Lockwood 2000). Additional obstacles which need to be overcome to achieve effective co-operation in rangeland areas include financial constraints faced by many leaseholders, as well as the large distances between pastoral stations and their remoteness from relevant management and administrative agencies; having a greater range of organisations with direct responsibility or interest in rangeland management may actually hinder such co-operation through increased bureaucracy and discouragement of local initiatives (Hughes and Jones 2010). In terms of opportunities, having a greater range of values and management objectives,

387 including conservation, may foster and promote greater focus and acceptance on
388 broad-scale restoration and land stewardship objectives more broadly (Kreuter *et al.*
389 2006). Furthermore, the rise in new, non-private leaseholders and land managers, such
390 as mining companies and conservation organisations, may help initiate and facilitate
391 cross-lease co-operation, and help fund management actions as required. This is
392 already happening locally in some rangeland areas where neighbours are building on
393 existing working relationships to improve communication and better manage
394 threatening processes such as fire and feral animals. A good example is from the
395 southern Yalgoo area where managers of contiguous leases/land (Bush Heritage
396 Australia, Australian Wildlife Conservancy, WADEC, Ninghan Indigenous Protected
397 Area, pastoralists and mining companies) are working towards forming an association
398 with some initial funding coming from the mining sector. The message emerging here
399 is that it may be more productive to let such collectives evolve through local contacts
400 rather than forcing co-operation via remote government bureaucracies.

401 A major focus of co-operation between neighbouring lessees and managers
402 revolves around managing boundary issues, especially where land managed for
403 conservation abuts that managed principally for livestock production (Brandis 2006,
404 2008). Boundary issues include movement of unwanted animals (livestock straying
405 into conservation areas and kangaroos moving into pastoral leases), maintaining
406 fences, weed invasion, fire movement, gate closure and access controls. The WADEC
407 has a “Good Neighbour Policy” which establishes responsibilities in such
408 circumstances (WADEC, 2007). Dramatic shifts in land ownership in rural areas often
409 leads to problems particularly where management objectives and ethos of new owners
410 differ from the status quo, and especially where such changes are perceived to be
411 imposed by government (Holmes 2006). There appears to be growing concern

amongst private pastoral leaseholders within parts of the study area over the lack of committed resources and on-ground managers on newly acquired leases, as well as increasing conflict between neighbouring lease-holders over different and sometimes opposing land management practices (Hughes and Jones 2010; Economics and Industry Standing Committee 2010). This has developed despite considerable public consultation during the lease purchase phase by the WADEC (Brandis 2008) and suggests that achieving effective working relationships between landowners and general acceptance of land use/tenure changes amongst local communities is not straight-forward and requires a sustained effort in terms of resources and time. Additionally it suggests that top-down approaches are less likely to be successful over the longer term than bottom-up, community-driven change (Hughes and Jones 2010).

Despite these difficulties, it is expected that government agencies will still have an important role in initiating and facilitating co-operative approaches over broad spatial scales involving many leases. A prime example of where this has worked in the study area is the Ecosystem Management Understanding Project, initially an element of the Gascoyne-Murchison Strategy and largely funded by the National Heritage Trust and co-ordinated by WADEC and Department of Agriculture for Western Australia. This programme involved the employment of landscape ecologists with local rangeland knowledge as facilitators to help landholders prepare Environmental Management Systems for their leases, as well as fostering an ecological sustainable land management ethos in which catchment-level processes and management were considered integral to achieving sustainable production outcomes. Lessees from some 77 properties within the study area (including 10 WADEC-acquired leases) took part in the Ecosystem Management Understanding Project between 2000 and 2004 (Pringle *et al*. 2003). The project was popular with pastoralists and was highly

successful, especially in terms of establishing working relationships between pastoralists, industry, indigenous groups and the ecologists involved. It has since been run in similar form in other parts of Australia (Walton and Pringle 2010).

Conclusions

New landholders, particularly mining companies, but also conservation agencies and aboriginal groups, are now, either directly or indirectly, managers of large expanses of current or former pastoral leases across the rangelands of arid and semi-arid Western Australia. The combined area of their leases, some 8.6 m ha, is some 20 % of the total area of the central rangelands of Western Australia, and in some regions they are the majority landholder with contiguous expanses of non-private leases linking with formal conservation reserves. As mining companies and conservation agencies, both private and government, are not dependent on earning a living from their leases, they may be in a better position to not only deploy ecologically sustainable pastoral practices and restoration on their own leases but also facilitate, fund and contribute to broader-scale management and nature conservation initiatives which cross lease and other land tenure boundaries.

Acknowledgements

Tony Brandis, David Goodall and Hugh Pringle are thanked for comments on earlier versions of this paper and general advice. DAFWA and other agencies mentioned in Table 1 are thanked for supplying GIS data. Karel Eringa and two anonymous reviewers are thanked for providing constructive criticisms which greatly improved the paper.

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673 **Table 1**. **Geographic Information System (GIS) coverages used in this study,**

674 **together with source of information and date of last update.**

675

GIS Coverage	Custodian	Last Revised
National Land and Water Resources Audit of Australian rangelands (1955 to 2000)	Australian Bureau of Agricultural and Resource Economics	28-9-2005
Pastoral lease boundaries for Western Australia with ownership categories	Department of Agriculture and Food, Western Australia	30-11-2008
Interim biogeographic regionalisation for Australia, Version 6.1	Department of Sustainability, Environment, Water, Population and Communities	20-12-2004
Nested catchments data for the Australian continent - minimum area threshold 500 km^2	Department of Sustainability, Environment, Water, Population and Communities	10-1-2004

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Table 2. Percentage of total land area for different types of land tenure and pastoral lease holders in the central rangelands of Western Australia as of 2008. % of total current and former pastoral lease area are in parentheses. Catchment and interim Biogeographic Regionalisation for Australia (IBRA) regions are defined and spatially delineated as per Table 1.

Region	Pastoral Lease			Ex-Pastoral Lease	Other Tenure		
	Private	Mining	Aboriginal	WADEC *	Conservation Reserve[@]	UCL	Freehold & Other[#]
Catchment							
Murchison	71.6 (81.2)	4.2 (4.8)	8.8 (10.0)	3.5 (4.0)	2.7	3.5	5.7
Fortescue	31.4 (51.0)	27.2 (44.1)	3.0 (4.9)	0	6.2	21.8	10.3
Ashburton	52.1 (80.2)	8.1 (12.4)	4.2 (6.4)	0.6 (1.0)	8.5	24.5	1.8
Gascoyne	71.3 (77.3)	6.7 (7.3)	4.5 (4.9)	9.7 (10.6)	1.8	2.1	3.7
IBRA Region							
Carnarvon	76.7 (86.6)	0.3 (0.3)	5.0 (5.7)	6.6 (7.4)	3.9	6.3	0.9
Coolgardie	14.9 (61.8)	5.9 (24.4)	0	3.4 (13.8)	26.5	46.0	3.4
Gascoyne	61.2 (77.5)	4.2 (5.3)	5.6 (7.1)	8.0 (10.1)	2.5	16.8	1.5
Murchison	60.0 (69.1)	15.3 (17.6)	4.9 (5.6)	6.7 (7.8)	1.7	10.4	0.8
Pilbara	40.7 (63.3)	12.6 (19.7)	7.8 (12.1)	3.2 (4.9)	6.1	23.8	5.9
Yalgoo	48.2 (63.4)	5.3 (6.9)	3.9 (5.1)	18.7 (24.6)	8.3	11.9	3.6
Total Central W.A. Rangelands	51.2 (71.7)	9.2 (12.9)	4.9 (6.8)	6.2 (8.6)	5.3	20.4	2.9

[@]Conservation Reserve here refers only to formal or gazetted reserves. [#]Other land tenure include water reserves, road reserves, indigenous tenure (not including pastoral leases) and reserves for special purposes. *This category refers to recently purchased pastoral leases by the WADEC for conservation which are in process of being converted to formal conservation reserves via temporary reversion to Unallocated Crown Land.

686 **Table 3. Examples of ecological processes and phenomena operating at landscape to regional**
687 **spatial scales which may require co-operation amongst neighbouring pastoral leaseholders and**
688 **other land managers to effectively manage, together with examples of management issues and**
689 **relevant case studies from the Western Australian rangelands.**
690

Ecosystem Process	Western Australian rangelands examples	Case study reference(s)
Energy and Material Flows		
Erosion-deposition patterns and processes	Incisions causing lowering of base levels and upstream desiccation and erosion	Pringle and Tinley (2003); Pringle *et al*. (2006)
Water and nutrient flows	Disruption of sheet (surface) flow by roads and railways	Bertuch and van Etten (2004)
Biotic movement and gene flow		
Seed and pollen dispersal	a) Long distance seed dispersal by emus and other fauna b) Weed colonisation	Calvino-Cancela *et al*. (2006, 2007) Grice (2006)
Movement of larger vertebrates	a) Barriers to seasonal migration of macropods and emus; b) Effective feral animal control, e.g. goats, wild dogs; c) Distribution of watering points	Davies (1984) Letnic (2007) Kennedy *et al*. (2012)
Landscape heterogeneity and connectivity		
Home range area	Adequate habitat for conservation of top order predators, such as birds of prey and (perhaps) dingo	Letnic (2007) Kennedy *et al*.(2012)
Patch mosaics of preferred habitats, including refuge areas	a) Fire management to create replicated post-fire seral stages; b) Species which may require long unburnt patches (e.g. mallee fowl) c) Maintenance of refuge areas for species to survive extremes (e.g. drought)	Burrows *et al*. (2006); Parsons and Gosper (2011)
Corridors to facilitate movement between habitat patches	Healthy, well-vegetated riparian and floodplain zones	Stafford Smith and McAllister (2008)
Species turnover (between and within communities)	Reservation and off-reserve strategies to protect biodiversity and communities	Brandis (2008); Gibson *et al.* (2011)
Fire regimes		
Wildfire spread and behaviour	a) Wildfires burning across properties due to lack of resources to control wildfires b) Prescribed fire to control fuel build up over whole landscapes	Burrows *et al.* (2006) Nano *et al*. (2012)

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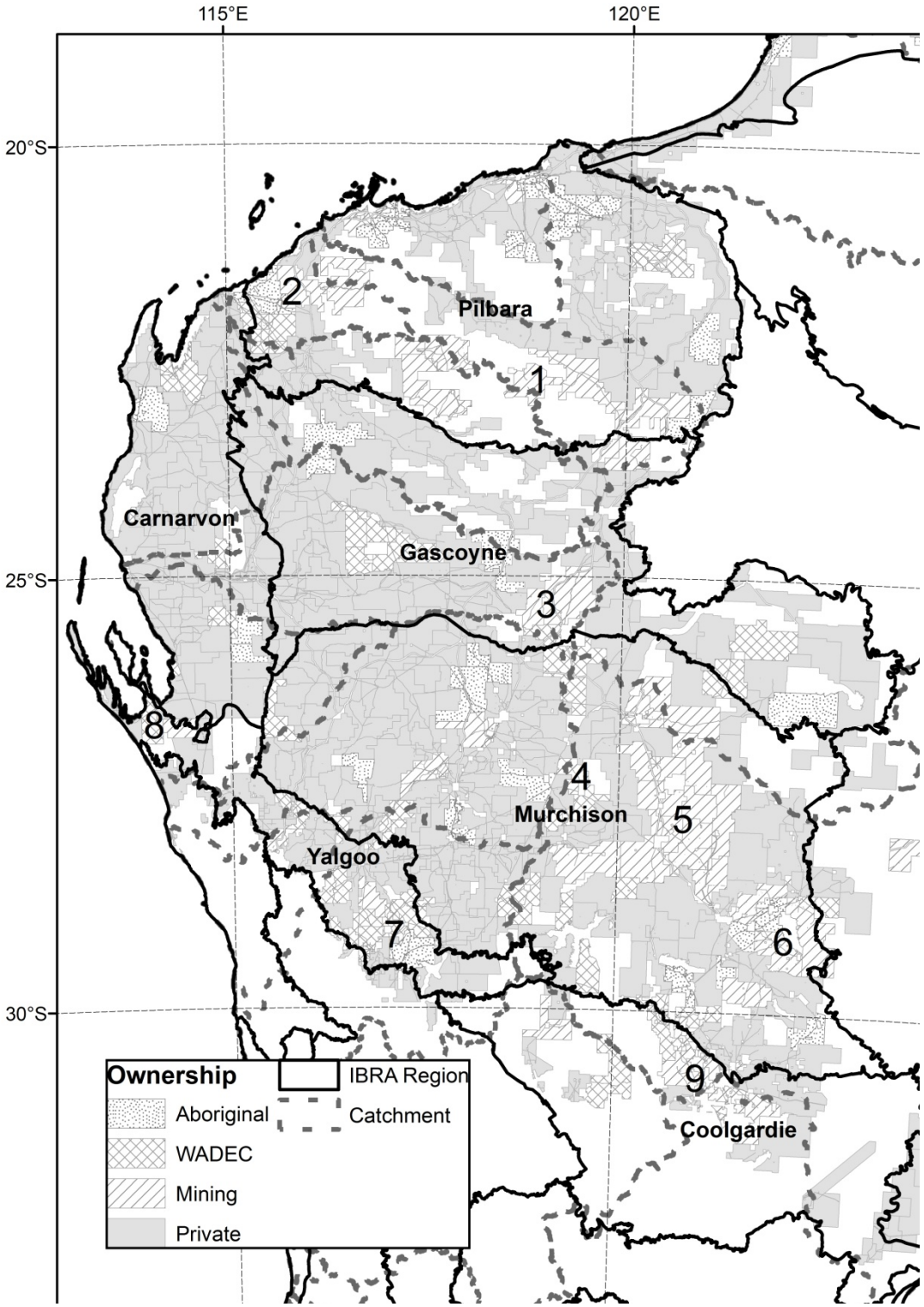


Fig. 1. Map showing ownership type of current and recently relinquished pastoral leases in central Western Australian rangelands (study area comprising 6 interim Biogeographic Regionalisation for Australia (IBRA) regions and major catchment boundaries are indicated). Leases shown here are active pastoral leases as of 2008 as well as recently relinquished leases purchased by government for conservation between 1998 and 2008 (shown as WADEC). Numbers 1 to 9 cross-reference to text.

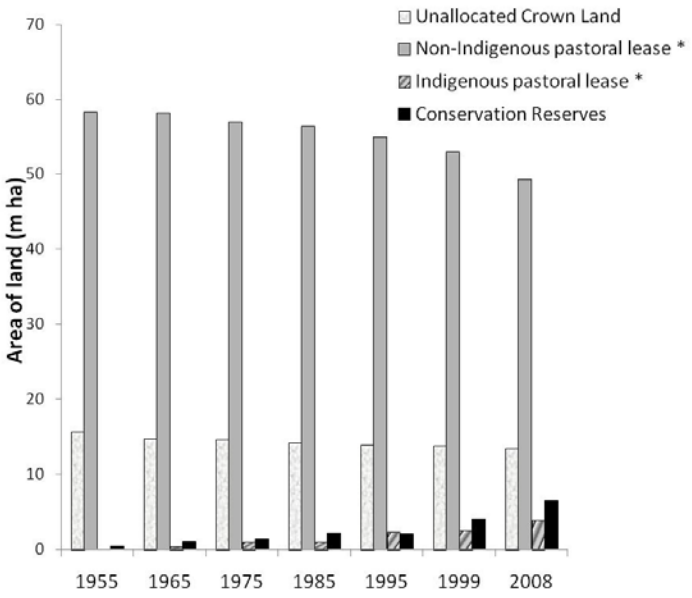
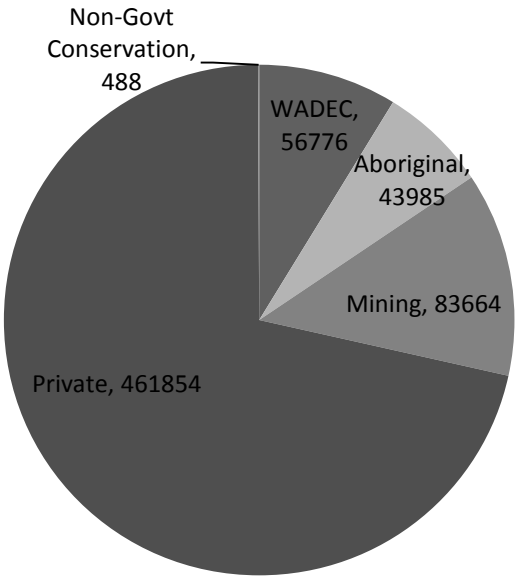


Fig. 2. Temporal trends in area of major land tenure types of central W.A. rangelands (6 interim Biogeographic Regionalisation for Australia regions: Pilbara, Gascoyne, Murchison, Carnavon, Coolgardie & Yalgoo) from 1955 to 2008. (*Indigenous pastoral lease and non-indigenous pastoral lease are the same tenure but have been sub-divided to show the proportion of leases that come under indigenous administration. Indigenous pastoral leases do not include aboriginal land administered or owned by Aboriginal land trusts, land councils or Aboriginal local governments.) Unallocated Crown Land (UCL) here does not include temporary reversions of WADEC-purchased pastoral leases.

a)



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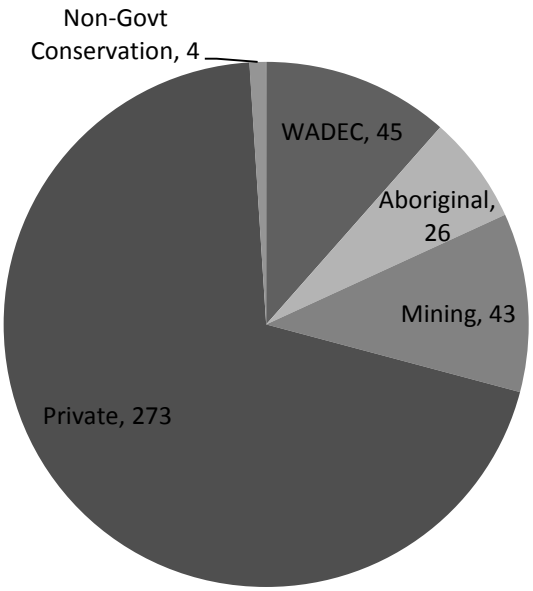

Fig. 3. Types of holders of pastoral leases within study area as of 2008 by: a) area in km^2; and b) number of leases (including part leases). Note: WADEC are pastoral leases recently purchased by the Western Australian Dept of Environment and Conservation and have been reverted to Unallocated Crown Land as an interim measure before conversion to conservation tenure at a later date.