From presumed extinct to probably secure? The resurrection and ongoing management of *Hibbertia rufa* (brown guineaflower) in north-east Tasmania

M. Wapstra[1]*, B. French[1], V. Tyquin[2] and R. Skabo[3]
[1]Environmental Consulting Options Tasmania (ECO*tas*), 28 Suncrest Avenue, Lenah Valley, Tasmania 7008
[2]Forestry Tasmania, GPO Box 207, Hobart, Tasmania, 7001
[3]6 Kootara Place, Trevallyn, Tasmania, 7250
*e-mail: mark@ecotas.com.au (corresponding author)

Abstract

Hibbertia rufa *(brown guineaflower) was rediscovered in wet heathlands west of The Gardens, north-east Tasmania, in December 2008, after not having been recorded in Tasmania since 1892. Surveys were conducted in potential habitat north of St Helens between The Gardens, Priory and Ansons Bay Road.* H. rufa *was found to be relatively widespread within a minimum convex polygon of 53.23 km*^{2}*. The species occurs mainly in wet heathland, but also extends through to buttongrass moorland and occasionally to sedgy-scrubby* Eucalyptus ovata-E. amygdalina *forest/woodland.*

H. rufa *occurs mainly on public land, and is relatively well reserved: subpopulations occur in the Doctors Peak Forest Reserve, Bells Marsh Forest Reserve, Mount Pearson State Reserve and several sites on State Forest protected through Forestry Tasmania's Management Decision Classification (MDC) land-use planning system. Limited direct threats to the conservation status of* H. rufa *were identified. Potential threats include inappropriate fire regimes, grazing pressure, competition with weeds, risk of disease, disturbance to wet heathland habitat from adjacent activities and road construction/maintenance, and clearing of habitat. Of these threats, only land clearing has probably resulted in a minor reduction in the area occupied by* H. rufa. *Virtually all sites on State Forest occur in vegetation types usually excluded from forestry activities and coded as "protection", "non-commercial" or some other non-forestry land use. We discuss recent management actions to further protect the species including the establishment of Special Management Zones.*

At the time of survey, H. rufa *was classified as Presumed Extinct under the Tasmanian Threatened Species Protection Act 1995. Based on new information, the species now qualifies as Rare, although only meeting some of the criteria of the Rare category used under the Act if a conservative approach is taken to the listing of species, which is considered appropriate at the present time.*

Introduction

Hibbertia rufa (brown guineaflower) occurs in Victoria (localised near Genoa in the far east, near the New South Wales border), New South Wales (widespread but not common in a narrow coastal band), and Queensland (Curtis 1975; Toelken 1996; Harden and Everett 2000). In Tasmania, until December 2008 the species was presumed to be extinct (Buchanan 2009), its occurrence represented by one collection from 1892. This status was recognised with a formal listing as "presumed extinct" (Schedule 3.2)

under the Tasmanian Threatened Species Protection Act 1995. In December 2008, *H. rufa* was re-discovered in wet heathland in the hinterlands of The Gardens, north-east Tasmania (Skabo 2008, 2009; Photo 1). The re-discovery of the species after 116 years prompted surveys within the potential range of the species (ECO*tas* 2009).

This paper presents the distribution, habitat characteristics, management issues, conservation and reservation status of *H. rufa* in Tasmania.

Collecting history of *Hibbertia rufa* in Tasmania

The Tasmanian Herbarium (HO) holds a single sheet of *H. rufa* (HO3043), and the National Herbarium of Victoria (MEL) holds a sheet (MEL35557) that is very likely a duplicate of HO3043 (A. Buchanan and H. Toelken, pers. comm. March 2009); both are dated 1892. Based on annotations on the MEL collection, the likely collector of both specimens was W. Fitzgerald. HO3043 was annotated with "George Bay" as the collection location, and MEL35557 with

Photo 1. Images of Hibbertia rufa. *A. Open flower of* Hibbertia rufa. *Note the small petals and low number of stamens (usually less than four). The tuft of hairs at the acute to obtuse leaf apex is also clearly visible. This specimen does not show the characteristic reddish-brown branchlet colouration (image: R. Skabo). B. Flower of* Hibbertia rufa *on branchlet showing typical reddish-brown colour. C. Fruit of* Hibbertia rufa *amongst tangled mass of reddish-brown branchlets with widely spaced, blunt leaves. D. Ground-hugging growth habit of* Hibbertia rufa *in small openings in dense heathland. It rarely ascends above 5 cm, but scrambles through thicker undergrowth making counting individuals difficult.*

"St. Helens, Tasm". It is likely that "George Bay" referred to a relatively large area of coastal and near-coastal hinterlands in and around the modern town of St Helens and the bay now known as Georges Bay, the outfall of the George River. Much of the environs of Georges Bay have been substantially modified since 1892 and it is impossible to know precisely where Fitzgerald collected his specimens.

Methods

Defining target areas for survey of Hibbertia rufa

The *Natural Values Atlas* database (NVA; Tasmanian Department of Primary Industries, Parks, Water and Environment; www.naturalvaluesatlas.tas.gov.au) was accessed (April 2009) to obtain records of *Hibbertia rufa.* These data and recent aerial imagery were transferred to GIS to assist in defining target search areas. The habitat at the locations known to support *H. rufa* (based on the authors' own initial explorations of the re-discovery site and a subsequent site detected by R. Skabo in March 2009) was used as the basis of predicting sites that may potentially support the species. These sites had wet heathland and similar vegetation associated with drainage systems on granite-based soils at low elevations.

Target areas were defined between St Helens and Eddystone Road, with a focus on the Doctors Peak Forest Reserve and surrounding areas (Figure 1, Figure 2). Most target areas were on public land, including State forest (which includes Forest Reserves) and Crown land (which includes National Parks, State Reserves and other Public Reserves). Due to limited resources, our extension surveys were focused on north-

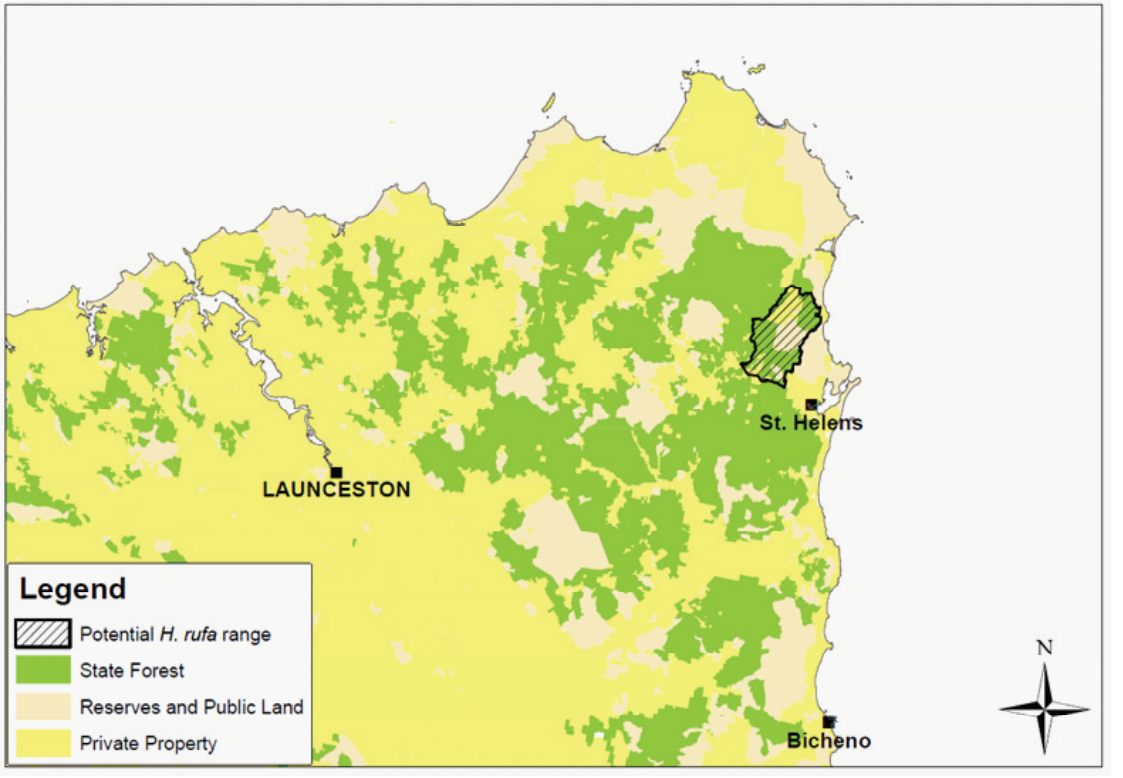

Figure 1. Statewide distribution of Hibbertia rufa.

eastern Tasmania, in the vicinity of the site of re-discovery. However, wet heathlands superficially suitable for the species occur virtually throughout Tasmania, and the fact that it also occurs on mainland Australia means that other parts of Tasmania remain a possibility for the species.

Botanical survey

This paper reports on various surveys undertaken by the authors between December 2008 and January 2010.

All sites assessed were surveyed by meandering transects slow-walked by the observers. Surveys aimed to assess the range of heathland vegetation types and successional ages present within each target area, without any deliberate bias towards patches of heathland with particularly higher chance of supporting *H. rufa.* However, it became reasonably clear to the observers that certain features of a heathland (e.g. species composition, vegetation structure, drainage conditions, etc.) could be more strongly associated with *H. rufa.* As much as possible of each heathland patch was assessed to provide a more accurate picture of the local distribution of the species, and to ensure that unwarranted bias was not applied to a poorly understood species. Transects covered the transition zone between forest/woodland defining the marshy heathlands, as well as the more tree-less heathland core.

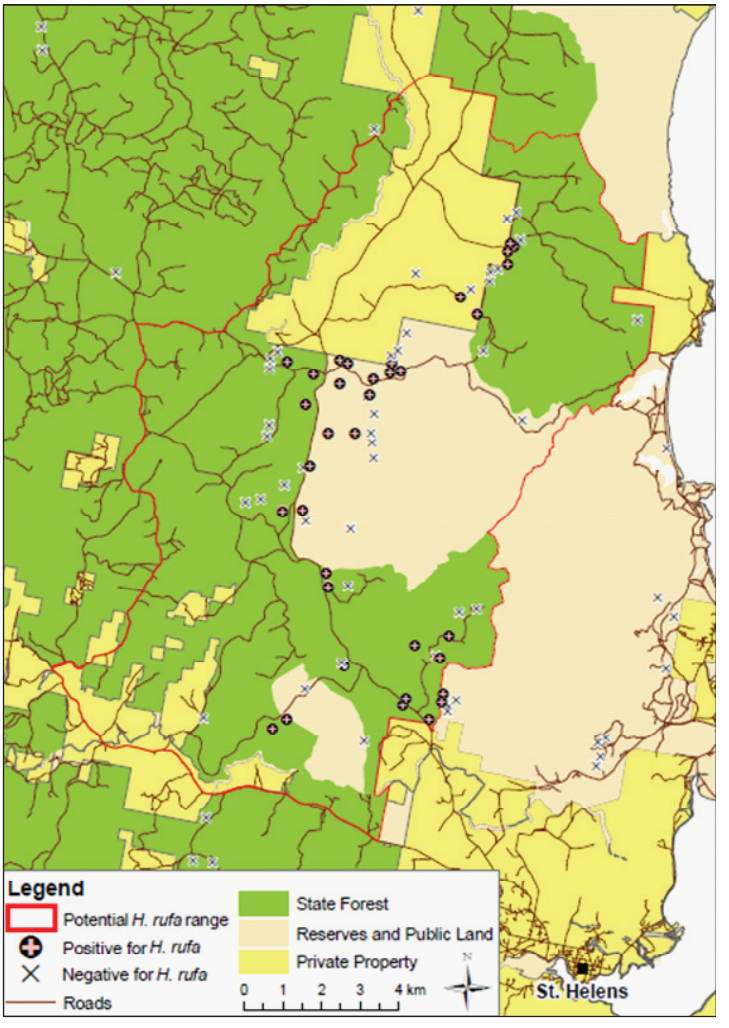

Figure 2. Distribution of Hibbertia rufa *in north-east Tasmania, and a potential range boundary. Note the conservative approach that extends the boundary well beyond the known sites for the species.*

At every target area, broad site characteristics (including vegetation types, land use and disturbance history) were recorded and photographs taken for later reference. For sites where *H. rufa* was detected, more details on site characteristics were recorded including a description of the representative structure and composition of the vegetation associated with the majority of the population of *H. rufa.*

Where *H. rufa* was detected, precise locations were determined using hand-held eTrex™ GPS units accurate to between 5-10 m, depending on satellite availability. Unless the detected population occupied a very limited area, several GPS points were

collected to allow later estimation of the extent of occurrence using GIS software.

Demographic information was collected for each population of *H. rufa*. Counting individuals of the species in a particular patch was impractical because it is usually a ground-hugging plant that becomes densely entangled amongst dense grasses, sedges and low shrubs; combined with a suckering habit, this makes separation of individuals time-consuming and very difficult. When large clumps of *H. rufa* were extracted from amongst dense grass (for preparation of herbarium voucher material), separation of branchlets in the lab proved almost impossible, since each clump was comprised of numerous individuals connected through a complex rooting system tangled amongst other plant species, soil, moss and lichen. Due to these limitations, demographic information was restricted to presence/absence statements and, where the species was present, qualitative notes on its abundance and micro-distribution (e.g. "localised to old track verges", "widespread and continuous between point X and point Y", "patchy distribution of scattered individuals", etc.).

The health of individuals was noted, with healthy plants defined as those without obvious symptoms of disease or drought stress such as browned leaves or stunted growth.

Management issues were identified by reference to site characteristics and observed disturbance history.

Plant collection and database entry

All plant material was collected under DPIPWE permit numbers TFL 08251, TFL 08070, TFL 09255 (in the names of Mark Wapstra, Brian French and Roy Skabo, respectively). Material from each population of *H. rufa* was collected, curated, and supplied to the Tasmanian Herbarium.

Mature fruit was present on some collected material. Fruit was hand-picked from as many plants as possible, and supplied to the Tasmanian Seed Safe project for long-term storage, as part of the Millennium Seed Bank project conducted under the auspices of the Royal Botanic Gardens, Kew, UK.

Site and demographic data for each of the described populations of *H. rufa* was supplied to the Department of Primary Industries, Parks, Water and Environment's *Natural Values Atlas* database.

Results and discussion

Distribution

Hibbertia rufa was relatively widespread between Priory and Thomas Creek, north-east Tasmania (Figure 1, Figure 2). Approximately 90 "wet heathland" sites (or parts of different wet heathland sites) were surveyed, 35 of which were positive for the presence of *H. rufa*. The formal Listing Statement for the species provides a detailed list of subpopulations (Threatened Species Section 2010). A minimum convex polygon encompassing all positive sites indicated an extent of occurrence of 5,323 ha (or 53.23 km^2). A minimum enclosing rectangle indicates a north-south linear extent of 12.66 km and an east-west linear extent of 6.40 km. The farthest distance between positive sites (Bells Marsh to Thomas Creek area) is 14.14 km. Minor range infillings and extensions are highly likely in the vicinity of mapped sites.

However, the potential range of the species, based on the distribution of potential habitat, is much larger (161.60 km^2). It is possible that the species occurs further afield in the north-east (e.g. wet heathlands of the northern part of Mount William National Park, Old Port Road/Banca Road area, Old Chum

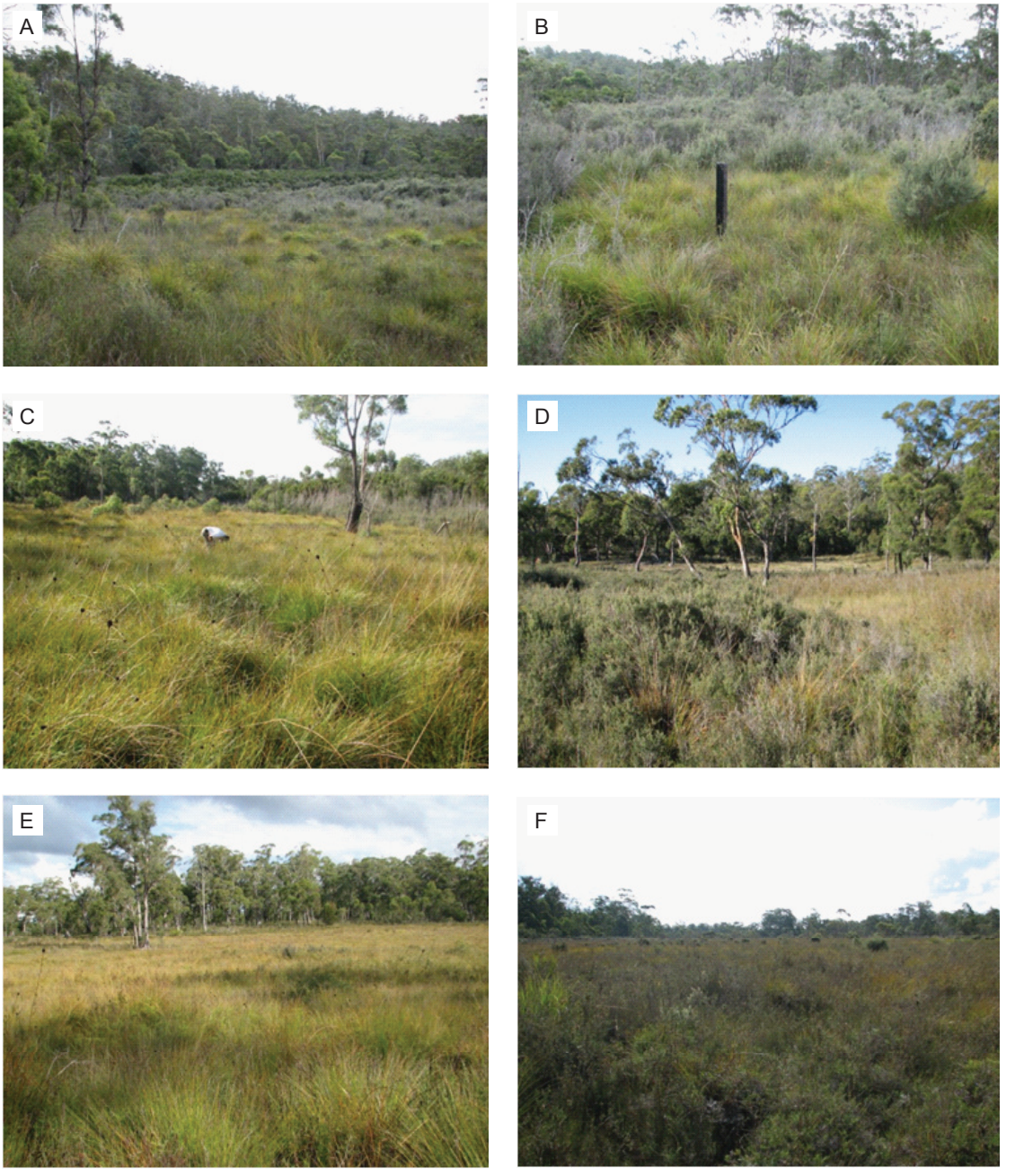

Photo 2. Images of habitat of Hibbertia rufa. *Top left (A), wet heathland in southern section of Charlies Marsh.* Hibbertia rufa *occurs at the lower end of the wet heathland. Top right (B), closer image of Charlies Marsh (south) site.* Hibbertia rufa *is localised to the foreground of the image but appears to be absent from the dense shrubby growth in background. Middle left (C), habitat of* Hibbertia rufa *in the Last River catchment. This was one of the few sites where the species occurred in dense buttongrass. Middle right (D), marsh just north of Priory (west of Ansons Bay Road).* Hibbertia rufa *is localised in the wet heathland near the emergent eucalypts. Bottom left (E), classic habitat of* Hibbertia rufa *in the Fight Creek catchment showing the mosaic of wet heathland and buttongrass with the distinct heathland/forest boundary in the background. Bottom right (F), similarly classic habitat of* Hibbertia rufa *in the Last River catchment, showing a shrubby wet heathland with a dense sedgy understorey.*

Dam area, etc.) or even further afield in wet heathlands in other parts of the State (e.g. Freycinet Peninsula, Rocky Cape area, etc.). That *H. rufa* has been overlooked for so long suggests that we should be alert for it in potential habitat anywhere in the State. However, it would be logical for the focus of further extension surveys to radiate out from the presently mapped distribution.

Habitat

Vegetation associations

H. rufa occurs mainly in wet heathland, but also extends through to buttongrass moorland and occasionally sedgy-scrubby *Eucalyptus ovata-E. amygdalina* forest/ woodland (Photo 2).

The majority of sites for *H. rufa* occur in typical low-lying, north-eastern Tasmanian wet heathland dominated by low sclerophyllous shrubs and a dense ground layer of sedges and rushes (Cyperaceae/ Restionaceae).

H. rufa rarely extends into sites that would be considered as dry heathland, but it can occur in the transition zone between typical wet heathland (which is often associated with poorly-drained terrain) and adjacent dry heathland/heathy woodland. Because the adjacent open forest is usually close to the drainage depression, *H. rufa* thus often occupies a narrow band of wet heathland.

Most wet heathland sites are topographically and vegetatively distinct from surrounding vegetation, which is usually open heathy/ shrubby *E. amygdalina* (occasionally *E. sieberi*) forest/woodland. *H. rufa* rarely occurs in the wettest parts of a wet heathland, usually being present several metres from the dense shrubby vegetation that often characterises the most poorly-drained parts of the heathland. Such sites often support dense swards of *Gymnoschoenus sphaerocephalus* (buttongrass) or thickets of *Melaleuca* spp./ *Leptospermum* spp., although the presence of these species does not provide an indication of the absence of *H. rufa* in all cases. *H. rufa* only occasionally occurs in sites dominated by buttongrass. *H. rufa* does not seem to extend into the open heathy woodland/forest that usually surrounds the wet heathlands supporting the species. The presence of a canopy of trees, however, is not an indication of the likely absence of *H. rufa* because it can occur beneath lightly canopied sites within wet heathlands.

H. rufa appears to be absent from most wet heathlands that have become overgrown, but this may be an artefact of sampling (or lack of sampling in the densest, shrubbiest parts of the wet heathlands), although often the dense stands of shrubs in overgrown heathlands are almost devoid of understorey species. In Thomas Creek, *H. rufa* occurs in a narrow overgrown wet heathland surrounded by relatively steep slopes. Near Kates Marsh, *H. rufa* is locally abundant in a sedgy-scrubby patch of forest dominated by *E. ovata.* In some marshes (e.g. Bells Marsh, Rattrays Marsh), *H. rufa* extends into open heathy/scrubby woodland copses scattered through the marshes.

H. rufa occasionally occurs in sites dominated by buttongrass, but rarely occurs in the most poorly-drained parts of marshes dominated by buttongrass.

Vegetation types occupied by *H. rufa* were classified under TASVEG nomenclature, a contemporary vegetation mapping coverage of Tasmania based largely on aerial photography (Harris & Kitchener 2005). Overlaying the positive sites for *H. rufa* with TASVEG vegetation mapping indicated a strong association with several mapping units (Figure 3), including SHW (wet heathland), SLW (*Leptospermum* scrub), SHL (lowland sedgy heathland), MBU (buttongrass moorland undifferentiated) and DAC (*Eucalyptus amygdalina* coastal forest and woodland). Association with the only listed forest mapping unit, DAC, is usually only on the fringes of the polygon, and is always close to the other listed non-forest mapping units.

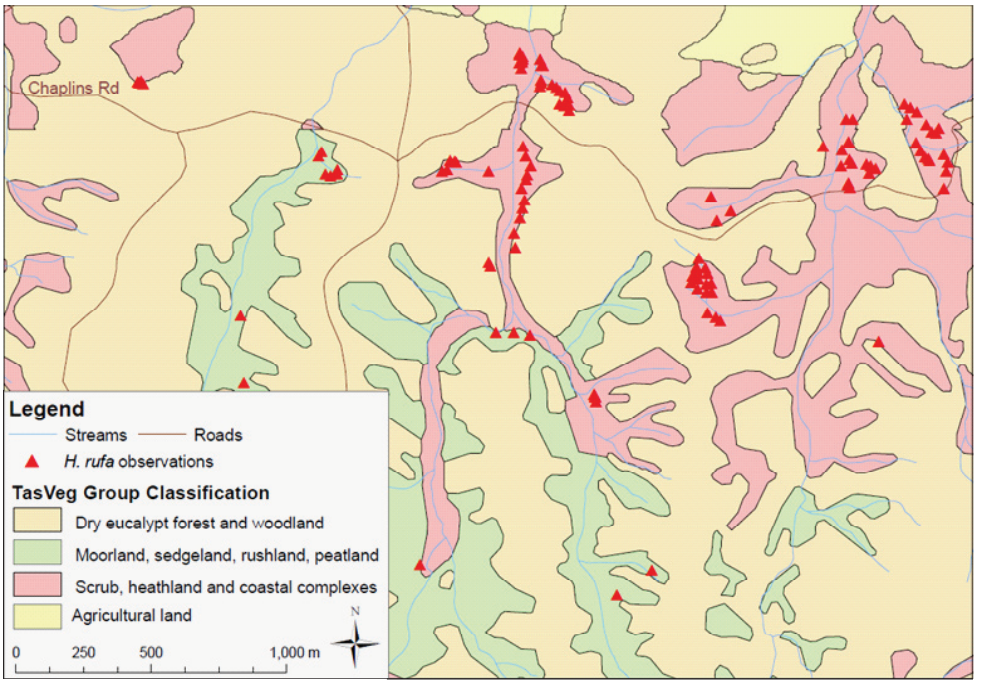

Figure 3. Distribution of Hibbertia rufa *in the context of TASVEG vegetation mapping.*

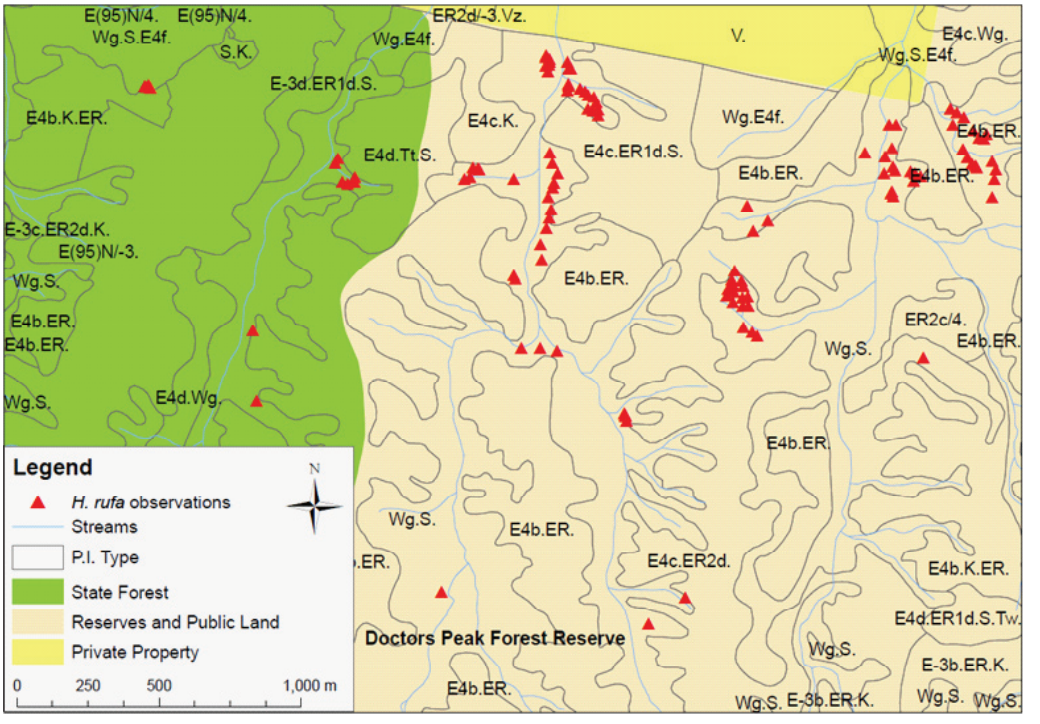

Figure 4. Extract of Forestry Tasmania Photo-Interpretation (P.I.) mapping system showing the association of Hibbertia rufa *with non-forest (e.g. Wg.S, S.Wg.E4f and E4c.ER2f) and low-quality forest (e.g. E-3b.ER.K and E4b.ER) PI types.*

These associations present a reasonable reflection of mapping units that are potential habitat for *H. rufa*, if TASVEG were to be used as a basis for a survey for the species. *H. rufa* was also detected in DOV (*Eucalyptus ovata* forest and woodland), DOW (*Eucalyptus ovata* heathy woodland) and mosaics of DOW, DOV, DAC and the aforementioned non-forest mapping units. However, TASVEG rarely maps localised forest/woodland polygons, so these mapping units are really only a useful guide if vegetation types have been mapped at a local scale (e.g. as part of a development proposal assessment).

Forest type (photo-interpretation) mapping

Forestry Tasmania maintains a mapping coverage of forest type based on aerial photographic interpretation (referred to as P.I. maps). These maps show canopy type (e.g. eucalypt, shrub, non-forest, pasture, etc.), height and density (in categories). Virtually all sites supporting *H. rufa* are associated with a relatively narrow range of P.I. types, including Wg.S, S.Wg.E4f, and E4c.ER2f, which all represent effectively treeless vegetation with a dominant heath, scrub or buttongrass component (Figure 4). Very few sites are associated with P.I. types that would be identified as forest (e.g. E-3b.

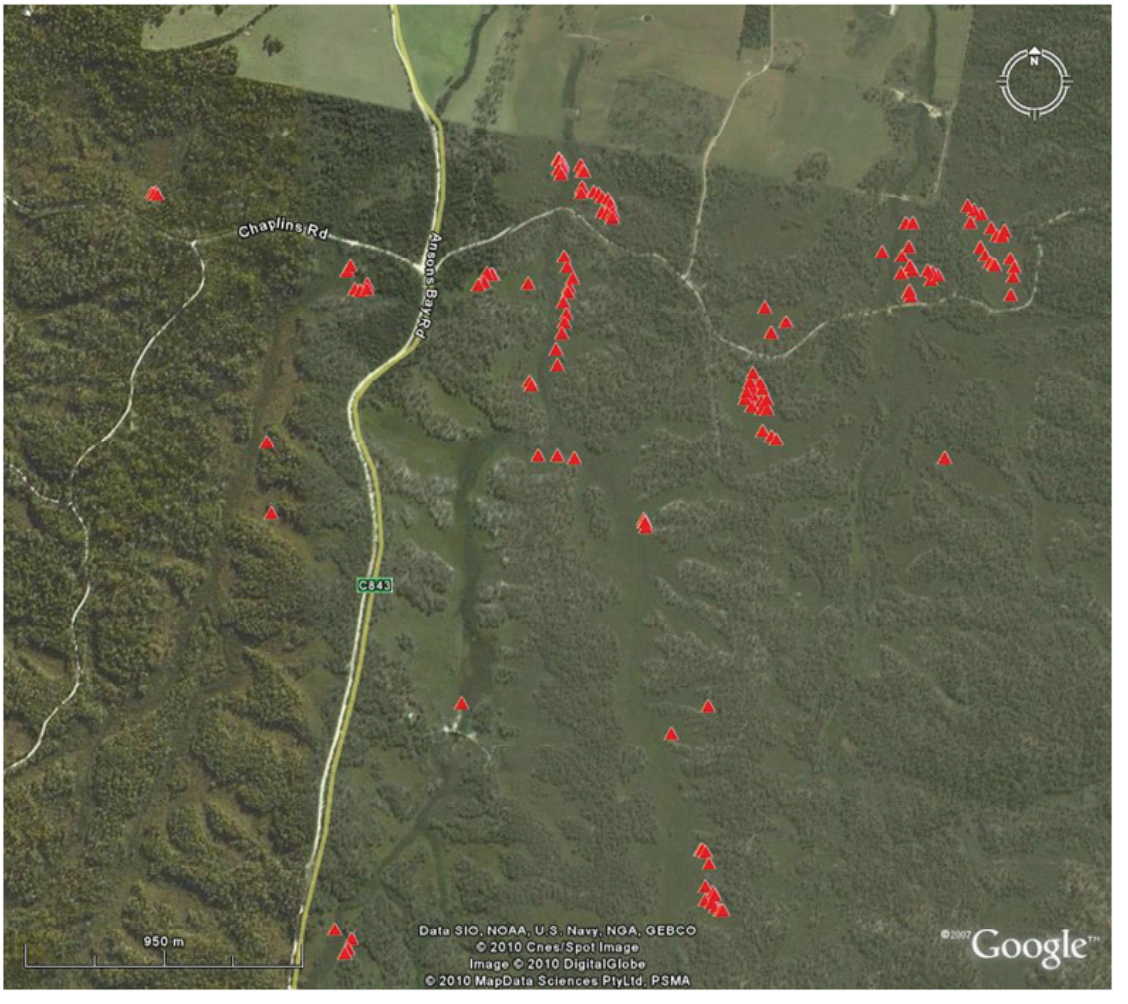

Figure 5. Aerial photography of part of the range of Hibbertia rufa *showing the association of the species with non-forest habitats.*

ER.K or E4b.ER). The strong association with non-forest vegetation types is shown in Figure 5.

Topography

H. rufa is almost wholly restricted to very gentle slopes in the low-lying parts of wet heathlands. Very few sites occur on steeper slopes, with the patch north of Chaplins Road occurring at the top of a moderate slope leading into a broadly sloped, wet sedgy heathland. Aspect does not appear to influence the occurrence of *H. rufa.*

Soil drainage appears to have the strongest influence on the localised distribution of *H. rufa* within a particular wet heathland. Very poorly drained sites appear to be unsuitable.

While it was not measured in the field, the presence of *H. rufa* was regularly associated with a minor break in slope (not detectable on a topographic map), which was sometimes correlated with a minor shift in the composition of the vegetation (e.g. shift from more open dry heathland to denser, sedgier wet heathland).

Geology

It is possible that underlying geology has an influence on the distribution of *H. rufa.* While all sites for the species occur on Devonian granitic substrates, examination of a finer-scaled geology map indicates that most sites are associated with two particular mapping units, "porphyritic to seriate to equigranular coarse-grained biotite-minor muscovite adamellite" (Dgac) and "medium- to coarse-grained biotite-hornblende granodiorite" (Dgrh). If geology affects the distribution of *H. rufa* at this localised scale in Tasmania (noting that the species occurs on different substrates elsewhere in Australia), it might explain why the species has not been located beyond the presently mapped range. Granites weather by hydration of feldspars and micas to clay minerals, leaching of relatively soluble elements, and redistribution of the various weathering products to more stable positions within the landscape, which suggests that geomorphology may also be potentially significant in explaining the distribution of *H. rufa* (J. Bradbury, pers. comm.).

Demographics

Defining subpopulations, especially based on the distance between locations, relies to a certain extent on an understanding of how genetic exchange can occur between subpopulations and the frequency of such exchange.

Some species of *Hibbertia* are pollinated by native bees (Bernhardt 1984; Bernhardt 1986), which are often implicated in the pollination of yellow-flowered species. If this is the case for *H. rufa,* genetic exchange between subpopulations situated up to 2 km apart is a distinct possibility, although the rate and frequency of this exchange is unknown and probably differs between adjacent subpopulations depending on factors such as the abundance and distribution of *H. rufa* within a particular wet heathland and surrounding topography. For example, in Charlies Marsh, *H. rufa* was only detected as relatively small patches separated by relatively large distances (at least at the scale of the wet heathland extent), but the next wet heathland supporting *H. rufa* is approximately 1.5 km away, separated by relatively heavily wooded forest on dissected topography. So, while genetic exchange between the patches within Charlies Marsh is likely at short time-scales, exchange with the next nearest subpopulation will probably occur at a much slower rate. A similar situation is probably applicable with the patches in Bells Marsh. By contrast, the patches located within the Rattrays Marshes-Livelys Bog drainage systems are effectively connected through continuous wet heathland (albeit sometimes dense) and only relatively short spans of more lightly wooded forest on gentle topography, so genetic exchange between virtually any part of the "population" is possible over relatively short time-frames.

On this basis, on the one hand *H. rufa* can be considered to occupy a small number of discrete subpopulations (perhaps about 15-20), and on the other hand it can be considered to have a single, almost continuous population. This concept has few management implications but can affect an assessment of the conservation status of a species. Estimating numbers of individuals is also difficult, but it is likely that the total population substantially exceeds 10,000 mature individuals, with the populations within the Bells Marsh and Last River wet heathland systems being the largest.

Species of *Hibbertia* have relatively large and heavy seeds that probably fall to the ground directly below fertile plants, where germination and growth occurs. This is almost certainly the case for *H. rufa*, which forms extensive low shrubs through the undergrowth, and the opportunity for seeds to be spread a significant distance from the fertile plant is low. This might explain the tangled nature of seemingly large numbers of individual plants in any one dense mass of the species.

Seeds may be dispersed to new locations by mammals either picking up seeds embedded in mud on their feet, or carrying fruiting capsules (that dislodge relatively freely from plants) on fur, or even consuming seeds (either by directly eating parts of *H. rufa* plants or accidentally from amongst herbage eaten at ground level) and excreting them in a still viable state. Echidnas and wombats are particular common within and surrounding the north-east wet heathlands, and their diggings might assist the spread of seeds at a local level. If these animal vectors are the primary means of seed dispersal, dispersal is a likely to be a chance event, and establishment of new populations in novel wet heathlands or in novel parts of the "parent" wet heathland will be relatively slow, although events such as fire might facilitate them. Browsing mammals such as wombats and wallabies are likely to take

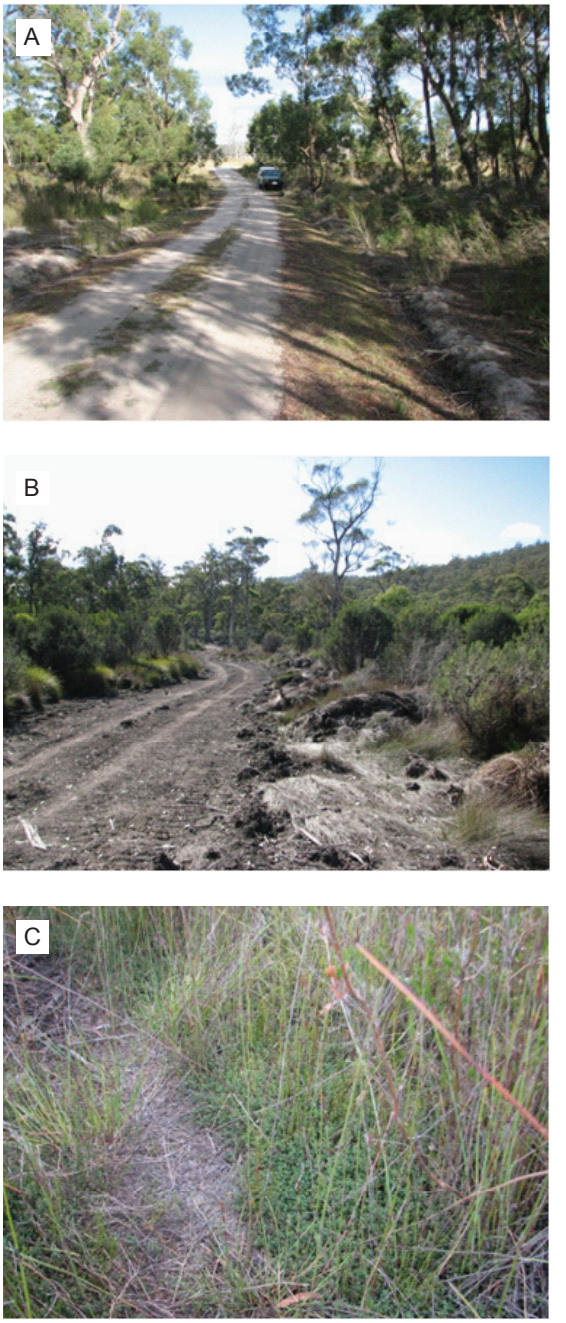

Photo 3. Images of habitat of Hibbertia rufa. *(A) Road through sedgy-scrubby* Eucalyptus ovata *forest (right of road in image) and shrubby wet heathland (left of road in image).* Hibbertia rufa *occurs on both sides of the road and virtually to the road edge. (B) Recently upgraded fire trail through Bells Marsh shrubby wet heathland.* Hibbertia rufa *grows on the dense sedgy understorey on track edge. (C) Dense sward of* Hibbertia rufa *on the edge of an old track through wet heathland.*

advantage of fresh green growth in burnt wet heathlands and visit similar freshly burnt areas within and between different wet heathlands, potentially spreading seeds of *H. rufa*. Evidence for this comes from the frequent observation that *H. rufa* is particularly strongly associated with animal trails through wet heathlands (Photo 3). Whether this is also due to microhabitat conditions (e.g. marginally more open, slightly better drainage, or less competition with surrounding denser vegetation) or degree of detectability is not known.

Threats and management implications

Fire

All the heathlands supporting *H. rufa* have had a long history of fire events, although the timing, frequency and intensity of particular events are poorly recorded. Many of the sites supporting *H. rufa* have not been burnt for more than 10 years. A particular example of this is Charlies Marsh, which used to be a very open, easily traversed heathland in the mid-1990s but is now quite dense, sedgy heathland with virtually impenetrable patches dominated by *Melaleuca squarrosa* and/or *Leptospermum lanigerum. H. rufa* was found in this work to be quite restricted in Charlies Marsh, but whether it was more widespread when fires were more frequent is not known. Certainly, the long-unburnt parts of marshes supporting dense vegetation rarely support *H. rufa,* but openings amongst such dense patches or on the fringes of such sites can support the species. Vegetation types such as wet heathlands are probably ideally burnt at a frequency of 15-20 years (for ecological purposes) and 10-15 years (for fuel-reduction purposes), with minimum and maximum frequencies of 8 and 30 years, respectively, depending on various factors (Marsden-Smedley 2009). It is likely that *H. rufa* benefits from periodic mosaic burns that open up different parts of the heathland, creating a mosaic of ages and density of vegetation.

Seed-coat scarification and smoke are thought to play a key role in breaking seed dormancy in several species of *Hibbertia* (Dixon *et al.* 1995; Allan *et al*. 2004), while environmental factors, time, heat and burial are all likely to play a role in triggering germination. If such factors are also applicable to *H. rufa*, or it is spread by species such as wallabies and wombats carrying seed on feet and/or fur (or even via the gut), periodic and patchy opening of heathland is likely to be beneficial to *H. rufa* because such species would utilise the fresh growth in the recently created open areas.

The greatest fire-related risk to *H. rufa* is probably from an inappropriate fire regime, i.e. leaving heathland unburnt for too long. Burning all or part of different heathlands on a 5-10 year cycle is probably ideal for maintaining *H. rufa* at different sites. An indirect risk of fire to *H. rufa* may arise from activities such as deliberate fuel-reduction burning that require the construction and/or maintenance of fire trails, although the risk posed from this activity is probably low.

Disease

Several species of *Hibbertia* are highly susceptible to the root-rot pathogen *Phytophthora cinnamomi* (Schahinger *et al*. 2003). No evidence of infection by the pathogen in any population of *H. rufa* was noted. Without exception, all observed plants were healthy, showing no symptoms of any disease. Importantly, at one site where a fire management track had been upgraded through a population of *H. rufa,* plants growing on the immediate edge of the disturbance and "downslope" of the track were all healthy and actively growing with fertile material present.

The potential susceptibility of *H. rufa* to *Phytophthora cinnamomi* remains the greatest unknown risk to the species. Determining the susceptibility of the species to the pathogen should be regarded as a high priority, to better inform the assessment of the formal conservation status of the species and facilitate development of suitable

management prescriptions, especially for operations related to road construction and maintenance.

Competition with weeds

None of the sites supporting *H. rufa* support significant populations of exotic plant species. A few of the sites close to pasture support localised populations of pasture grasses and weeds (e.g. *Holcus lanatus, Hypochoeris radicata*), and similar species are very occasional at other sites. There appears to be little contemporary or predicted deleterious impact from weeds to populations of *H. rufa.*

Grazing

No sites on public land supporting *H. rufa* appear to have any deliberate, active, stock grazing on them at present. The majority of sites show evidence of some level of stock use. Several sedgy heathlands have old fences through them, indicating that such sites were probably used in a staged manner in different years.

The long history of stock grazing on the different heathlands supporting *H. rufa* appears to have had little detrimental impact on the distribution of the species. It seems unlikely that the absence of the species from some heathlands is adequately explained by grazing history. A limited number of sites on private land supporting *H. rufa* have been subject to cattle grazing pressure but at an approximately similar intensity to public-land sites, thus providing little evidence one way or the other on the impacts of grazing. However, we do not support the recommencement of formal stock agistment on public land at sites supporting *H. rufa* because of the risk of weed invasion (e.g. thistles and pasture grasses).

Forestry activities

H. rufa occurs in a production forest landscape, being essentially restricted to State forest managed for various uses. *H. rufa* is not a forest-dependent species, occurring mainly in non-forest vegetation types. However, it should be assumed that any species that occurs in a forest/non-forest mosaic (especially where the populations are so close to the transition zone of major vegetation types, as is the case with *H. rufa*) will be potentially affected by alterations to forest vegetation adjacent to populations.

To date, none of the known sites supporting *H. rufa* have been deleteriously affected by forestry activities such as timber harvesting. Some sites are relatively close to forests that have been subject to native forest silviculture (mainly forms of selective logging), but it is standard practice under the *Forest Practices Code* (Anon 2000) to retain an informal buffer zone on open heathlands, which means any potential deleterious impacts on populations of *H. rufa* have been effectively mitigated. The susceptibility of the species to *Phytophthora cinnamomi*, a disease that can be spread by forestry machinery, vehicles and equipment, is unknown. However, there are strict provisions embedded in the *Forest Practices Code* in relation to hygiene protocols for operations in and near disease-susceptible vegetation, and these provisions are appropriate for forestry activities within the range of *H. rufa.*

Activities peripheral to standard forestry operations have the potential to impact on populations of *H. rufa*. Such activities include fire management and road construction (to access forestry coupes, and for other purposes such as fire trails). Generally speaking, roads are usually constructed outside open heathlands and marshy areas (for engineering and environmental reasons), but some roads within State forest do cross through marshes. During the present study, any such roads through potential habitat for *H. rufa* were carefully examined for the presence of the species. One road through part of the Bells Marsh system of heathlands dissected a population of *H. rufa.* This road appeared to be an old 4WD track/fire trail improved in recent years by simple grading with a bulldozer blade. While some plants of *H. rufa* were undoubtedly destroyed and others disturbed, the plants on the pushed-up track verge and in surrounding sedgy heathland were all healthy and actively

growing (including on disturbed soil). A well-established gravel road linking the Kates Marsh area on private property and The Gardens (through State forest) also dissects a population of *H. rufa*, again without any apparent deleterious impact.

The potential impacts of forestry and peripheral forestry activities are relatively easily managed through the existing planning processes of the forest practices system. The *Forest Practices Code* requires that threatened flora are taken into account during planning for forestry activities. A system of consultation between the forest planner, the Forest Practices Authority and the Department of Primary Industries, Parks, Water and Environment is already in place and can be used effectively to manage threatened flora on a case-by-case basis. Simple management prescriptions such as informal buffers on known sites and/or potential habitat, and avoiding and/or minimising disturbance to known sites and/or potential habitat by activities such as road construction and maintenance, would be relatively easily implemented. In some situations, additional pre-operational surveys may be warranted.

Land clearing

Land clearing may have contributed to localised reduction in the range of *H. rufa.* While the precise location of the 1892 collection of the species in the St Helens area will never be known, it is likely it was somewhere on the flats outside St Helens, perhaps close to the present hamlet of Priory. Given that the heathlands immediately north of Priory support *H. rufa* but that Mill Marsh immediately west of Priory and heathlands east of Priory near the old St Helens water supply reservoir do not appear to, the historical extent of *H. rufa* on the low-lying ground near Priory (now cleared land used for primary production) is difficult to ascertain.

Relatively large areas of habitat superficially suitable for the species have been cleared on private property north of the Doctors Peak Forest Reserve, in the Last River catchment, although several patches of remnant vegetation remain. *H. rufa* only extends several hundred metres onto private property north of the boundary with State forest, even in some areas of superficially suitable habitat, and where present it is very patchy and sparse. This suggests that the existing land clearing may have had a limited impact on the species.

Dam construction

Dam construction is a specific case of land clearing that has the potential to impact on populations of *H. rufa*, because virtually all sites for the species are in low-lying areas suitable for water storage. While the authors are unaware of any current proposals for dam construction within the now understood range of *H. rufa*, any such proposals would need to carefully consider the presence or potential presence of the species. The magnitude of this threat is difficult to estimate because it would depend on the type of any proposal. Larger-scale proposals (e.g. water storage for primary production enhancement) would need to be considered quite differently to smaller-scale proposals (e.g. fire-fighting dams on State forest), because small dams could probably be sited to avoid, or at least significantly minimise disturbance to, populations of *H. rufa.*

There have been dams within the Rattrays Marshes system (at the southern end near the old stock and machinery building). At this site, *H. rufa* is apparently absent from the now very poorly-drained ex-dam site, but is widespread and locally common below the old dam "wall".

Stochastic risk

Species with naturally restricted distributions are often regarded as having a high level of risk from stochastic events, i.e. unpredictable occurrences that eliminate populations such that the risk of extinction is significantly increased. Stochastic events are by definition unpredictable. Apart from planned fuel reduction burns, events such

as fire are largely unpredictable in sites occupied by *H. rufa*, except to the extent that it is inevitable that a fire will occur at some point. However, while a fire is therefore a stochastic event, it does not follow that it presents a risk to *H. rufa*. Other events, such as sudden and illegal intensive stock grazing, can also be regarded as stochastic, but such incidents are unlikely to affect any more than one subpopulation of *H. rufa* at any one time (and probably only part of any particular subpopulation), so by their extent are unlikely to pose a significant risk to the species as a whole.

Outbreak of disease within populations of threatened plants is correctly regarded as a stochastic risk. In the case of *H. rufa*, the susceptibility of the species to pathogens such as *Phytophthora cinnamomi* is unknown. While it is not logical to list every plant species as threatened because one day it might become infected with a disease, the high susceptibility of *H. rufa* to *P. cinnamomi* suggests that this is a realistic stochastic risk.

Ongoing management

H. rufa occurs predominantly on public land managed as State forest, for which Forestry Tasmania is the land manager. Through Forestry Tasmania's planning systems, *H. rufa* can be taken into account in a number of ways, some of which are outlined below.

1. Provision of a "potential range boundary" to forest planners showing a conservative potential distribution developed by specialists, based on

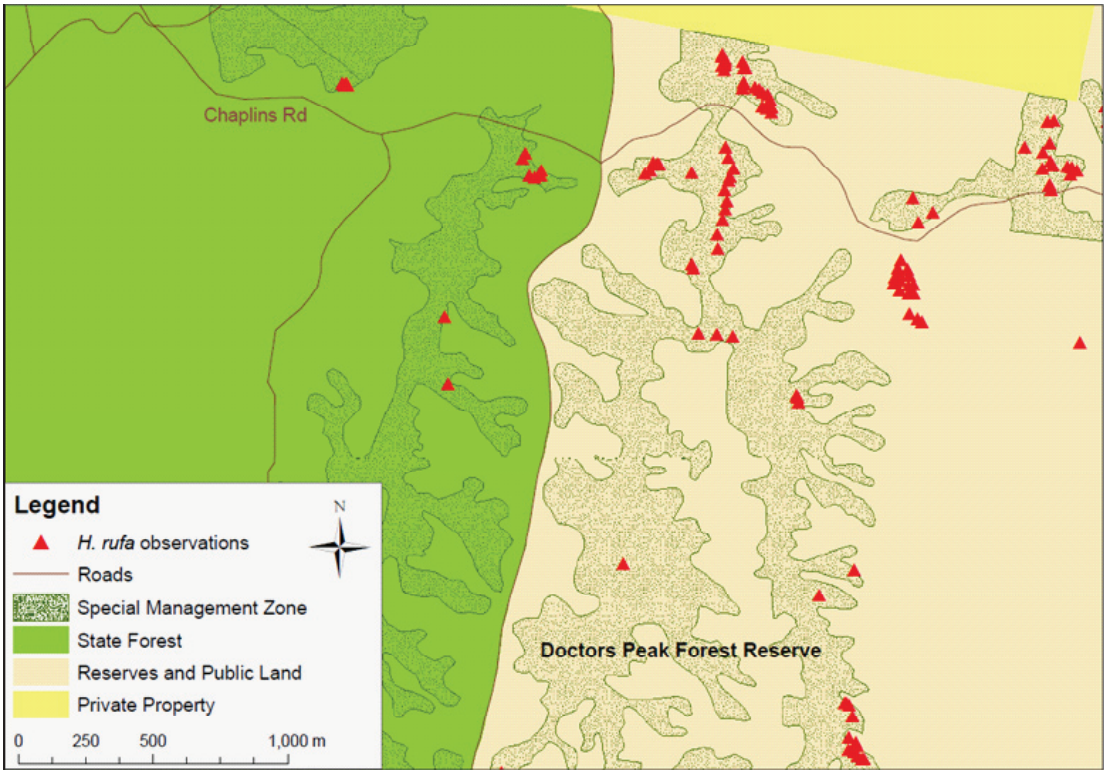

Figure 6. Extract of Forestry Tasmania Management Decision Classification planning system showing an example of the establishment of a Special Management Zone for Hibbertia rufa *on State forest, centred on known sites with a nominal buffer of 20 m.*

known sites, results of surveys to date, distribution of other potential sites, and practical management boundaries such as major roads, rivers and tenure (Figure 1, Figure 2). The potential range for *H. rufa* is 161.60 km^2, almost 3 times the present occurrence of 53.23 km^2 defined by a minimum convex polygon.

2. Inclusion of known sites within Special Management Zones, coded for the presence of threatened flora, on the Management Decision Classification System (Orr and Gerrand 1998) (Figure 6). These can be updated as new information is provided.

3. Training of technical, professional and managerial staff on the management requirements of the species, especially in relation to forest management activities such as road construction and maintenance and fuel reduction burning.

Reservation status

Despite a restricted distribution, *H. rufa* is relatively well reserved (Figure 2). Populations occur in the Doctors Peak Forest Reserve, Bells Marsh Forest Reserve and Mount Pearson State Reserve. Several populations occur on State forest, with most sites protected through Forestry Tasmania's Management Decision Classification (MDC) planning system (Orr and Gerrand 1998). Most sites on State Forest occur in vegetation types usually excluded from forestry activities and coded as "protection", "non-commercial" or some other non-forestry land use. Less than 5% of the mapped distribution of the species occurs on private property.

Conservation status

At the time of the re-discovery of *H. rufa* and the majority of the extension surveys, the species was listed as Presumed Extinct (Schedule 3.1) under the Tasmanian *Threatened Species Protection Act 1995*. The species has since been accepted as meeting the criteria for Rare (Schedule 5) of the Act due to its extent of occurrence being less than 80 x 80 km or 2000 km^2, and its area of occupancy being not more than 50 hectares. While *H. rufa* appears to be relatively secure from obvious threats, a conservative approach to its threatened status is warranted. The response of the species to different forms of land management (e.g. fire management regimes), ongoing climate change and associated drought, and its susceptibility to *Phytophthora cinnamomi* remain as unknown factors. Long-term demographic monitoring of a subset of populations is suggested, combined with targeted extension surveys to more clearly define the extent of occurrence and occupation.

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