based shrub species (Bell 2004). The species has also been observed in recently burnt areas where understorey vegetation (including grasses) is very sparse.

5.3 *Viability of Fragmented Populations*

Genetic influences on the viability of plant populations may occur in a variety of ways, including effects of genetic erosion on mate availability in self-incompatible species; loss of adaptive potential; increased hybridisation with disturbance, and elevated inbreeding (Young, Pickup & Gregory 2003). In *Rutidosis leptorhynchoides*, mate limitation has been shown to reduce seedling fitness in small populations, primarily as a result of low *S* allele richness and erosion.

Strong self-incompatibility has both advantages and disadvantages for isolated population fragments of plants. The population is protected from the endemic weakness conferred by inbreeding, however seedling recruitment can be reduced to negligible levels if the genetic make-up is similar for all of the members of the population. This lack of succession means that the population is limited to its current numbers and can only slowly become extinct as individuals die (Young et al 1999; 2000).

Studies of *Rutidosis leptorhynchoides* have shown that the genetic make-up of fragmented populations will gradually deteriorate over time, and mutation can result in a breakdown of the self-incompatibility mechanism to the extent that the population becomes further weakened through inbreeding depression of genetic richness (Young *et al.*, 1999; Young & Murray 2000). In an investigation of the breeding system of the lakeside daisy in the Great Lakes region in USA, De Mauro (1993) showed that self-incompatibility in isolated populations resulted in a total lack of seed production in these populations which rendered them functionally extinct. In an attempt to preserve the lakeside daisy, populations were established in reserves using plants translocated from different genetic areas in order to facilitate fertile seed production in these newly established populations.

5.4 *On-going Management*

Rutidosis heterogama can frequently be found growing in areas of soil disturbance such as road and trail edges or contour drains, and it would be tempting to conclude from this that the soil seed bank responds favorably to this disturbance. However, this is unlikely to be the case if the life of the *R. heterogama* seeds in the soil is only around 4 months as has been demonstrated for *R. leptorhynchoides* (Morgan 1995a). The germination of seed in disturbed areas would then be most likely from plants that were already present, with the seed from these plants having been spread by the disturbance process.

The fact that seed dispersal is likely to occur over a short distance from the parent plant, and that the life of the seed in the soil may be limited to around 4 months, has implications for the plants that occur in roadside reserves where these areas are regularly slashed. Slashing cuts off the flowering heads before the reproductive process can be completed to the stage of seed maturity and dispersal, and this means that the population is generally limited to the perennial parent plants. Cropper (1993) reported that the related *Rutidosis leptorhynchoides* has benefited from the slashing of a population at Truganina Cemetery, stating that without this annual maintenance the species would have probably been out-competed by *Themeda australis* (Kangaroo Grass) long ago. In the case of *Rutidosis heterogama*, we have observed this species growing in areas with very dense (>90% cover) understorey vegetation, including grasses such as *Themeda australis* and the sedge *Ptilothrix deusta*, and shrubs such as *Melaleuca nodosa* (Figures 17 & 18). It would appear from these anecdotal observations, therefore, that competition from surrounding graminoids does not limit the persistence of *Rutidosis heterogama.*

5.5 *Translocation*

In the past, *Rutidosis leptorhynchoides* has been translocated to secure grassland reserves because donor populations occurred on land inappropriate for conservation (Cropper 1993). While in the short term such translocations have appeared successful, there is evidence that genetic bottlenecks are reducing the fitness of subsequent generations. Young and Murray (2000) report on the results of a study examining the genetic makeup of subsequent generations of *Rutidosis*

Figures 17-18: *Rutidosis heterogama* in dense grass and in sparser habitat (© C.Driscoll & S.Bell).

leptorhynchoides emanating from translocations undertaken since 1987 in Victoria. Direct seeding and planting of tube stock was employed, with material sourced from natural populations from up to 40km away. The results of this study demonstrated that re-established populations of *Rutidosis leptorhynchoides* have different levels of genetic diversity when compared with their wild progenitors, and has resulted in a genetic bottleneck. The higher frequency of chromosomal abnormalities in re-established plants also present possible problems for population persistence if they are accompanied by reductions in individual fitness.

Without similar in-depth studies into the genetics of *Rutidosis heterogama*, it would be difficult to gauge the success of any translocation of this species. It would appear, however, that similar stagnation would occur to that of *Rutidosis leptorhynchoides*, with a gradual breakdown of population fitness and viability.

6.0 Conclusions & Recommendations

This study has revealed the following major points in regard to *Rutidosis heterogama* in the Central Coast and lower Hunter Valley:

- There are currently 13 known extant populations of *Rutidosis heterogama* within the LHCC region;
- The southern limit of *Rutidosis heterogama* now extends to Warnervale within Wyong LGA, and the species extends regionally to Cessnock in fragmented, disjunct populations;
- Population sizes within the LHCC region vary from 10 to >20000 individuals (three are less than 50). A total estimation for the Wyong/ Lake Macquarie area is at least 2000 plants. Including all known populations in the LHCC region, it is possible that at least 30000 plants are present. Extant populations of *Rutidosis heterogama* are significantly lower than the related and vulnerable *Rutidosis leptorhynchoides*, which numbers in excess of 100,000 plants. *Rutidosis heterogama* may well qualify for upgrading to Endangered on both the *TSC* and *EPBC Acts*;
- Habitat in the region differs from the heath and disturbed roadside reported in the literature, with most populations occurring within dry open forest with a grassy understorey. Roadside populations are most likely remnants of populations present prior to European disturbance;

- Only one of the thirteen extant populations (C4) occurs within secure conservation zonings (ie: national park or nature reserve), and part of population C1 also extends into Werakata NP. One population (C2) occurs within Aberdare SF, and three others (LM1, LM3, LM4) within low security reservation (road reserve, powerline easement) subjected to on-going maintenance.

- Populations within Wyong LGA are particularly significant, as they form a disjunct population at the southern limit of distribution, and comprise around 1800 plants. This compares with the 400 plants at Cooranbong in Lake Macquarie.

- Based on the findings in this report, the Cessnock area is by far the most important locality in the region for *Rutidosis heterogama*, with possibly up to 25000 plants present, or 83% of the regional population.

Excluding populations C1 and C4 from Cessnock LGA, the population of *Rutidosis heterogama* at Sparks Road (W1), within the proposed Warnervale town centre, is the largest currently known in the region. This population occupies most of the ridges and upper slopes of the DIPNR-owned land west of the Main Northern Railway, and is prevalent along the railway easement. The evidence presented in this report would suggest that this population is highly significant, both for its size and its occurrence at a new distributional limit. The two other populations present in Wyong (populations W2 Hakone Road and W3 Arizona Road) both occur in fragmented environments, at least one of which (W2) is already the subject of investigations for urban development. Of the three Wyong populations, only that at Sparks Road offers a realistic option for preservation of the species, due to its occurrence at the southern end of a large parcel of Crown land. However, the W3 (Arizona Road) population also supports one of only two extant populations of the Endangered *Genoplesium insignis* (Jones 2001; Bell 2002), and this site may be preferable for conservation. In addition, two individuals of the small tree *Eucalyptus parramattensis* subsp. *parramattensis* (an Endangered Population in Wyong LGA under the TSC Act 1995) are present on this land, although their origin is uncertain as habitat is not typical for the species.

Based on research carried out on *R. leptorhynchoides,* any proposal to sub-divide or sacrifice part of the Sparks Road (W1) population may result in a break-down of self incompatibility and a loss of hybrid vigour in the population, with a consequent population decline and ultimate failure. The separation of over 2 kilometres from other plants means that the viability of the existing plants is totally dependant on cross-pollination within the population.

With regard to the Hakone Road (W2) and Arizona Road (W3) populations, the long-term viability of both of these is questionable given their locations within a highly fragmented environment. The next issue therefore is what the most appropriate measures to take with these plants would be. Young and Murray (2000) have shown that there can be negative genetic modifications in re-established populations of *R. leptorhynchoides,* so it is not necessarily a simple option to relocate the W2 and W3 plants to areas where other *R. heterogama* occur. However, there is a strong similarity between the habitat at W2 and W1, where it is suggested a formal reserve be established. This may imply that local genotypic differences between the populations at these locations might not be great and that a re-established population made up of plants from both of these areas could be successful. The W3 population occurs within a previously cleared landscape, where (presumably) the species existed prior to that clearing taking place. The different habitat supported there (regrowth Doyalson Scribbly Gum Woodland) may suggest that translocation may not be as successful.

A possible scenario to ensure conservation in the region, and to allow development to continue in an already fragmented Charmhaven-Woongarrah precinct, may be to dedicate the Sparks Road (W1) population as a formal reserve, and to boost its numbers by translocating the plants from W2 (Hakone Road), and possibly also the W3 (Arizona Road) population. For this to occur, a detailed translocation plan would need to be prepared, adhering to the accepted translocation

guidelines included in George (1997) and Monks (2003), and extending for a period long enough to ensure subsequent generations are produced. Genetic studies may also be possible with subsequent generations to enable comparisons of genetic transfer with results obtained for the congener *Rutidosis leptorhynchoides.*

In summary, the following **recommendations** are made:

1. Any loss of *Rutidosis heterogama* plants comprising all or part of the three populations known from Wyong LGA (W1, W2, W3) will trigger the need for a Species Impact Statement (SIS) to be prepared before any development consent is obtained. It is recommended that other avenues be explored prior to this process, as on current information all three Wyong populations of *Rutidosis heterogama* are considered highly significant.

2. Consequently, it is recommended that all or part of the W1 population at Sparks Road be set aside for reservation of *Rutidosis heterogama,* since of the three populations in Wyong, W1 is the largest and offers the greatest potential for conservation. If this is not possible, retention of some of the population is recommended within an open space environment, such as a natural parkland with little active management (but including selective weed control). This would provide some 'breathing space' to enable research to be undertaken on pollination biology and other matters relating to the life history of the plant, and also to allow for additional populations on more secure tenure to be found. An SIS would also be required for consent to destroy the remainder of the population.

3. If conservation of the entire W1 population is not possible, investigations should be made into the feasibility of undertaking a translocation of all affected plants. Ideally, a pilot translocation involving a small number of plants and trailing different translocation methods should be undertaken prior to removal of the entire population. Consultation will be required with the Department of Conservation for this to occur.

4. As development plans already exist for the W2 population at Hakone Road, all attempts be made to salvage as many plants as possible from this site for incorporation into a translocation project at a more secure location. An SIS will also be required prior to any destruction or removal of plants, as well as appropriate licensing from the Department of Conservation.

5. Population W3 at Arizona Road be conserved, as in addition to the presence of *Rutidosis heterogama* it is also the site of one of only two known populations of the endangered terrestrial orchid *Genoplesium insignis,* and supports a few individuals of *Eucalyptus parramattensis* subsp. *parramattensis,* an Endangered Population in Wyong LGA. There is potential for the western portion of the W3 population to be incorporated into a small corridor to link with proposed conservation areas in the Wallarah Creek catchment.

6. Additional surveys be undertaken in appropriate habitat in more secure land zonings within Wyong LGA to locate additional populations of the species. Targeted tenures should include national parks, nature reserves, state forest, crown lands, and other lands with secure conservation zonings, acknowledging those areas proposed for conservation in the draft Wyong Conservation Strategy.

7. Research into the genetics and biology of *Rutidosis heterogama* be undertaken, involving researchers working on the related *Rutidosis leptorhynchoides,* to gain a better understanding of the long-term viability of this species, particularly as it relates to possible translocation of individuals.

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