Assessing the vulnerability of native vertebrate fauna under climate change, to inform wetland and floodplain management of the River Murray in South Australia:

Bird Vulnerability Assessments

Attachment (2) to the Final Report
June 2011

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Scientific Name:	*Acrocephalus australis*	Common Name:	Australian Reed Warbler

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? Some reported use of alternative vegetation types (e.g. crops), but not to large extent. Unsure how opportunistic bird will be if loss of freshwater wetlands with dense reed beds occurs. Literature suggests some capacity for adaptation but dense vegetative habitat is the key (plant less so). Heavily dependent on dense freshwater vegetation for cover and breeding, saline and brackish habitats do not provide optimum quality. Elaborate nest is important for breeding success, unsure of how successful alternative vegetation habitats may be (P. Wainwright 2010, pers. Comm.).	Habitat specialists that forage in association with fringing and emergent habitat; low aquatic or dense riparian vegetation (mainly reeds, rushes, sedges, and other vegetation with similar vertical structure) and in and around nearly any type of fresh, brackish or saline wetlands. In SA found in paperbarks around brackish teatree lagoons. Agriculture has facilitated some range extensions through provision of additional reed beds (e.g. in Qld where artesian bore flow is combined with Cumbungi reed growth). Some coastal habitats lost through land reclamation and development (Higgins Peter & Cowling 2006; Ecological Associates 2010). *Specialist edge and riparian habitat requirements. Highly dependent on dense vegetative freshwater habitat (e.g. reed beds) for protection and provision of foraging and breeding habitat. While species shows tolerance to saline and brackish wetlands they are not preferred and are not optimal. Freshwater riparian habitats are under severe threat of degradation through climate change (reduced flows, drought, salinisation etc.). Uncertainty of species capacity to use artificial habitats (e.g. crops) reduces confidence in assessment. Species should be considered at high risk but with medium confidence*	**M**	**H**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change? Limited capacity to move very long distances and tend to be more residential/sedentary as opposed to nomadic within study area. Species shows some ability to move possibly in response to quality of available habitat (P. Wainwright 2010, pers. Comm.). 'Migratory, and common throughout Aust. and therefore a possible decline in the SA MDB population wouldn't impact on the species' national population' (P. Waanders 2011, pers. comm.).	Full range of movement not clear, some populations in WA and Qld thought sedentary/resident but largely migratory in SE Australia. Leave breeding sites Feb to Apr, and returning Aug to Sep although some remain in winter. Show marked seasonal changes in conspicuousness especially in breeding season. Species is more vocal during breeding and perhaps exaggerates impression of seasonal movements. Banding studies indicate majority of birds (>93%) were recovered within 10km of banding place (Higgins Peter & Cowling 2006). Migratory bird species listed under the Republic of Korea Australian Migratory Bird Agreement (ROKAMBA) and the Chinese Australian Migratory Bird Agreement (CAMBA) (Ecological Associates 2010). *Listed migratory bird species and known movements in SE Australia. Range, frequency and driving mechanisms are unclear but banding studies suggest a limited range (<10km) possibly of residential birds but may also move from eastern states. Tend to be more sedentary as opposed to nomadic within study area but will move in response to quality and availability of habitat. Species should be considered at low risk but with medium confidence due to lack of specific knowledge of movements within study area.*	**M**	**L**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Diet consists of mainly arthropods but also molluscs and occasionally seeds. Known to defend breeding territories and reported as being extremely aggressive to intruders when raising nestlings. Drought can force conspecific competition for nest sites, especially the first of the season. Nestlings predated on by rats (also takes eggs) and snakes (Higgins Peter & Cowling 2006). Young of species may have a greater ability to escape predators because chicks readily climb out of their nests and into surrounding dense vegetation in order to escape potential predators prior to fledging (Eikenaar Berg & Komdeur 2003). *Direct competition for food not documented. Species shows good capacity to compete through aggressive territorial behaviour during breeding however conspecific competition for nest sites may increase as a result of further habitat loss under climate change. Aggregation may induce further predation pressure through degradation/loss of nesting habitats in dense vegetation (eggs more vulnerable). Species should be considered at moderate risk*	**H**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? Some reported use of alternative vegetation types (e.g. crops), but not to large extent. Unsure how opportunistic bird will be if loss of freshwater wetlands with dense reed beds occurs. Literature suggests some capacity for adaptation but dense vegetative habitat is the key (plant less so). Heavily dependent on dense freshwater vegetation for cover and breeding, saline and brackish habitats do not provide optimum quality (P. Wainwright 2010, pers. Comm.).	Reliant on dense aquatic and riparian vegetation for foraging, roosting and breeding. Can use fresh, brackish or saline wetlands. Agriculture has facilitated some range extensions through provision of additional reed beds (e.g. in Qld where artesian bore flow is combined with Cumbungi reed growth). Diet consists of mainly arthropods but also molluscs and occasionally seeds (Higgins Peter & Cowling 2006). *Dependent on dense aquatic vegetation e.g. reed beds, that only occur in freshwater. Brackish and saline wetlands are also used but apparently not preferred as they do not offer optimum conditions for type and density of vegetative habitat. These specialist habitat requirements are likely to be limiting under climate change as the vegetation and associated food web show a high sensitivity to salinity and have already been degraded within the study area. Climate change is expected to cause a transition from less permanent freshwater wetlands to more temporary, saline wetlands. Ability to use artificial habitats reduces risk but only slightly as uncertain how opportunistic bird will be. Species should be considered at moderate risk*	**H**	**M**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? Heavily dependent on dense freshwater vegetation for cover and breeding, saline and brackish habitats do not provide optimum quality. Unsure of how successful alternative vegetation habitats may be, likely to not offer same level of cover/protection. Speciew does not take to open habitat as it needs dense cover for nest concealment/protection. Salinisation may degrade and thin out reed beds and remove suitable nesting habitat (P. Wainwright 2010, pers. Comm.).	Aggressive defense of nestlings and both parents care for young feeding at regular intervals through to fledging and recorded for up to 19 days after fledging. Diet consists of mainly arthropods but also molluscs and occasionally seeds. Total time to independence is around 5 weeks but fledglings cannot fly immediately and need to remain within dense vegetation (e.g. reeds, rushes, nearby trees etc.) for cover (Higgins Peter & Cowling 2006). *Moderately long period of parental care compared to other species assessed in this study. This raises risk to species as parental investment is higher and young are more vulnerable for longer. Dense vegetative habitats provide critical cover (especially for flightless fledglings) for foraging, roosting etc. These typically freshwater habitats are threatened by degradation under climate change and may force nesting and foraging in more open areas where food and cover is more limited and predation pressure is higher. Species should be considered at high risk*	**H**	**H**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? Heavily dependent on dense freshwater vegetation for cover and breeding, saline and brackish habitats do not provide optimum quality. Elaborate nest is important for breeding success, unsure of how successful alternative vegetation habitats may be. Secretive, solitary nesting (not colonial). Don't take to open habitat as need dense cover for nest concealment/protection. Salinisation may degrade and thin out reed beds and remove suitable nesting habitat (P. Wainwright 2010, pers. Comm.).	Breeding widespread in south east Australia and extending west as far as the Adelaide Plains in SA (Higgins Peter & Cowling 2006). Usually breed from early Sep to early Mar. Nests in deep cups of grass/dried reed sheaths/willows etc. (Slater et al 2001), typically in dense low aquatic or riparian vegetation, in and round nearly any type of fresh, brackish or saline wetland (Ecological Associates 2010). Young of species may have a greater ability to escape predators because chicks readily climb out of their nests and into surrounding dense vegetation in order to escape potential predators prior to fledging (Eikenaar Berg & Komdeur 2003). *Critical dependence on dense stands of aquatic and riparian vegetation for nesting and cover for nestlings and fledglings. These typically freshwater habitats are at risk of loss or degradation through drought, salinity and reduced flow and lowered river height under climate change. Building of elaborate nest in reeds increases success, unsure if alternative habitats (e.g. crops, vegetation in brackish/saline wetlands), will provide adequate cover. Species should be considered at high risk*	**H**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? Degree of intermixing evident, WA populations maybe more isolated than rest of Australia. Mixing of populations likely occurs at scales smaller than the continental scale. Likely to incorporate genetic material form other regional populations (e.g. Lake Eyre Basin), as is relatively abundant and well distributed. Some seasonal movement to coastal areas to breed likely due to less water availability in warmer months, movement back to inland wetlands during winter. This means birds are moving through the MDB system at times (P. Wainwright 2010, pers. Comm.).	Widespread distribution especially along upper and middle reaches of River Murray and tributaries and also parts of Mallee region in Vic. In SA, distributed across south east part of state and largely migratory in SE Australia (Higgins Peter & Cowling 2006). Moderate number of records (516) within SA MDB floodplain since 1990 evenly distributed across region (BDBSA 2010) compared to other species assessed in this study. Subregionally listed as near threatened and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). *Widespread distribution and moderate to low abundance of birds in SA MDB study area indicated in the literature and verified by BDBSA records and regional rating work. Species has the capacity to disperse and populations are mainly migratory in SE Australia implying that regional populations are probably not isolated within the study area. Species should be at considered low risk*	**H**	**L**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? Degree of intermixing evident, WA populations maybe more isolated than rest of Australia. Mixing of populations likely occurs at scales smaller than the continental scale. Likely to incorporate genetic material form other regional populations (e.g. Lake Eyre Basin), as is relatively abundant and well distributed. Some seasonal movement to coastal areas to breed likely due to less water availability in warmer months, movement back to inland wetlands during winter. This means birds are moving through the MDB system at times (P. Wainwright 2010, pers. Comm.).	Full range of movement not clear, some populations in WA and Qld thought sedentary/resident but largely migratory in SE Australia. Leave breeding sites Feb to Apr, and returning Aug to Sep although some remain in winter. Show marked seasonal changes in conspicuousness especially in breeding season. Species is more vocal during breeding and perhaps exaggerates impression of seasonal movements. Post-breeding dispersion and migration known to occur for populations in SE Australia but some populations may also be sedentary. A 50 year, Australia wide banding study found the majority of birds (>93%) were recovered within 10km of banding place (Higgins Peter & Cowling 2006). Population in SA appears moderately abundant and evenly distributed across floodplain (BDBSA 2010). *Populations do not appear fragmented, range of birds according to banding studies is not very far but combined with migratory aspect and reported seasonal movements associated with water availability in the study area reduces threat. Species should be considered at low risk but with medium confidence due to uncertainty over movement patterns and breeding migrations limiting interpretation of potential population mixing*	**M**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change? Degree of intermixing evident, WA populations maybe more isolated than rest of Australia. Mixing of populations likely occurs at scales smaller than the continental scale. Likely to incorporate genetic material form other regional populations (e.g. Lake Eyre Basin), as is relatively abundant and well distributed. Some seasonal movement to coastal areas to breed maybe due to less water availability in warmer months, movement back to inland wetlands during winter. This means birds are moving through the MDB system at times (P. Wainwright 2010, pers. Comm.).	Polytypic although unresolved. Conjecture over subspeciation, majority of genetic evidence defines *A. australis* as a separate full species and part of a large monophyletic group containing a number of other species in the genus. Currently 2 subspecies are recognized in Australia, nominate *A. australis* (eastern Australia) and subspecies *gouldi* (south-western WA). *A. a. gouldi* has longer wing, bill and tail lengths. Intermediates between *A. australis* and New Guinean species are reported from NE Qld (Higgins Peter & Cowling 2006). *A. vaughani, australis, stentoreus, orientalis* appear to form a monophyletic complex of larger reed warblers (Leisler et al 1997). *Taxonomy is largely unresolved and reduces confidence in assessment. A. australis is probably part of a monophyletic clade within a large monophyletic group of large reed warblers. Reports of hybrids and intermediates with New Guinean species in NE Qld could be evidence of mixing but viability and occurrence of different phenotypic traits requires further research. Most evidence implies species is monophyletic and hence unlikely to be highly genetically flexible which may limit species under climate change. Species should be considered at high risk but with medium confidence due to problems with taxonomic resolution*	**M**	**H**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change? ‘Data may be deficient in this case, they are relatively common, each wetland with a few reeds has them. Migratory, and common throughout Aust. and therefore a possible decline in the SA MDB population wouldn’t impact on the species’ national population’ (P. Waanders 2011, pers. comm.).	Widespread distribution especially along upper and middle reaches of River Murray and tributaries and also parts of Mallee region in Vic, in SA distributed across south east part of state, very occasionally on Eyre Peninsula (Higgins Peter & Cowling 2006). 516 records within SA MDB floodplain since 1990, widely distributed throughout study area (BDBSA 2010). Subregionally listed as near threatened and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). *Moderate population size with wide distribution across SE Australia and River Murray. This is verified by pattern of records held in BDBSA. IBRA sub-regional assessment lists species as near threatened and in probable decline within study area but thought to be relatively common in wetlands with reeds. Species should be considered at low risk*	**H**	**L**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Breeding early Sept-mid-Feb, usually 3, sometimes 2 or 4 eggs laid, rarely one. Can be double-brooding, one female recorded with 3 broods in one season (Higgins Peter & Cowling 2006). *Moderate egg laying capacity compared to other birds assessed in this study. Ability for multiple broods increases potential fecundity. Species should be considered at low risk*	**H**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? Likely to have a moderate lifespan around 8-10 years given large size of bird. Probably matures quickly, e.g. by end of first year, and is a reasonably good breeder. Availability and quality of breeding habitat is a major factor in recruitment and reproductive success in species (P. Wainwright 2010, pers. Comm.).	Potential for high fecundity with moderate clutch sizes and multiple broods as success rates for fledging are relatively high (47% equaling 1.32 young per nest). Age at first breeding and generation time unknown but one individual in Vic was found dead near banding place 7 years after being banded (Higgins Peter & Cowling 2006). *Recruitment potential is relatively high given clutch sizes, multiple brooding and good fledging success rates. Species is likely to reach breeding maturity by end of first year and probably has a moderately high longevity of 8-10 years. A lack of quantified information on generation time (age at maturity, longevity) reduces confidence in assessment. A major factor in determining recruitment success is the availability of good quality breeding habitat. These typically dense, freshwater aquatic and/or riparian habitats are under threat through climate change and may limit recruitment to a large extent if breeding sites are lost. Species should be considered at moderate risk but with medium confidence due to lack of quantified data on maturation period and longevity*	**M**	**M**

Scientific Name:	*Anas castanea*	Common Name:	Chestnut Teal

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change	Inhabit terrestrial wetlands and estuarine habitats mostly near coast; shallow areas of fresh or saline permanent and semi-permanent wetlands. 'One of few species of ducks that tolerates high salinity…though need of freshwater for drinking has been suggested (Marchant & Higgins 1990)'. Non-selective, opportunistic and omnivorous feeder (Frith 1982). In the Lower Murray River Floodplain, most abundant in evaporation basins where salinity and wetland productivity relatively high. In study region, abundances of waterfowl at the Clover Lake – Lake Merreti – Lake Woolpolool complex demonstrated clear patterns of variation with water levels, with abundances increasing in proportion to water level increases and peaking immediately after peak water levels (Ziembicki 1997 [in SAAB 2001]). ***Tolerates high salinity and is a generalist feeder but in study region a decline in ephemeral wetlands with a reduce in flood events is expected to decrease habitat for species. Species not observed to breed in study region. 'Habitat' preference is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change	Few detailed studies, but evidence suggests birds are generally sedentary, but that there is some dispersive movement during summer in which individuals may travel long distances. Often breeding dispersal is local and birds breed in immediate vicinity (Frith 1982 [in SAAB 2001]). ***Can disperse long distances but generally sedentary. 'Mobility & dispersal' is expected to be a moderate limitation to the ability of the regional population of the species to tolerate climate change.***	L	M
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Non-selective, opportunistic and omnivorous feeder. Though said to prefer hollows for nesting (Marchant & Higgins 1990) nest can be a scrape placed on the ground in long grass, rushes, in rock crevices, or in a tree hollow (Frith 1982 in [SAAB 2001]). ***No information to suggest that the species has increased competition for food or other resources such as nesting sites. 'Competition' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Very abundant in salt-water of the Coorong, but much less common in the adjacent freshwater lakes Albert and Alexandrina (Frith 1982 [in SAAB 2001])'. 'One of few species of ducks that tolerates high salinity (Marchant & Higgins 1990)'. 'In the Lower Murray River Floodplain, most abundant in evaporation basins where salinity and wetland productivity relatively high (Ziembicki 1997 in SAAB 2001)'. Non-selective, opportunistic and omnivorous feeder (Frith 1982 [in SAAB 2001]). ***Its tolerance to salinity and generalist feeding habitat suggests that 'survival tolerances' are expected to be a minor limitation on the ability of the regional population to tolerate climate change.***	H	L

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'One of few species of ducks that tolerates high salinity (Marchant & Higgins 1990)'. 'In the Lower Murray River Floodplain, most abundant in evaporation basins where salinity and wetland productivity relatively high (Ziembicki 1997 in SAAB 2001)'. Non-selective, opportunistic and omnivorous feeder (Frith 1982). In study region, abundances of waterfowl at the Clover Lake – Lake Merreti – Lake Woolpolool complex demonstrated clear patterns of variation with water levels, with abundances increasing in proportion to water level increases and peaking immediately after peak water levels (Ziembicki 1997 [in SAAB 2001]). Development of nestlings inhibited on saline waters (Marchant & Higgins 1990). ***Though species is documented to increase in abundance with fluctuating water levels in ephemeral wetlands suggesting water regime is important, species is very tolerant of high salinity, is a generalist feeder and isn't recorded to breed in the study region (e.g. development of young not applicable) so growth tolerances of species are not expected to be exceeded under climate change conditions in study region. 'Growth tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Development of hatchlings inhibited on saline waters (Marchant & Higgins 1990). 'River Red Gum Eucalyptus camaldulensis wetlands managed for waterfowl should be allowed to dry out entirely between floods, as most duck breeding occurs in wetlands which have dried out between floods (Briggs and Thornton 1999 in SAAB 2001)'. Requires water to remain under the nest trees for several months following flooding (Briggs and Thornton 1999 [in SAAB 2001]). Generally said to prefer hollows but ground nesting recorded (Marchant & Higgins 1990). ***Reduced flooding of temporary wetlands, shortened inundation periods and an increase in wetland salinity are expected to restrict breeding in this species across its range, however there are no records of species breeding in study region (Harper pers.com.). 'Reproductive tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.-***	H	L
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	'In South Australia, widespread distribution south-east of line from Lake Blanche and Lake Eyre south area to Ceduna (Marchant and Higgins 1990), including Kangaroo Island (SAAB 2001). Species not listed as conservation significant within state or region, but species is not common within study region. ***No information on gene pool of species found, but with moderate dispersal ability and widespread distribution though small population size within study region the specie's gene pool is expected to be moderately heterogenous. 'Gene pool' is expected to have moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Breeding pairs monogamous, bonds maintained between seasons (Marchant & Higgins 1990). 'Few detailed studies, but evidence suggests birds are generally sedentary, but that there is some dispersive movement during summer in which individuals may travel long distances. Often breeding dispersal is local and birds breed in immediate vicinity (Frith 1982 [in SAAB 2001])'. ***No information on gene flow within species found documented but with moderately good dispersal ability, though breeding generally local and breeding pairs monogamous, moderate gene flow within population is suggested. 'Gene flow' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	L	M
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	***Unknown: No information found on the extent that 'phenotypic plasticity' limits the ability of the regional population of the species to tolerate climate change.***	L	M

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Species not listed as conservation significant within South Australia but species is not common within study region and population size is considered moderate. ***'Population size' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	H	M
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	'Most accurate estimation of average clutch size 10.6, size of clutches given in (Marchant and Higgins 1990) varied from 2 to 22 eggs (SAAB 2001)'. ***However, there are no records of species breeding in study region (Harper pers.com.) and therefore 'Reproductive Capacity' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change***	H	L
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Frith (1982) reported 65% of 169 clutches produced hatchlings. Little Ravens *Corvus mellori* take many eggs and young. Snakes, Blue-Tongued Lizards *Tiliqua scincoides* may take eggs. Purple Swamphens *Porphyrio pophyrio* and Musk Ducks *Biziura lobata* take ducklings (Marchant and Higgins 1990). ***Moderate rate of hatchling success and predation on nests reported. However, there are no records of species breeding in study region (Harper pers.com.) and therefore 'Recruitment' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change***.	H	L

Scientific Name:	*Anas rhynchotis*	**Common Name:**	Australasian shoveler

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change	'Bill specialized for filter feeding limits foraging to aquatic habitats on open water or soft mud in fertile wetlands with abundant prey (Marchant & Higgins 1990)'. Prefer large deep permanent lakes and swamps where conditions stable and aquatic flora abundant; may be found on floodwaters; in NSW numerous on swamps where small seasonal fluctuations in water-level promote development of rich littoral flora and fauna (Frith et al 1969; Marchant & Higgins1990). 'Prefer fresh water, but can occur on high numbers on brackish or saline lakes…(Marchant & Higgins 1990)'. ***Able to utilise saline habitats but productive ephemeral wetland habitat will decline with reduced flood frequency and increased evaporation rates. 'Habitat' is expected to be a moderate limitation to the ability of the regional population of the species to tolerate climate change.***	H	M
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change	'Dispersive but poorly known…distribution and size of population correlated with conditions within Murray Darling Basin (Marchant & Higgins 1990)'. In New Zealand highly mobile with dispersal to nest sites 800km away recorded (Marchant & Higgins 1990)'. ***Documented to disperse long distances particularly in inland areas where habitat conditions are variable. 'Mobility & Dispersal' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	'Bill specialized for filter feeding limits foraging to aquatic habitats on open water or soft mud in fertile wetlands with abundant prey (Marchant & Higgins 1990)'. 'Mosquito fish are carnivores and may compete directly with waterfowl for invertebrates. They are very effective predators and can greatly reduce plankton and insect populations. Other carnivorous fish compete with waterfowl. (Hurlbert et al. 1972 [in Crome 1986])'. ***Though information on 'competition' specific to the species was not found, some competition with introduced fish is expected with overlapping food source and specialised feeding mode, and likely to increase with a reduction in temporary wetland habitat often low in fish abundance. 'Competition' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Prefer fresh water, but may occur on high numbers on brackish or saline lakes…(Kingsford & Porter 1994; Marchant & Higgins 1990)'. Invertebrates are often more abundant in saline waters (Kingsford & Porter 1994). 'Bill specialized for filter feeding limits foraging to aquatic habitats on open water or soft mud in soft mud in fertile wetlands with abundant prey (Marchant & Higgins 1990)'. In NSW numerous on swamps where small seasonal fluctuations in water-level promote development of rich littoral flora and fauna (Frith et al 1969; Marchant & Higgins1990). ***Though a reduction in ephemeral wetlands is expected to reduce food abundance, species does not require a specific water regime for survival, and as a generalist filter feeder tolerant of saline waters some negative influence may be offset in circumstances where increased salinity reduces turbidity of surface waters resulting in abundant aquatic vegetation and increased wetland productivity. 'Survival' tolerances are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Prefer fresh water, but may occur on high numbers on brackish or saline lakes…(Kingsford & Porter 1994; Marchant & Higgins 1990)'. 'Bill specialized for filter feeding limits foraging to aquatic habitats on open water or soft mud in soft mud in fertile wetlands with abundant prey (Marchant & Higgins 1990)'. In NSW numerous on swamps where small seasonal fluctuations in water-level promote development of rich littoral flora and fauna (Frith et al 1969; Marchant & Higgins 1990). ***Although no specific information on growth tolerances was found, a reduction in highly productive wetlands documented as particularly important to this species (e.g. due to reduced flood events/ alteration water regime), is expected to impact on the health, growth &/or development of this species due to specialised filter feeding habit . No information to suggest salinity has significant effect on growth as found in high abundance in saline habitats. 'Growth tolerance' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	L	M

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Mean salinity of wetlands used by 12 broods in south-western Australia 9.246 g/L [~ 15000uS/cm] (range 0.970 [~1600 -22.200 [~36000uS/cm]) mean pH 8.4 (range 6.2-10.0, (Goodsell 1990 [in SAAB 2001])'. Inland populations probably opportunistic breeders in response to rainfall events (SAAB 2001). In NSW found to breed more widely in swamps with high levels of organic matter, complex flora and diverse invertebrate populations in early stages of succession after drying and refilling (Crome 1988). *Though can utilize brackish-saline waters for breeding, available information suggests that a reduction in flood events and alteration to natural water regimes of temporary wetlands significantly restricts breeding of the species.* ***However, there are no records of species breeding within study region therefore 'Reproductive tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	'Probably has always been a relatively uncommon duck (Frith 1982 [in SAAB 2001]). Listed as 'rare' in SA and though not uncommon in the study region, still usually observed in low abundance - ones, twos or small groups. ***Though no information on the gene pool of this species found, a small population size but ability to disperse long distances, suggest a gene pool of moderate heterogeneity. 'Gene Pool' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	'Dispersive but poorly known…distribution and size of population correlated with conditions within Murray Darling Basin (Marchant & Higgins 1990)'. In New Zealand highly mobile with dispersal to nest sites 800km away recorded (Marchant & Higgins 1990). 'Probably monogamous (Frith 1982 (in SAAB 2001) but not known how long pairs remain together (Marchant & Higgins 1990)'. ***Gene flow not specifically documented in the literature but moderate gene flow expected due to high mobility of species in regions of variable habitat and probable monogamous pair bonding. 'Gene Flow' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	'That shovelers also respond sexually to conditions suitable for breeding was suggested by an increase in gonad activity in 1966. This corresponded with a high water level and an extensive littoral flora that supported an abundance of favoured foods…(Braithwaite & Frith 1969)'. ***Information suggests species can alter timing of breeding in response to climatic and environmental conditions however not enough information is available to determine the extent of limitation that 'Phentotypic plasticity' has on the ability of the regional population of the species to tolerate climate change.***	L	L
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	'…probably has always been a relatively uncommon duck (Frith 1982 [in SAAB 2001])'. Listed as 'rare' in SA and though not uncommon in the study region, still usually observed in low abundance - ones, twos or small groups. ***Small population size: 'Population Size' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	H	H

	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Relatively large clutch size: 'Usually 9-11 eggs per clutch (Marchant & Higgins 1990)'. ***However, there are no records of species breeding in study region (Harper pers.com.) and therefore 'Reproductive Capacity' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change***	H	L
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Sexually mature at 1 year old (Marchant & Higgins 1990). 'In NZ unconfirmed reports of 50% mortality rates of juveniles compared with 44% adult mortality rate (Marchant & Higgins 1990)'. 'The open nature of their nests would also make ducklings and adults prone to predation by foxes and cats and also possibly ravens that have increased in abundance since European settlement (Blakers et al 1984 [in SAAB 2001])'. *Low-moderate hatchling success and high predation on nests reported*. ***However, there are no records of species breeding in study region (Harper pers.com.) therefore 'Recruitment' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change***.	H	L

Scientific Name:	*Anhinga melanogaster novaehollandiae*	**Common Name:**	(Australian, Oriental, Diver) Darter

FAMILY: Anhingidae

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	Of a family of large aquatic birds of still inland waters. Roost and nest typically in trees and bushes over water and rarely on ground or in reeds (Marchant and Higgins 1990b). Most commonly on permanent water bodies with extensive open water at least 0.5m deep e.g. lakes, estuaries, and large rivers. Require smooth open water for feeding and need fringing or projecting trees, branches or other perches for drying wings. Forage where emergent vegetation is sparse probably to allow unobstructed swimming and diving. Nature of fringing vegetation is not important as long as perching sites are available. Regularly use artificial impoundments but avoid narrow, steep-banked, turbid sites fringed with weeds. Deep open water bodies preferred by Darters suffer less from drainage than other wetland types. Salinity, land clearing, grazing, frequent burn-offs and groundwater extraction are identified as main threats particularly to breeding sites (various studies cited in Marchant and Higgins 1990b). Restricted to fresh and brackish wetlands with extensive sedges and live trees and secondary saline wetlands with dead trees, avoids hypersaline and species poor freshwater wetlands (Halse et al. 1993). *Reasonably flexible salinity tolerances ranging from fresh to saline but not hypersaline, low risk of extensive hypersalinisation of wetlands within study area due to climate change. Also uses artificial impoundments. Fringing vegetation is required but nature is insignificant as evidenced by use of dead trees as perches in secondary saline wetlands. Major threat due to reliance on permanent, deep water bodies required for diving/swimming foraging and fishing activities. While deep water bodies suffer less from drainage, increased pressure on water resources under climate change may mean more extractions for irrigation, higher evaporation and lower recharge and may lead to problems with salinity that could affect food supply. River regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Movement poorly known but apparently dispersive when not breeding to distances of 2000km. Almost entire population contracts to breeding areas in summer though extent of philopatry is unknown (Marchant and Higgins 1990b). No seasonal movements recorded in or out of Vic. (Vic. Atlas as cited in Marchant and Higgins 1990b). Irruptive movements to coast in times of inland drought may occur (Nicholls et al. 1919 as cited in Marchant and Higgins 1990b). *Movement is not well known but reasonable evidence from literature that bird is able to move in response to water availability and is dispersive to long distances especially in non-breeding season. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	A very large bird with a wingspan around 120cm and weighing up to 2.6kg. Consumes mainly fish and other large aquatic animals but also some insects and occasionally vegetable matter. Tend to be gregarious but nest solitarily and defend nest territories within several meters against conspecifics but does not maintain any other territories. Breeds solitarily up to 1 km apart or in small, loose colonies of up to 10 nests often in association with cormorants, ibises and herons. Sometimes mistakenly shot at opening of duck-hunting season, adults also drowned in fishing nets and immature birds occasionally attacked by Marsh Harriers. Some inland population feed extensively on 'pest' fish species e.g. carp and redfin. Eradication of these animals may be detrimental if not replaced with native prey (Marchant and Higgins 1990b). *As a very large bird it has competitive advantages compared to smaller birds and is unlikely to suffer a lot of predation pressure except possibly when young. Gregarious nature also protects birds to an extent. Nest sites are defended with various threat displays including chasing and sometimes fighting but mainly against conspecifics. As an apex predator in its habitat, it may suffer some competition for food with other large water birds and fish e.g. Murray Cod but this is not mentioned in the literature and may not be significant. Species should be considered at low risk.*	**H**	**L**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Restricted to fresh and brackish wetlands with extensive sedges and live trees and secondary saline wetlands with dead trees, avoids hypersaline and species poor freshwater wetlands (Halse et al. 1993). Consumes mainly fish and other large aquatic animals but also some insects and occasionally vegetable matter. Requires smooth open water for feeding and need fringing or projecting trees, branches or other perches for drying wings. Most commonly on permanent water bodies with extensive open water at least 0.5m deep e.g. lakes, estuaries, and large rivers. Forage where emergent vegetation is sparse probably to allow unobstructed swimming and diving. Nature of fringing vegetation is not important as long as perching sites are available. Some inland population feed extensively on 'pest' fish species e.g. carp and redfin. Eradication of these animals may be detrimental if not replaced with native prey (Marchant and Higgins 1990b). *Reasonably flexible salinity tolerances ranging from fresh to saline but not hypersaline. Also uses artificial impoundments. Fringing vegetation is required but nature is insignificant as evidenced by use of dead trees as perches in secondary saline wetlands. Major threat due to reliance on permanent, deep water bodies required for diving/swimming foraging and fishing activities. While deep water bodies suffer less from drainage, increased pressure on water resources under climate change may mean more extractions for irrigation, higher evaporation and lower recharge and may lead to problems with salinity that could affect food supply. River regulation also aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation. Problems with habitat and water quality may also affect food supply and pest eradication may remove critical food sources in some areas unless carefully managed. Species should be considered at moderate risk.*	**H**	**M**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	No specific information on growth or fledging to maturity. At Booligal in NSW, breeds in swamps with climax vegetation of ribbon weed and abundant fish, and when swamps dry and then refill, breeding is inhibited until the flooding climax is reached (Crome 1988). Young are altricial and nidiculous so spend a relatively long time (up to 40 days) as dependent nestlings (Marchant and Higgins1990b). Both parents incubate and tend young until a few weeks after fledging. Time to independence is unknown but is not recorded being fed after 60 days of age and said to fledge at around 50 days (Vestajens 1975 as cited in Marchant and Higgins 1990b). Small chicks (and eggs) rely on shading and watering by parents for survival in hot weather (Marchant and Higgins 1990b). Mean salinity of wetlands used by 5 broods in south-western Australia 4.832ppt, mean pH 7.7 (Goodsell 1990). *Lack of specific information on early growth stages limits confidence in assessment. Breeding is usually timed to coincide with flood peaks and abundance of vegetation and food. If breeding in ephemeral wetland areas, hydrological regime is important and may threaten species under climate change. Young hatch poorly developed and spend considerable time in vulnerable nestling stage which also increases load on parents (feeding, shading and watering). Broods appear to be preferably raised in fresh water systems but this is based on very few observations. Salinisation of breeding areas may affect growth of young in these areas. Species should be considered at moderate risk but with medium confidence due to lack of knowledge and low number of studies.*	**M**	**M**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	At Booligal in NSW, breeds in swamps with climax vegetation of ribbon weed and abundant fish, and when swamps dry and then refill, breeding is inhibited until the flooding climax is reached (Crome 1988). Nest is cup constructed of twigs and leaves and is typically around 3.5m above water in forks of branches of live or dead trees in at least 30cm of water. If water level falls during breeding, birds may move to deeper water (Vestjens 1975 as cited in Marchant and Higgins 1990b). Mean salinity of wetlands used by 5 broods in south-western Australia 4.832ppt, mean pH 7.7 (Goodsell 1990). Breeds solitarily up to 1 km apart or in small, loose colonies of up to 10 nests often in association with cormorants, ibises and herons. Both parents incubate eggs and tend young until a few weeks after fledging. Young may scramble from nest quite early and are not recorded being fed after 60 days of age but nestling period and time to independence is unknown. Erratic and irregular breeding not restricted to a strict season and apparently dependent on suitable water, food and shelter conditions. Some wetlands used for breeding threatened by increased salinity, clearing, grazing and groundwater extraction (Marchant and Higgins 1990b). *No strict breading season and is dependent on favourable environmental conditions. Breeding is usually timed to coincide with flood peaks and abundance of vegetation and food. Climate change is expected to affect flood timing and reduce frequency and magnitude of events raising risk to opportunistic breeding in species. Nature of vegetation for nest sites is unimportant, presence of structure is key e.g. may be in live or dead trees over water. If breeding in ephemeral wetlands, hydrological regime is important and may threaten species under climate change. A transition from permanent, freshwater wetlands to more temporary and saline wetlands is expected through increased flow regulation to mitigate effects of climate change and drought. Birds may however move if water level drops in breeding sites thus nullifying risk to an extent. Broods appear to be preferably raised in fresh water systems but this is based on very few observations. Species should be considered at moderate risk.*	**H**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Is at least seasonally monogamous but length of pair-bond is not verified through banding studies. Breeds solitarily up to 1 km apart or in small, loose colonies of up to 10 nests often in association with cormorants, ibises and herons. Mainly solitary and intolerant of conspecifics but readily mingle with other water bird species. Almost entire population contracts to breeding areas in summer though extent of philopatry is unknown (Marchant and Higgins 1990b). Reasonably low number of sighting in Murray-Darling Depression under Atlas surveys and estimated to represent a moderate percentage of the national population (ANRA 2010b). High number of records (609) within study area above Wellington compared to other birds assessed in this study (BDBSA 2011). Listed as 'rare' in DENR Murraylands region and IBRA sub-regions throughout study area and in probable decline in Murray Scroll Belt (Gillam and Urban 2010). *Atlas surveys agree with regional and sub-regional status assessments indicating a low to moderate population in the study area. BDBSA records suggest higher numbers but probably over-represented through survey effort and conspicuousness of species. Contraction of majority of population to breeding areas increases chance of genetic mixing. Species should be considered at low risk.*	**H**	**L**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Is at least seasonally monogamous but length of pair-bond is not verified through banding studies. Breeds solitarily up to 1 km apart or in small, loose colonies of up to 10 nests often in association with cormorants, ibises and herons. No estimates of total population, last aerial survey data current to 1988 relevant to eastern Australia. Reasonably low number of sighting in Murray-Darling Depression under Atlas surveys and estimated to represent a moderate percentage of the national population (ANRA 2010b). Almost entire population contracts to breeding areas in summer though extent of philopatry is unknown (Marchant and Higgins 1990b). Almost entire population contracts to breeding areas in summer though extent of philopatry is unknown (Marchant and Higgins 1990b). *Atlas surveys agree with regional and sub-regional status assessments indicating a low to moderate population in the study area. BDBSA records suggest higher numbers but probably over-represented through survey effort and conspicuousness of species. Contraction of majority of population to breeding areas increases chance of gene flow but lack of knowledge of duration of pair-bonds limits confidence. Bird appears at least partially monogamous but probably not limiting at population scale. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic species with 3 subsepcies recognized throughout the globe. Australian subspecies (*novaehollandiae)* is distinct from other subspecies and shows no geographic variation or indication of different phenotypes (Marchant and Higgins 1990b). *While species is polytypic, only one subspecies is known to occur in Aust. and no geographic variation is noted. Species does not appear to display phenotypic plasticity within its range in Aust. Species should be considered at high risk.*	**H**	**H**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Low-moderate relatively number of sighting in Murray-Darling Depression bioregion through Atlas surveys estimated to represent a moderate percentage of the national population (ANRA 2010b). High number of records (767) within floodplain and study area above Wellington (609) compared with other birds assessed in this study (BDBSA 2011). Listed as 'rare' in DENR Murraylands region and IBRA sub-regions throughout study area and in probable decline in Murray Scroll Belt (Gillam and Urban 2010). *Atlas surveys agree with regional and sub-regional status assessments indicating a low to moderate population in the study area. BDBSA records suggest higher numbers but probably over-represented through survey effort and conspicuousness of species. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change? <u>May have multiple broods but capacity is probably limited (P. Wainwright pers. comm. 2011).</u>	Average of 4 and range of 2-6 eggs (Vestjens 1975 as cited in Marchant and Higgins 1990b). No information on multiple brooding or clutch replacement capacity. Erratic and irregular breeding not restricted to a strict season and apparently dependent on suitable water, food and shelter conditions (Marchant and Higgins 1990b). *Moderate clutch size compared to other birds assessed in this study. May have multiple broods but with limited capacity as is a large species with altricial, nidiculous young that take a relatively long time to reach independence. This is complicated by erratic and irregular breeding throughout the year and reliant on suitable environmental conditions. Conservatively, species should be considered at high risk but with medium confidence due to knowledge gaps of brooding capacity.*	**M**	**H**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>May have multiple broods but capacity is probably limited (P. Wainwright pers. comm. 2011).</u>	Erratic and irregular breeding not restricted to a strict season and apparently dependent on suitable water, food and shelter condition (Marchant and Higgins 1990b). Moderate clutch size compared to other birds assessed in this study but no information on multiple brooding or clutch replacement capacity, longevity or age at first breeding. Age adult plumage is attained is also not defined in the literature. No recent estimates of total population, last aerial survey data current to 1988 and only relevant to eastern Australia (Marchant and Higgins 1990b). Relatively low number of sighting in Murray-Darling Depression under Atlas surveys and is estimated to represent a moderate percentage of the national population (ANRA 2010b).High number of records (609) within study area compared with other birds assessed in this study (BDBSA 2010). Listed as 'rare' in DENR Murraylands region and IBRA sub-regions throughout study area and in probable decline in Murray Scroll Belt (Gillam and Urban 2010). *Large bird and probably long lived however no information on age at first breeding or age adult plumage is attained. Clutch size is moderate compared to other species assessed in this study and may have more than one brood in a season/year presumably depending on environmental conditions. As a large bird with altricial, nidiculous young that take a relatively long time to reach independence, reproductive cycle is probably long. Moderate population base from which to recruit from but likely in decline in study area. Opportunistic breeding and multiple brooding possible but probably restricted. Conservatively, species should be considered at high risk as large birds like this probably have longer generation times and take a long time to reach breeding maturity. Confidence is low however due to extensive knowledge gaps in reproductive biology and recruitment success.*	**L**	**H**

Scientific Name:	*Ardea alba*	**Common Name:**	Great Egret

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change. <u>Seen transitioning from fresh/brackish/saline wetlands but not hypersaline as fish (main prey) drop out if salinity gets too high. More adaptable than yellow-billed spoonbill and sufficiently habitat generalist to be considered at moderate risk (P. Wainwright 2010, pers. Comm.).</u>	Inhabits great variety of wetlands particularly in the interior (Slater et al 2001). Inland use a variety of habitats, prefer permanent water bodies on flood plains, shallow or deep permanent lakes, either open or vegetated with shrubs or trees, semi-permanent swamps will tall emergent vegetation. Regularly uses saline habitats, estuaries and mudflats mainly in summer/autumn or drought refuges (Ecological Associates 2010). *Habitat generalist reduces threat level, some reliance on aquatic vegetation for foraging and critical for breeding, preference for permanent wetlands, species should be considered at moderate risk*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Listed under Japanese Australian Migratory Bird Agreement (JAMBA) and Chinese Australian Migratory Bird Agreement (CAMBA). Dispersive, though some seasonal movements regular, possibly migratory and sometimes irruptive (suddenly) into NZ (Ecological Associates 2010). *As a migratory species with recorded irruptive movements to coasts in times of drought, the species shows the ability to relocate if conditions become unfavourable, as such the species should be considered at low risk*	**H**	**L**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? No quantified studies but observed to consume fish almost exclusively in Lower Lakes and Coorong but can adapt diet to area e.g. can take marine fish, so no significant competition for food. A large, aggressive wader unlikely to suffer major interspecific competition (P. Wainwright 2010, pers. Comm.).	When nesting, other species occupying branches too close to nest are ejected by displacement (Marchant and Higgins 1990). Hunts aquatic animals, principally fish but also freshwater snails, shrimp, crayfish and frogs, insects, small birds and snakes. Decline in breeding in Lower Lakes possibly associated with carp introduction (Ecological Associates 2010). *Generalist diet and territorial nature around breeding sites means species is a good competitor, breeding habitat quality outside of study area possibly affected by carp but not quantified. Species should be conservatively considered at moderate risk*	**M**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Broad habitat and diet requirements, ability to switch diets and use a variety of habitats for foraging, limited tolerance to acidity (Marchant and Higgins 1990). *Varied diet means unlikely to be limited through food availability, some reliance on habitat for foraging but is not specific and uses fresh to saline wetlands. Low tolerance to acidification may pose greatest threat in River Murray system. Species should be considered at moderate risk*	**H**	**M**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	No detailed knowledge of growth stage. Nestlings thought to be fed predominantly fish although not many studies, diet and habitat requirements of adults are broad and can switch according to availability. Time to independence around 64 days from hatching, parents feed young until then (Marchant and Higgins 1990). Never recorded with a brood in waters with a pH < 7 suggesting no tolerance of acidic waters (Ecological Associates 2010). *Relatively long time to independence increases risk to parent and young as parental investment is required for longer periods and the young spend more time as vulnerable juveniles. Acidification of some areas of River Murray wetlands is a risk under climate raising risk to successful growth and survival. The species should be considered at moderate risk*	**H**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Never recorded with a brood in waters with a pH < 7 suggesting no tolerance of acidic waters. Breeding decline since 1970s possibly related to carp introductions (Ecological Associates 2010). Colonial nesting in trees and swamps, sometimes apart from other egrets but often near cormorant and night herons (Slater et al 2001). Nests in living River Red Gums (Leslie 2001) and responds to areas that are flooded for at least 4 months (Briggs et al 1997). Vegetation is critical for breeding (Kingsford and Norman 2002). Darling Riverine Plains and Riverina breeding populations may be declining due to reduced water flow to colony sites and predicted declines in catchment rainfall (DEHWA 2010c). *Acidification and salinisation threatens critical breeding riparian woodland habitat e.g. River Red Gums. This coupled with critical dependence on flooding and long term inundation of wetlands for breeding puts species at high risk*	**H**	**H**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? As a colonial nesting, migratory bird the gene pool will be large as mixing occurs through formation of large breeding colonies, this also translates to good gene flow and potential for genetic flexibility by providing generic sets of gene codes that have high diversity (P. Wainwright 2010, pers. Comm.).	IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). However as a cosmopolitan species the available gene pool is potentially large. Global population roughly estimated at 60000, Australian population not estimated, unlikely genuine subpopulations exist due to broad range and high mobility of species (Jaensch 2003 as cited in DEHWA 2010). The species can disperse great distances (1000's km but more commonly 100's km) (McKilligan 2005) so breeding flocks may contain individuals from different populations thus lessening the chance of gene pool limitation. *Unlikely to be limited as global populations are moderate and species has high mobility and broad ranging capacity increasing the chances of mixing of diverse gene pool despite regional threat listings. Species should be considered at low risk*	**H**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? As a colonial nesting, migratory bird the gene pool will be large as mixing occurs through formation of large breeding colonies, this also translates to good gene flow and potential for genetic flexibility by providing generic sets of gene codes that have high diversity (P. Wainwright 2010, pers. Comm.).	No specific studies. Banding studies reveal movement of significant distances (to NZ in winter (Warbuton 1957 as cited in Marchant and Higgins 1990) but mixing with other populations is not quantified. Appearance of several subspecies from NZ, Japan, India and China and intermediates (Marchant and Higgins 1990) suggests some degree of population mixing. *Dispersal and cosmopolitan subspeciation raises confidence of gene flow between populations. Gene pool is also likely to be very diverse due to this character so it follows that gene flow must also occur at large scales. Species should be considered at low risk*	**H**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change? As a colonial nesting, migratory bird the gene pool will be large as mixing occurs through formation of large breeding colonies, this also translates to good gene flow and potential for genetic flexibility by providing generic sets of gene codes that have high diversity (P. Wainwright 2010, pers. Comm.).	Geographic variation and subspeciation apparent between Australian, NZ, and Asian populations, several subspecies identified according to size and colour of bare parts (Marchant and Higgins 1990). *No indication of driving factor behind variationsat global scale but could be associated with environmental factors as well as genetic drift. Populations in Australia likely to form one phenotypic clade but diverse potential gene pool and good gene flow (population mixing) negates detrimental effects of allopatric speciation as genetic base is so strong. Phenotypic plasticity may therefore not factor in limiting the species tolerance to climate change and may be considered at low risk*	**M**	**L**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Cosmopolitan and generally plentiful with stronghold in northern Australia. In decline in Coorong and Lake Albert, variable in Murray Estuary and Lake Alexandrina (Ecological Associates 2010). Global population roughly estimated at 60000, Australian population not estimated, unlikely genuine subpopulation due to broad range and high mobility of species (Jaensch 2003 as cited in DEHWA 2010). 1545 records since 1990 within floodplain, majority (1298) in Lower Lakes, rest widely distributed across system (BDBSA 2010). Significant indicator species for Murray Estuary (Rodgers and Paton 2009). IBRA sub-regionally listed as 'vulnerable' and in 'probable decline' in Murray Mallee and Murray Scroll Belt under IUCN criteria (Gillam and Urban 2010). *The species is migratory and has widespread populations across Australia and appears concentrated in the Lower Lakes region in the SA MDB. Population size must be considered at the scale of the range of the species and so must include birds from all over Australia and possibly some from abroad. Population size is therefore not likely to be limiting and the species should be considered at low risk*	**H**	**L**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Breeding season (from NSW studies) is from Nov to early May, in SA thought to be active in Nov. Clutch size generally between 2-6 eggs (frequently 3-4) incubated by both parents. Flood following drought thought to have triggered second brood in one event recorded in NSW (Marchant and Higgins 1990). *Potentially large clutch size and evidence of opportunistic breeding following flood event. Increased flow regulation to mitigate climate change effects may affect the timing and magnitude of such events to the detriment of the species unless carefully managed. Species should be considered at low risk*	**H**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Suggestion that immigration is not a mechanism for colony reformation. While egrets still breed in the forest, breeding numbers have generally declined by at least one order of magnitude, the number of traditional nest sites has declined and successful breeding has become increasingly less frequent and reliable. Reduced flood duration acting to decrease nest security and food availability during fledging is suggested as the main stress factor responsible for the population change (Leslie 2001). For egrets to initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least 5 and up to 10 months following flooding (Briggs and Thornton 1999). Breeding maturity age unknown. NSW studies have shown good success rate of fledglings, 91% of nests fledged an average of 2 chicks per successful breeding pair, in wet years the average was slightly higher (Marchant and Higgins 1990). *Recruitment appears limited to only what the population is able to brood, i.e. immigration from other populations is not likely. While species shows high breeding success rates in some regions this is associated with wet years and flooding. Loss of suitable nesting sites through altered flow regimes and reductions in flood frequency and magnitude under climate change is likely and is a major threat to recruitment. Species should be considered at high risk*	**H**	**H**

Scientific Name:	*Botaurus poiciloptilus*	Common Name:	Australasian Bittern

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change. <u>Dependent on fresh wetlands for vegetation cover and provision of prey habitat. Transition from permanent to temporary wetlands under increased management of climate change must be careful, vegetation monitoring diagnostic of water and habitat quality for prey. Species likely 'on brink' of being severely limited by climate change (P. Wainwright 2010, pers. Comm.).</u>	Narrow habitat preferences, preferring shallow, vegetated freshwater or brackish swamps. They are seen most frequently in exceptionally wet years, possibly because the population size increases and they occupy isolated ephemeral wetlands. Pairs occupy territories containing a mixture of tall and short sedges for breeding (Garnett and Crowley 2000). Habitat specialist that forage in association with fringing and emergent habitat (Ecological Associates 2010). The main threats are diversion of water for irrigation and salinisation or drainage of permanent swamps, overgrazing by stock, and inappropriate fire regimes that can reduce habitat suitability (Garnett and Crowley 2000). *Species has comparatively specialised habitat requirements so are more sensitive to overall habitat loss than are many wetland species and as such should be considered at high risk*	**H**	**H**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Probably sedentary in permanent habitat, but possible regular short-distance movements among wetlands (Ecological Associates 2010). Able to move between wetlands as suitability changes however they have specialised habitat requirements (Garnett and Crowley 2000). *While the species can move if conditions are unfavourable its options may be reduced due to specialist requirements and as such should be considered at moderate risk*	**H**	**M**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Not limited by competition with other species as is large bird and strong competitor. Some conspecific competition possible in small habitats but biggest competitor is human activity (need for good quality water, land use) (P. Wainwright 2010, pers. Comm.).</u>	Preys on medium-sized aquatic animals including eels, frogs and freshwater crayfish (Ecological Associates 2010). Medium size bird to around 1.4kg. Cryptic and secretive in nature. Have been known to take fish, spiders, insects and crustaceans, lizards, birds, rats and mice and leaves and fruit. Territoriality and nest defence unknown as is secretive (Marchant & Higgins 1990b). Predation not noted in literature. *No direct competition identified in literature, as other food types are taken this can reduce potential competition by switching diets. Species should be considered at low risk*	**H**	**L**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Cryptic, hard to study, hides in reeds and emergent vegetation. Intrinsic link to narrow habitat (inundated fresh riparian vegetation), lives in its specific habitat. If this habitat goes the species has nowhere to go (P. Wainwright 2010, pers. Comm.).</u>	Can tolerate only minor increases in salinity (Ecological Associates 2010). Have been known to take fish, spiders, insects and crustaceans, lizards, birds, rats and mice and leaves and fruit (Marchant & Higgins 1990b). *Habitat availability main limiting factor in survival through provision of food and cover. Narrow habitat preferences are intrinsic link to lifestyle, preferred habitats threatened by climate change. Species should be considered at high risk*	**H**	**H**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Like survival, growth most limited by habitat availability which is under threat, ratings should reflect this (P. Wainwright 2010, pers. Comm.).</u>	Nestlings probably have similar diet to adults; no specific information on nestling growth or success. Breeds mainly in freshwater amongst dense fringing or emergent vegetation. Bittern family typically have poorly developed young taking 4-8 weeks to fledge and may be semi-dependent for even longer (Marchant & Higgins 1990b). *Juveniles likely to have low tolerance to salinity like adults, climate change more likely to affect habitat availability for bittern and its prey, species should be considered at high risk*	**H**	**H**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Breed in deep, densely vegetated freshwater swamps and pools, building nests in deep cover over shallow water, in rushland they avoid densest areas (Ecological Associates 2010). Vegetation is critical for breeding (Kingsford and Norman 2002). Nests close to water using reeds and rushes as material . Breeding season Oct-Feb(5 months) (Marchant & Higgins 1990b). *No specific information on laying or incubation conditions or times, dense vegetative habitat availability for nesting and breeding most critical factor to reproductive success; increased habitat degradation is likely under changing climates so species should be considered at high risk*	**H**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Limited numbers in SA (<10000) and thought to be in decline (Ecological Associates 2010). Global and State threat listed as vulnerable (Garnett and Crowley 2000; Kingsford and Norman 2002). Only 2 records within study area since 1990 and 46 within SA MDB floodplain, majority in Lower Lakes region (BDBSA 2010). Nationally listed as vulnerable, sub-regionally listed as critically endangered in Murray Mallee and in probable decline (Gillam and Urban 2010). *Small regional population in SA concentrated in Lower Lakes and no indication of large-scale movements. Gene pool likely to be restricted for this species placing it at high risk.*	**H**	**H**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Appears not to move seasonally or over long distances and probably sedentary in permanent habitats (Marchant and Higgins 1990). Within South Australia the population is estimated to be less than 10,000 mature individuals with evidence of continuing decline. No subpopulation is estimated to contain more than 1000 mature individuals. (Ecological Associates 2010). Nature of pair-bonds unknown but in simple pairs solitarily (Marchant and Higgins 1990b). *Residential tendency and lack of dispersal of birds coupled with declining numbers and apparent distribution concentrated in Lower Lakes, species should be considered at high risk*	**H**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Monotypic, no evidence of any geographic variation e.g. plumage, size, breeding etc., all species of *Botaurus* are similar and allopatric, have been considered one super-species (Marchant & Higgins 1990b) *No sign of phenotypic plasticity, intolerant of changes in salinity indicating narrow physiological tolerance and specialist habitat requirements suggest a degree of niche specialization. Species should be considered at high risk*	**H**	**H**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Within South Australia the population is estimated to be less than 10,000 mature individuals with evidence of continuing decline. No subpopulation is estimated to contain more than 1000 mature individuals (Ecological Associates 2010). Listed as globally vulnerable, Australian populations are roughly estimated at 2500 individuals (Garnett and Crowley 2000). Species is State listed as vulnerable (SA, NSW) and endangered in Vic (Kingsford and Norman 2002). Only 2 records within study area since 1990 and 46 within SA MDB floodplain, majority in Lower Lakes region (BDBSA 2010). Nationally listed as vulnerable, sub-regionally listed as critically endangered in Murray Mallee and in probable decline (Gillam and Urban 2010). *Very low abundance in the study area indicated in the literature and supported by BDBSA records, species should be considered at high risk*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	No quantified data but clutch size reported between 4-5 eggs. No information on number of broods or replacement broods. Bittern family are generally single-brooding but do lay replacement clutches (Marchant & Higgins 1990b) *Species appears to have a moderate fecundity potential but information gaps in breeding biology mean interpretation is limited. Conservatively the species should be considered moderately at risk*	**L**	**M**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>Species that rely on permanent fresh wetlands for breeding will be less affected by climate change than those relying on ephemeral wetlands as flood frequency, duration and timing will be altered through increased management of river under climate change (P. Wainwright 2010, pers. Comm.).</u>	No specific information. Thought to breed from Oct to Feb but not quantified, no information on success rates (Marchant & Higgins 1990b). Breed in deep, densely vegetated freshwater swamps and pools, building nests in deep cover over shallow water, in rushland they avoid densest areas (Ecological Associates 2010). Vegetation is critical for breeding (Kingsford and Norman 2002). Nests close to water using reeds and rushes as material (Marchant & Higgins 1990b). *Species appears to rely mainly on permanent fresh wetlands (deep with dense vegetation). Dependence on this type of wetland puts species at less risk than species using ephemeral wetlands but extent of permanent wetlands is expected to decrease. Extremely limited information on actual success rates forces conservative treatment of species and should be considered at moderate risk*	**L**	**M**

Scientific Name:	*Biziura lobata*	Common Name:	Musk Duck

	Question	Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change.	Ideal habitat is deep permanent water with dense vegetation, but not too dense as birds need clear open pools among reeds for feeding and display ((Frith 1982 [in SAAB 2001])'. Almost entirely aquatic preferring deep water of large permanent swamps, lakes and estuaries where conditions are stable and aquatic flora abundant (Fjledsa 1985). 'When breeding, dispersed on deep fresh swamps, lakes, billabongs and rivers where dense vegetation provides nesting cover (Marchant and Higgins 1990)'. Regularly breeds on Bool lagoon and numbers greatest during high water levels (Harper 1990). Many freshwater wetlands suitable for breeding have been destroyed or modified by drainage, clearing, grazing, burning, increased salinity and increased inundation (Marchant and Higgins 1990) '. The deep water swamps they inhabit are not numerous (Frith 1982 [in SAAB 2001])'. Decline of musk ducks in region observed after increase in carp abundance (Harper pers.com). Carp expected to be favoured by reduced flows under climate change. Factors like water turbidity have implications for the diversity and abundance of food resources available in deeper water, with highly turbid water limiting the primary productivity of a lake to the upper parts of the water column or the fringes of the lake. ***Loss of quality deep freshwater foraging and breeding habitat with reduction in large productive ephemeral/ semi-permanent wetlands, and reduced quality e.g. increased turbidity/ altered water regime, of permanent pool level wetlands. 'Habitat' preference is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	H	H
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change	'During breeding season it is restricted to the dense breeding swamps, but in Autumn and Winter there is some movement and large concentrations form on clear lakes and swamps elsewhere (Frith 1982). Adults on permanent water apparently sedentary, but adults on ephemeral water dispersive (Marchant & Higgins 1990). Long distance movements also undertaken to colonise remote ephemeral water bodies such as lake Eyre (Frith 1982 [in SAAB 2001])'. ***Though some restrictions to dispersal due to sedentary nature of species on permanent water individuals on ephemeral water bodies (more common in study region) are highly dispersive. 'Mobility & dispersal' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	'The hardhead, musk duck, and blue-billed duck are adept at diving to the bottom of deep water, and so have food resources that are not available to the surface-feeding waterfowl (Frith et al 1969)'. ***Though some competition with other species e.g. other diving ducks, fish, turtles, is expected the diving ability of the species and access to large foraging area would reduce the impact. 'Competition' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Forage on either fresh or saline water bodies (Marchant and Higgins 1990 [in SAAB 2001]). In SW Australia preferred brackish water bodies (Halse et al 1993). At Bool Lagoon, SA abundance positively correlated with water levels with numbers greatest during high water levels (Harper 1990 [in SAAB 2001]). Ideal habitat is deep permanent water with dense vegetation, but not too dense as birds need clear open pools among reeds for feeding and display (Frith 1982 [in SAAB 2001]). 'The hardhead, musk duck, and blue-billed duck are adept at diving to the bottom of deep water, and so have food resources that are not available to the surface-feeding waterfowl (Frith et al 1969)'. ***Occur on fresh or brackish swamps (not documented on hypersaline sites) but ideal wetlands are those with consistent deep waters for feeding with increasing water levels and depth of water shown to determine presence of the species. 'Survival tolerances' are expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	H	M
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	***As above ' Occur on fresh or brackish swamps (not documented on hypersaline sites) but ideal wetlands are those with consistent deep waters for feeding with increasing water levels and depth of water shown to determine presence of the species. However, it is unclear at what point salinity, water regime tolerances etc would be exceeded and growth would be limited.***	L	M
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'The breeding cycle of musk dicks is more regular, owing to their permanent habitat (SAAB 2001)'Out of season breeding can occur in wet years (Marchant & Higgins 1990) suggesting water level is very important in initiation of breeding (SAAB 2001)'. When breeding, dispersed on deep fresh swamps (Marchant and Higgins 1990 [in SAAB 2001]). In September of each year preferred wetlands with low salinity (Halse et al 1993 [SAAB 2001]). ***Though species is described as a 'seasonal' breeder flooding is documented to increase breeding success, and in study region species has been observed to breed only in freshwater wetlands.Reduced river flow s and flooding and increased salinity of wetlands is expected to significantly impact breeding of species within region. 'Reproductive tolerances' are expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.-***	M	H
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Species is listed as 'Rare in SA', and although not uncommon on preferred habitat occurs in very low numbers compared to most other duck species. ***Though no specific information on the gene pool of this species was found, a relatively small population size but with good dispersal abilities suggests a moderately heterogenous gene pool. 'Gene Pool' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Widespread in eastern South Australia (SAAB 2001), and though listed as 'rare' is not uncommon in study region. Capable of long distance movements ' to colonise remote ephemeral water bodies (Frith 1982 [SAAB 2001]) and regular dispersal during breeding season, though 'Adults on permanent water apparently sedentary…(Marchant & Higgins 1990)'. Extended pair bonding unknown but none expected (Marchant & Higgins 1990)'. ***No specific information of gene flow within this species was found, and although population is small and adults can be relatively sedentary, distribution is widespread, the species is capable of long ranging movements and monogamous pair bonding is unlikely. 'Gene Flow' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M

	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	***Unknown: no information found on the extent that 'phenotypic plasticity' limits the ability of the regional population of the species to tolerate climate change?***	L	M
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Species is listed as rare in SA and although not uncommon on preferred habitat in very low numbers compared to most other duck species often solitary. ***Small population size: 'Population size' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change. ??***	H	H
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Low reproductive capacity: 1-3 eggs per clutch (Marchant & Higgins 1990). ***Though little information is known of breeding, clutch size is small and no large scale reproductive events were found documented suggesting even under ideal conditions breeding rates are low and population increase would be slow. 'Reproductive capacity' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	M	H
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	'No information except from some well vegetated farm dams in WA where of 24 nests only 5 produced ducklings in 7 seasons. Purple swamp hen seen to destroy nests and eat eggs (R &M Brown [in Marchant & Higgins 1990])'. ***Though little information available reproductive capacity combined with low recruitment rates and predation suggest overall recruitment success is low. 'Recruitment' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	L	H

Scientific Name:	*Charadrius ruficapillus*	**Common Name:**	Red-capped Plover

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>Specific to saline wetlands, when saline more likely to see Red-caped plover and when fresh more likely to see Black-fronted dotterel. Range may even extend under climate change due to increased salinity problems. May occupy a greater range within study area as more temporary and saline wetlands are expected to form through climate change and increased river flow regulation (P. Wainwright 2010, pers. Comm.).</u>	Common resident or nomad mainly associated with salt or brackish water throughout Australia (Slater et al 2001). Forage in shallow water and along the water edge in association with the intertidal, wind affected and seiche zone taking mostly invertebrates in littoral, estuarine and terrestrial wetlands. Prefers saline and brackish waters, but tolerate varying salinities from fresh to hypersaline. Prefers inland salt lakes with wide open bare mudflats sparsely vegetated on margins. In coastal areas prefer saline wetlands behind coast including salt marsh and saltpans, also inlets, estuaries and lagoons. Commonly recorded around artificial wetlands including sewage ponds and saltworks (Marchant and Higgins 1993). Other areas of international importance in South Australia include The Coorong, Penrice Saltfields, Spencer Gulf, Price Saltfields and Clinton Conservation Park (Watkins 1993) Coorong hosts >1% of flyaway population, meets Criterion 6 of Ramsar Convention (Paton et al 2009). *Strongly associated with brackish to saline wetlands, salt fields and the Coorong. Will use coastal and aquatic vegetation but not essential and will utilize artificial wetlands and salt works. Increased salinisation and scarring caused by land clearing and irrigation are expected to increase with climate change and may actually benefit species by extending its potential range. Species should be considered at low risk*	**H**	**L**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Generally higher numbers coastally during summer as there is usually little surface water inland, though this is affected by unpredictable seasonal rainfall (Marchant and Higgins 1993). Count data suggests that Red-capped Plovers are able to move in large numbers to seasonal wetlands in response to rainfall (Alcorn 1990) or to food availability (Marchant and Higgins 1993). Analysis of the 1983 Summer Count in Victoria found that 72% of the birds were distributed on inland brackish and saline wetlands, compared to 28% at coastal and near-coastal sites (Lane and Jessop 1983 as cited in Watkins 1993). The Regular Count Project found that the number of Red-capped Plovers at coastal sites increases in the summer and decreases in autumn and winter. In winter and spring the birds are very dispersed (Alcorn 1990). *Capacity to move in response to environmental cues and indication of seasonal distribution patterns of birds between inland and coastal habitats. Species shows good dispersal and large-scale movement. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Omnivorous diet consisting of annelids, molluscs (gastropods), small crustaceans (ostracods, isopods, amphipods, and small crabs), diverse range of insect taxa, and some vegetation. Defends nesting territory against other birds e.g. Black-fronted Plover, shows parental anti-predator responses to Raven and Kestrals when nesting. Can breed and nest in a wide variety of places either in pairs or as colonies of up to 44 pairs (Marchant and Higgins 1993). *Unlikely to be in competition for food or nesting space as has broad preferences. Potential to be a good competitor as shows nesting territory defence and parental anti-predator responses. Species should be considered at low risk.*	**H**	**L**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Can use fresh to brackish, saline and hypersaline environments and has a wide diet (P. Wainwright 2010, pers. Comm.).</u>	Omnivorous diet consisting of annelids, molluscs (gastropods), small crustaceans (ostracods, isopods, amphipods, and small crabs), diverse range of insect taxa, and some vegetation. Forages in shallow water and along the water edge in association with the intertidal, wind affected and seiche zone taking mostly invertebrates; littoral, estuarine and terrestrial wetlands. Prefers saline and brackish waters, but tolerate varying salinities from fresh to hypersaline (Marchant and Higgins 1993). *Wide habitat, diet and environmental tolerances and requirements and are unlikely to be limiting factors. Species should be considered at low risk.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Can use fresh to brackish, saline and hypersaline environments and has a wide diet (P. Wainwright 2010, pers. Comm.).</u>	No information on juvenile intake. Adults have an omnivorous diet consisting of annelids, molluscs (gastropods), small crustaceans (ostracods, isopods, amphipods, and small crabs), diverse range of insect taxa, and some vegetation. Forages in shallow water and along the water edge in association with the intertidal, wind affected and seiche zone taking mostly invertebrates; littoral, estuarine and terrestrial wetlands. Prefers saline and brackish waters, but tolerate varying salinities from fresh to hypersaline. Both parents tend young but duration and feeding regimes not clear, one study recorded hatchlings leaving nests after being brooded for only 1 hour (Marchant and Higgins 1993). *Juvenile diet and extent of parental care is unclear. Parental care (brooding and feeding) appears relatively limited and may benefit species through less parental investment and juveniles being vulnerable for less time. Wide foraging habitat and diet requirements of adults also reduce threat to species and juvenile diet assumed similar. Species should be considered at low risk but with medium confidence due to gaps in knowledge of juvenile growth requirements or time to independence.*	**M**	**L**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? May occupy a greater range within study area as more temporary and saline wetlands are expected to form through climate change and increased river flow regulation (P. Wainwright 2010, pers. Comm.).	In southern Australia, generally seasonal laying starting in July or August, and continuing until January and occasionally into February and March. May be opportunistic, breeding in nearly any month if conditions suitable. Can breed and nest in a wide variety of places. Nest is always on the ground in sand, shell grit, mud or stone in stony areas. Nests on beaches, dunes, sand-spits, sandflats along rivers, on islands in samphire, lagoons, sewage ponds, saltpans and grass tufts. Nests usually near water, but rarely closer than 40m and those placed far away from water usually sited close to a bush (Marchant and Higgins 1993). On coast, breeding is seasonal, with birds dispersing to breed Aug-Jan. Inland breeding occurs in response to rainfall and flooding (Ecological Associates 2010). *Broad nesting and breeding site requirements and capacity to take advantage of rainfall and flooding events on seasonal inland wetlands. May benefit from increase in availability of temporary and saline wetlands expected to occur through increased flow regulation to mitigate drought and climate change. Species should be considered at low risk.*	**H**	**L**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Widespread population in Australia estimated at 95000 (Watkins 1993). High reporting rate in Atlas project (Blakers et al 1984 as cited in SAAB 2001). Marked increases since 1990s in Lower Lakes (Ecological Associates 2010). Count data suggests that Red-capped Plovers are able to move in large numbers to seasonal wetlands in response to rainfall and in winter and spring the birds are very dispersed (Alcorn 1990). 534 records since 1990 within floodplain, majority (492) in Lower Lakes and Coorong, 7 in Murray Mallee and 35 in Murray Scroll Belt (BDBSA 2010). IBRA sub-regionally listed as 'vulnerable' and in 'definite decline' in Murray Mallee and Murray Scroll Belt and DENR Murraylands region (Gillam and Urban 2010). *Widespread distribution and moderately high abundance reported in literature. BDBSA records show concentration o f birds in Lower Lakes and IBRA sub-regional listings suggest depressed populations within study area. Distribution varies with season and water availability as species possesses a high capacity to move to suitable locations to breed. Regional populations are unlikely to be geographically and/or genetically isolated. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. On coast, breeding is seasonal, with birds dispersing to breed Aug-Jan. Inland breeding occurs in response to rainfall and flooding (Ecological Associates 2010). Count data suggests species is able to move in large numbers to seasonal wetlands in response to rainfall and in winter and spring the birds are very dispersed (Alcorn 1990). Breeds in single pairs or in loose colonies of up to 44 pairs (Marchant and Higgins 1993). *Good dispersal capacity and opportunistic inland breeding brings together flocks of birds at any time of year. Gene flow is likely to be good especially where larger colonies form. Link between movement and life strategy however is tenuous and not explicitly associated with breeding. Species should be considered at low risk but with medium confidence.*	**M**	**L**

	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic, slight variation in wing, head and possibly bill length in birds from WA compared to populations in southern Australia (Marchant and Higgins 1993). Morphometric data collected from birds in north-western and south-eastern Australia suggest some geographic variation (Jessop 1990). Biochemical analysis of allozyme of the Charadriiformes shows that the Charadriidae and Scolopacidae, as conventionally defined, are each close-knit monophyletic assemblages on two distinct phyletic lines and are consistent with both osteological and DNA-DNA hybridisation studies (Christian et al 1992). *No evidence of any significant phenotypic variability and little geographic variation within the species. Available gene pool is expected to be diverse due to large effective population size if species is as mobile as suggested. Gene flow between regional populations is also expected through formation of breeding colonies so potential for genetic flexibility and adaptation is possible although this might not translate to phenotypic differences. Species should be considered at low risk but with low confidence due to lack of specific knowledge of movement and breeding migrations and evidence for monophylly within the order.*	**L**	**L**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Widespread in Australia, mostly in the southern half, but scattered records in all districts, particularly near coasts (Marchant and Higgins 1993). Straggler to New Zealand with few records. Moderate Australian population estimated at 95000 (Watkins 1993). In the Atlas project it had the 4th highest reporting rate for a shorebird (Blakers et al 1984). Severe declines in Coorong since 1990's, however marked increases in Murray Estuary and Lake Albert, relatively stable in Lake Alexandrina (Ecological Associates 2010). Decline of 94% in South Lagoon since 1985 (Rodgers and Paton 2009). 534 records since 1990 within floodplain, majority (492) in Lower Lakes and Coorong, 7 in Murray Mallee and 35 in Murray Scroll Belt (BDBSA 2010). IBRA sub-regionally listed as 'vulnerable' and in 'definite decline' in Murray Mallee and Murray Scroll Belt and DENR Murraylands region (Gillam and Urban 2010). *Lower regions of the SA MDB have recorded significant declines in numbers, others have seen increases. Sub-regionally listed as vulnerable within study area. Clusters of records across SA MDB likely to represent seasonal or opportunistic colonization of certain areas. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Almost invariably 2 eggs per clutch, said to re-lay up to 5 times upon failure. No information on multiple brooding capacity (Marchant and Higgins 1993). On coast, breeding is seasonal, with birds dispersing to breed Aug-Jan. Inland breeding occurs in response to rainfall and flooding (Ecological Associates 2010). *Relatively low fecundity potential but may be offset by opportunistic breeding inland through increased availability of temporary and saline wetlands expected through increased flow regulation to mitigate drought and climate change. However climate is expected to become drier and hotter in southern Australia and may reduce inland breeding opportunities. Species should be considered at moderate risk with medium confidence as net effects are difficult to estimate.*	**M**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	No information on multiple brooding capacity, age at first breeding or longevity. Breeding season in southern Australia generally Jul-Jan, low recorded hatching success rate of 19-31%. Adult plumage attained by second winter, immatures may nest but no record of successful broods (Marchant and Higgins 1993). On coast, breeding is seasonal, with birds dispersing to breed Aug-Jan. Inland breeding in response to rainfall and flooding (Ecological Associates 2010). *Relatively low fecundity potential and hatching rate reduces recruitment potential. Birds may breed seasonally on coast and opportunistically inland but this depends on a hydrological and climate regime that is expected to become less favourable, i.e. drier, hotter and more variable. This may be offset by increased availability of temporary and saline wetlands expected through increased flow regulation to mitigate drought and climate change but only if applied cautiously. Species should be considered at high risk but with medium confidence as net effects of flow regulation and climate change are difficult to assess.*	**M**	**H**

Scientific Name:	*Circus approximans*	**Common Name:**	Swamp Harrier

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	In Australia mostly confined to wetlands, fresh or salt, often deep swamps with tall emergent vegetation of rush, reeds or sedge (*Phragmites, Typha, Scirpus, Eleocharis, Juncus*, and *Baumea*) and areas of open water. Uncommon over marine waters but occasionally recorded in coastal dunes and breeding on offshore islands. Will use artificial wetlands and small dams as long as emergent vegetation is present (Marchant and Higgins 1993). During breeding season prefers long grasses and reeds near swamps and range limited to SW and SE of Australian mainland. Structure of vegetation is more important than composition for raptors but destruction, degradation and alteration of habitat is the most critical factor in raptor conservation. Artificial habitats, e.g. agricultural land, sewage farms, also have great conservation value for breeding and wintering for resident and transient raptors. However nest sites, roosts and hunting perches must be conserved or provided to make them effective (Olsen 1998). *Reliant on proximity to water with emergent vegetation, will use saline environments but prefers fresh. Would tend to avoid intensively farmed or grazed lands unless suitable emergent vegetation is provided. Structure of vegetation is more important than composition. Optimal habitat is probably threatened through a transition to more temporary saline wetlands under climate change but may have some flexibility. Species should be considered at moderate risk*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Common migrant to Tasmania and residential, nomadic or migrant lifestyle on mainland (Slater et al 2001). In Australia is partly migratory. Breeding populations in SE migrate north in late summer and autumn and return during late winter and spring. Irregular movements recorded in some near-coastal areas in eastern Australia, may be dispersive following heavy inland rains. May move locally in response to flood events, and abundance of prey e.g. waterfowl and mice. Post breeding dispersion occurs to long distances (100+km) and some never establish home range (Marchant and Higgins 1993). Almost the entire Australian population migrates to Tasmania for the winter (Olsen 1998). *A highly dispersive and mobile species able to move great distances and in response to rain and flood events and food availability. Large home rane or completely nomadic and capable of long distance migrations.* *Species should be considered at low risk*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Highly territorial, defends breeding and hunting areas with aerial boundary displays and patrols against conspecifics and other brids. Sometimes attacked by Kites, Magpies and large waders but to little effect, flocks of Little Ravens recorded chasing Harriers from carrion (Marchant and Higgins 1993). Take small mammals, birds and eggs, large insects, frogs, fish and reptiles (DEH 2010a). Threatened by control measures (through secondary poisoning) of 'pest' species e.g. rabbits, mice but any broad-scale control of 'pest' species may also have a significant effect on dependent raptor populations through removal of prey sources. Species is also particularly sensitive to disturbance when nesting, failures attributed to various human activities e.g. land development (Olsen 1998). *Typical carnivorous diet and likely to be in competition with similar fauna e.g. other raptors and apex predators for food. Displays a strong capacity to compete for food and breeding sites through fierce territory protection but this requires a substantial investment of time and energy. Species should be considered at moderate risk*	**H**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Diet consists of wide range of prey and carrion ranging from mice and small insects to adult hares rabbits, frogs, reptiles and birds. Frequently documented taking advantage of mice, rat and rabbit population explosions (Marchant and Higgins 1993). Threatened by control measures (through secondary poisoning) of 'pest' species e.g. rabbits, mice but any broad-scale control of 'pest' species may also have a significant effect on dependent raptor populations through removal of prey sources (Olsen 1998). Commonly scavenge more in autumn and winter, immature rabbits and land birds taken in breeding season in spring and summer (Marchant and Higgins 1993). *Able to source food from wide range of prey and carrion, able to adjust diet to changing conditions e.g. seasonal variation in rodent prey; switch to scavenging in autumn-winter. Pest control poses potential problems through poisoning and eradication of food sources and may be expected to increase under climate change as pest species may undergo population explosions as they typically have competitive advantages in limiting environments. Species relies on suitable hunting habitat (freshwater swamps with ample emergent vegetation) but has a long range and flexibility as to prey items. Species should be considered at moderate risk*	**H**	**M**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Parental care for first 4-6 weeks with strong territory defense, fed piecemeal first and moving on to larger prey feeding themselves at about 4 weeks. Independent at 4-6 weeks and disperse after 7 weeks. Wide ranging diet from small insects and rodents through to adult hares ad rabbits (Marchant and Higgins 1993). Threatened by control measures (through secondary poisoning) of 'pest' species e.g. rabbits, mice but any broad-scale control of 'pest' species may also have a significant effect on dependent raptor populations through removal of prey sources (Olsen 1998). *Young of species take a moderately long time to reach independence compared to other birds assessed in this study. This increases risk to species as parental investment is high and young are more vulnerable to survival limitations for longer periods. Secondary poisoning and removal of potential prey through pest control poses additional threat. Species should be considered at moderate risk*	**H**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Nest in deep swamps with extensive beds of tall reeds or rush, particularly *Phragmites* and *Typha* in which nests are built near or on water, on a raised mounds of sticks, grass, reed stems (Ecological Associates 2010). Breeding season (based on Vic studies) is from late Sep to early Dec (Marchant and Higgins 1993), and prefers to nest in long grasses and reeds near swamps where its range is limited to SW and SE of Australian mainland (Olsen 1998). For 25 nests in south-east Australia, 17 were in *Phragmites*, 7 in *Typha* and 1 in *Juncus* over water. Breeding sites in deep, vegetated freshwater swamps lost or altered (through drainage, salinity, grazing etc.), can force nesting in crops where mortalities can be high during harvesting (Marchant and Higgins 1993). *Highly dependent on dense emergent aquatic vegetation typical of fresh water bodies. Breeding habitat range likely to decrease under climate through a transition to more temporary, saline wetlands that will not support the vegetative community preferred. Artificial habitats, e.g. crops, also used for nesting but potentially with high mortalities. Breeding appears purely seasonal and not triggered e.g. by flooding. Species should be considered at moderate risk.*	**H**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Current abundance in SA appears moderate (442 records within SA MDB floodplain in BDBSA since 1990) but almost no documented indication of trends reported in published literature. IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt, and near threatened in South Olary Plain. Not enough information to make 'endangered' as potentially shares population with Victoria (Gillam and Urban 2010). In Australia is partly migratory. Breeding populations in SE migrate north in late summer and autumn and return during late winter and spring. Irregular movements recorded in some near-coastal areas in eastern Australia, may be dispersive following heavy inland rains. May move locally in response to flood events, and abundance of prey e.g. waterfowl and mice. Post breeding dispersion occurs to long distances (100+km) and some never establish home range. Breeds in simple pairs and is mostly monogamous (Marchant and Higgins 1993). *The species capacity for dispersal and migration mitigates gene pool limitations of sparse abundance but specific studies into population genetic structures are lacking limiting confidence in assessment. IBRA sub-regional threat listings and observed population trends support the notion of a restricted gene pool through small population bases. Monogamous nature of species also decreases chance of diverse gene pools as gene flow is likely to be restricted. Species should be considered at moderate risk but with medium confidence due lack of published information on population genetic structures*	**M**	**M**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Post breeding dipersion is potentially long ranging (100s km) and species is said to be partially migrant with trans-Tasman and offshore migrations recorded. Almost the entire Australian population migrates to Tasmania for the winter (Olsen 1998).Thought to be mostly monogamous but polygamy has occasionally been recorded (Marchant and Higgins 1993). Breeds in simple pairs from late Sep to early Dec season (based on Vic studies) (Marchant and Higgins 1993) where its range is limited to the south-western and south-eastern parts of mainland Australia (Olsen 1998). *Potential for gene flow between populations is increased through the species capacity for wide dispersal and migration and its nomadic lifestyle. Mass migrations are made to Tasmania for wintering but are not linked to breeding. Species tendency to be mostly monogamous however, decreases chance of widespread gene flow significantly. Species should be considered at moderate risk*	**H**	**M**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic and no major geographic variation in plumage known. Interbreeding, hybridization and intergradation thought to occur between Asian Marsh Harrier species but conservatively *C. approximans* is treated as a full species within the Marsh Harrier complex (Marchant and Higgins 1993). *Expressions of different phenotypes or major geographic variations are not noted for the species. Species should be considered at high risk but with medium confidence due to lack of research into population genetic structures*	**M**	**H**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change? <u>Not an uncommon species in study area (P. Wainwright pers. comm. 2011).</u>	In South Australia, largely restricted to the South East, Murray River regions and Mt. Lofty Ranges. Records also from southern Eyre Peninsula (Blakers et al 1984 as cited in Marchant and Higgins 1993). 177 records since 1990 within study area and 480 across the SA MDB floodplain, majority in Lower Lakes, records become more sparse toward north of floodplain (BDBSA 2010). IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt, and near threatened in South Olary Plain. Not enough information to make 'endangered' as potentially shares population with Victoria (Gillam and Urban 2010). *Moderate to low abundance indicated by BDBSA records and is sub-regionally listed as vulnerable and in probable decline throughout majority of study area. Lack of specific research into population dynamics lowers confidence. Species should be considered at moderate risk but with medium confidence*	**M**	**M**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change? <u>Single brooding but commonly fledge more than one, better than some other raptors (P. Wainwright pers. comm. 2011).</u>	In south-east Australia, species averages 3.6 eggs per clutch (Baker-Gabb 1982 as cited in Marchant and Higgins 1993; various studies cited in SAAB 2001). Single brooding but will lay replacements if eggs are lost (Soper 1957; Baker-Gabb 1982 both as cited in Marchant and Higgins 1993) and breeds from late Sep to early Dec (based on Vic studies) (Marchant and Higgins 1993). *Moderate clutch sizes and capacity to replace brood lowers risk to species, it is however typically single brooding over a limited season. Species should be considered at moderate risk*	**H**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>Single brooding but commonly fledge more than one, better than some other raptors. Is not an uncommon species in the study area (P. Wainwright pers. comm. 2011).</u>	In south-eastern Australia laying occurs from late September to early December, hatching from late October to early January, and fledgling from early December to mid February. Time to sexual maturity unknown for either sex but adult plumage attained within first year (Marchant and Higgins 1993). Longevity is not described in the literature but in general, raptors tend to be long-lived with slow reproduction rates and low population densities (Olsen 1998). Fledging success rates in SE Australia vary between 1.48 fledged per nest and 2.06 per successful nest, 55% of eggs laid hatched and were successfully fledged (n=5) (Baker-Gabb 1982 as cited in Marchant and Higgins 1993). *Relatively good fledgling success rates and moderate clutch sizes reduce threat to species, age at first breeding unknown but adult plumage by 1 year suggests a short generation time but this is not consistent with general life history of raptors of long generation times and slow reproduction. Research is required to establish age at first breeding and longevity and this reduces confidence in assessment significantly. Good breeder compared to other raptors but moderate compared to other species assessed. Species should be conservatively considered at moderate risk but with low confidence*	**L**	**M**

Scientific Name:	Cygnus atratus	**Common Name:**	Black Swan

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change	Loss of submerged aquatic vegetation (*Myriophyllum; Ruppia*) uprooted during a storm caused breeding failure and serious long term decline in numbers (Williams 1975 [in Marchant & Higgins 1990]. Abundance of black swans negatively correlated with water level (Harper 1990). 'Range of salinities tolerated from fresh to hypersaline though usually limited to <60ppt which is threshold of tolerance of aquatic food plants, Ruppia and Lepilaena (Corrick 1982 [in Marchant & Higgins 1990)'. Prefer large permanent waters; avoid those where fast flow, strong wave action or where turbidity prevent establishment of aquatic vegetation… (Marchant & Higgins 1990)'. 'Although large expanses of water are preferred depth is critical. Birds can only secure food about 1metre below the surface, so abundant aquatic vegetation up to this level is essential to support a permanent population (Frith 1982 [in SAAB 2001])'. ***Utilise a range of habitats and tolerate saline conditions but largely limited to relatively shallow waters and/or where aquatic vegetation can be obtained close to water surface. Within study area suitable large semi-permanent/ ephemeral wetlands are likely to decline under climate change with reduced flooding and increased evaporation rates, and high turbidity in many permanent pool level wetlands (attributed to carp and permanent inundation) provide poor habitat for establishment of abundant aquatic vegetation. Increased evaporation rates and reduced river flows may benefit swans in some circumstances where declining water levels increase foraging area and slow flows allow establishment of aquatic vegetation. 'Habitat' preference is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	H	M

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change	'Adults are generally sedentary in permanently suitable habitat, however young and adults from ephemeral habitats move far and often (Marchant & Higgins 1990)'. ***Species capable of regular long distance movements. 'Mobility & dispersal' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	'Although the black swan had certain food plants in common with most other species, particularly during periods of drought…serious competition between these species was considered unlikely for various reasons. Otherwise, the species were well separated in their feeding places, depths of water utilized, and food collected (Frith *et al* 1969)'. Almost entirely herbivorous on variety of 'floating or submerged aquatic plants, algae, emergent vegetation or soft terrestrial herbage (Frith *et al* 1969; Marchant & Higgins 1990). Food source utilized depends on depth of water e.g. submerged deep water plants make up large part of diet when water levels low and more edge, emergent and terrestrial species when water levels higher and during flooding (Frith *et al* 1969)'. ***The specie's extended reach gives it advantage over other waterfowl species and is one of few species almost totally herbivorous so interspecific competition for same food source is limited. 'Competition' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Range of salinities tolerated from fresh to hypersaline though usually limited to <60ppt which is threshold of tolerance of aquatic food plants, Ruppia and Lepilaena (Corrick 1982 [in Marchant & Higgins 1990)'. Although prefer relatively shallow waters with easily accessible submerged plants can alter foraging behavior depending on water regime and water depth (Frith *et al* 1969). ***Species has relatively broad tolerances to salinity and water regime and can alter foraging behavior depending on the vegetation present. 'Survival tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
Physiology	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Loss of submerged aquatic vegetation (*Myriophyllum; Ruppia*) uprooted during a storm caused breeding failure and serious long term decline in numbers (Williams 1975 [in Marchant & Higgins 1990]). Higher breeding rates occurring on saline lake compared to nearby freshwater lake attributed to abundant macrophytes in saline lake (Kingsford & Porter 1994). ***Juveniles, with limited reach and no diving ability, are largely restricted to shallow water habitat where they can access abundant submerged aquatic vegetation. A reduction in productive shallow ephemeral wetlands through reduced flooding is likely to inhibit growth and development in juveniles. Higher breeding rates on saline lakes are an indication that salinity does not significantly limit development of juveniles. 'Growth tolerances' are expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	H	M

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Breed in fresh, brackish or saline wetlands with enough soft vegetation for nest-building and feeding…Freely exploit ephemeral waters; at times of widespread flooding nest in any shallow water collected…(Marchant & Higgins 1990)'. Loss of aquatic vegetation (*Myriophyllum; Ruppia)* uprooted during a storm caused breeding failure and serious long term decline in numbers (Williams 1975 [in Marchant & Higgins 1990]'. Require densely vegetated and relatively shallow wetlands for optimum breeding and respond to a change in water levels to initiate breeding (Marchant & Higgins 1990; Harper 1990). Increased food availability triggers reproduction (Braithwaite & Frith 1969). If wetlands dry too quickly desertion and loss of nests frequently occurs and sexual activity is reduced under drought conditions (Frith & Braithwaite 1969). Generally breed opportunistically whenever conditions are suitable; nests recorded in most months of year (Frith 1982 [SAAB 2001])'. ***Water depth, hydrological regime and abundant vegetative food source are stimuli for breeding. A reduction in temporary wetlands within study region due to decreased flood frequency/ duration and increased evaporation rates are expected to significantly reduce breeding rates. 'Reproductive tolerances' are expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	M	H
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Widespread in South Australia (Marchant & Higgins 1990) and considered 'Generally secure (Frith 1982 [in SAAB 2001])'. ***No information on gene pool of species found but with large widespread population, gene pool is expected to be heterogenous. 'Gene Pool' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Widespread in South Australia (Marchant & Higgins 1990) and 'known to regularly disperse long distances and breed widely throughout its distribution wherever and whenever conditions suitable (SAAB 2001)'. ***No information found on 'gene flow' within species but with large widespread population with individuals regularly dispersing long distances gene flow is expected to be significant. 'Gene flow' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	'Coinciding with drought conditions, there was no apparent peak in overall gonad activity among males during winter and spring…The stimulus to breeding provided by food itself is seen as a direct response to conditions that favour the production of eggs and the survival of cygnets (Braithwaite & Frith 1969'. Breeding can occur whenever conditions are suitable and nests may be started throughout year if local conditions favorable (Marchant & Higgins 1990). ***Food availability provides direct stimulus to breeding and gonad activity is reduced under drought conditions (Braithwaite & Frith 1969). Increased chance and rate of recruitment by adapting breeding cycle to take advantage of suitable conditions. However, it appears that a response to food often leads to unsuccessful breeding in fast-drying habitats, frequent desertion and loss of nests and broods can occur – e.g. no capacity for young to increase rate of development in response to deteriorating conditions once breeding has commenced. 'Phenotypic plasticity' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change***	L	M
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Widespread in South Australia (Marchant & Higgins 1990) and considered 'Generally secure (Frith 1982 [in SAAB 2001)'. ***'Population size' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L

	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	'…range of 4-10 eggs per clutch, average 5.5 (Frith 1982 [SAAB 2001])'. ***Moderate individual recruitment ability, but species as a population has capacity for high reproductive rates. Under ideal breeding conditions e.g. clear shallow waters and abundant submerged vegetation, species is observed to breed in abundance. 'Reproductive capacity' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	In fast-drying habitats, frequent desertion and loss of nests and broods can occur. Loss of aquatic vegetation (Myriophyllum; Ruppia) uprooted during a storm caused breeding failure and serious long term decline in numbers (Williams 1975 [in Marchant & Higgins 1990]'. Swans usually attain sexual maturity and breed at 18-24 or 33-36 months (Marchant & Higgins 1990). Little data on success of recruitment but 'Frith (1982) said that with mean clutch size of 5.5 eggs, 4.1 cygnets hatched and 2.7 survived to fledgling…many eggs lost by being rolled out of nest (Marchant & Higgins 1990)'. ***The persistence of shallow waters with abundant vegetation are required for successful recruitment and desertion of nests and young will occur if wetlands dry too quickly. Loss of productive ephemeral wetlands, increased evaporation rates, time to sexual maturity and moderate reproductive success reduce overall recruitment success. 'Recruitment' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	M	H

Scientific Name:	*Elseyornis melanops*	**Common Name:**	Black-fronted Dotterel (Plover)

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? Opposite of Red-capped plover in that it prefers freshwater wetlands and tends to avoid brackish and saline environments. Usually find Black-fronted dotterel in fresh wetlands and Red-capped plover in brackish and saline wetlands. Range may decrease with climate change as a transition to more temporary and saline wetlands are expected in the SA MDB (P. Wainwright 2010, pers. Comm.).	Margins of terrestrial wetlands, particularly fresh shallow ones with muddy bottoms and margins. Occasionally brackish wetlands, sometimes round waters of high salinity. Very rarely around estuarine or littoral habitats. Avoids densely vegetated areas. May inhabit margins of wetlands with little fringing or emergent vegetation. Generally forage on soft fine wet deposits of silt or mud, usually at edge of water and occasionally in shallow water. Sometimes on open mudflats with sparse low vegetation, near gravely shorelines of lakes. Occasionally forage in sand or shingle at edge of water, especially where rotting algae is stranded (Ecological Associates 2010). *Prefers shallow, fresh to brackish with low emergent vegetation typical of shoreline, mudflats and deltas. Avoids densely vegetated areas so reduced dependence on vulnerable freshwater vegetation. Drought and drying of wetlands, salinity and increased river regulation may force range contractions. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Poorly known in Australia. Mainly sedentary, many remain on or near breeding site, most birds remain within 1-2km, lack of marked seasonal changes implies no large-scale movements, may move daily to and from food source e.g. sludge pond (Marchant and Higgins 1993). Within Australia occupies wetlands when they form but the Australian Atlas suggests no large-scale pattern of seasonal movement (Blakers et al 1984 as cited in SAAB 2001). In the non-breeding season congregations of 20 to 250 occur at some sites in most states (Marchant and Higgins 1993). *Species is largely sedentary around natal site and only forages to short distances. Increased habitat fragmentation is expected through climate change and may force birds to travel farther for food or strand some populations. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Solitary nesting species are more at risk through predation than colonially nesting species (P. Wainwright 2010, pers. comm.).</u>	Omnivorous. Takes molluscs, annelids, crustaceans, arachnids and diverse range of aquatic and terrestrial insects, occasionally seeds. Eggs sometimes taken by feral cats or foxes, occasionally lost to trampling by stock or vehicles. Breed in simple pairs solitarily, in Australia nests are found in a wide variety of locations on the ground including in creeks, on lake shores, swamps, dams, on open sandy beaches, semi-desert areas, roadsides, borrow pits and even gravel on railway tracks (Marchant and Higgins 1993). *Competition for nesting space is not identified in the literature and food is unlikely to be limiting. Climate change raises the potential for habitat quality degradation and/or habitat range loss forcing greater competition e.g. with large aggressive waders. Some predation of eggs by feral animals and loss to trampling identified and as a solitary nesting species, is at greater risk than colonially breeding birds. Species should be considered at moderate risk.*	**H**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Opposite of Red-capped plover in that it prefers freshwater wetlands and tends to avoid brackish and saline environments. Usually find Black-fronted dotterel in fresh wetlands and Red-capped plover in brackish and saline wetlands. Range may decrease with climate change as a transition to more temporary and saline wetlands are expected in the SA MDB (P. Wainwright 2010, pers. comm.).</u>	Prefers shallow freshwater wetlands, however also occurs on brackish and saline wetlands, particularly in arid regions. Low emergent vegetation or detritus on mudflats, shorelines and deltas, occurs around receding floodwaters, characterised by large sheets of shallow turbid water, and surrounded by temporarily flooded creeks. Omnivorous, varied diet consisting of annelids, molluscs and crustaceans as well as aquatic and terrestrial insects and occasionally seeds (Marchant and Higgins 1993). *Survival relies on availability of suitable freshwater foraging habitats that are under threat through climate change. Species has limited ability to mitigate effects as largely sedentary. Increased habitat fragmentation and degradation expected through reduced/managed flows as well as a transition to less permanent, freshwater wetlands and more temporary, saline wetlands i.e. potential range decrease. Species should be considered at moderate risk.*	**H**	**M**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Prefers freshwater wetlands, however also occurs on brackish and saline wetlands, particularly in arid regions. Omnivorous, varied diet consisting of annelids, molluscs and crustaceans as well as aquatic and terrestrial insects and occasionally seeds. Often occur around receding floodwaters, characterised by large sheets of shallow turbid water, and surrounded by temporarily flooded creeks. Fledge at 5-8 weeks but remain in or near natal site (Marchant and Higgins 1993) No information on juvenile diet, assumed to be similar to omnivorous adult diet *Species has limited ability to mitigate effects as adults are largely sedentary, young stay with parents for extended period but remain near natal territory. Survival and growth of young relies on availability of suitable foraging habitats near breeding sites that are under threat through climate change. Increased habitat fragmentation and degradation expected and may affect food availability especially for young. Species should be considered at high risk*	**H**	**H**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	In Australia nests are found in a wide variety of locations on the ground including in creeks, on lake shores, swamps, dams, on open sandy beaches, semi-desert areas, roadsides, borrow pits and even gravel on railway tracks. Nest in same area every year, i.e. show site fidelity. Floodwater attributed for washing away eggs if timed with breeding, repeated flooding a high water levels has destroyed most nests at some sites (Marchant and Higgins 1993) *Relatively wide nesting site preferences although tendency for site fidelity may limit regional populations if traditional nesting sites suddenly become unsuitable, lack of mobility may compound this effect. Species should be considered at high risk.*	**H**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Most widespread wader in Australia, seen throughout Australasia (except New Guinea) and trending up; stable, uncommon or rare in Lower Lakes and Coorong (Ecological Associates 2010). Australian population estimated at approximately 17000 (Watkins 1993). Mainly sedentary species, many remain on or near breeding site, most birds remain within 1-2km, lack of marked seasonal changes implies no large-scale movements, May move daily to and from food source e.g. sludge pond (Marchant and Higgins 1993). 451 records since 1990 within study area (BDBSA 2010). Considered 'near-threatened' or 'rare' and in probable decline in DENR Murraylands region and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Identified in literature as widespread throughout Australia. BDBSA records indicate a good abundance and widespread distribution throughout the study area though probably not contiguous as is largely sedentary ranging less than 5km meaning regional populations may be isolated into several, small sub-populations along the River Murray. Gene pool likely to be limited in this circumstance, species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	No specific studies. Mainly sedentary species, many remain on or near breeding site, most birds remain within 1-2km, lack of marked seasonal changes implies no large-scale movements, May move daily to and from food source e.g. sludge pond (Marchant and Higgins 1993). 451 records since 1990 within study area, reasonably well distributed (BDBSA 2010). Proposed IUCN regional status as 'near-threatened' in Murray Scroll Belt (Gillam and Urban 2010). *Good abundance but patchy distribution indicated by BDBSA records, likelihood of smaller isolated regional effective populations where gene flow may be limited to an extent as species is largely sedentary with a small home range. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic genus, no geographical variation recorded. Mainly sedentary, many remain on or near breeding site, most birds remain within 1-2km, lack of marked seasonal changes implies no large-scale movements (Marchant and Higgins 1993). *No evidence of species ability to mitigate climate change effect through phenotypic plasticity. Effective population size and diversity of available gene pool are likely to be restricted given distribution and lack of mobility in species. The fact that allopatric speciation does not occur in response to local conditions supports evidence of little phenotypic plasticity. Species should be considered at high risk.*	**H**	**H**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Australian population estimated at approximately 17000 (Watkins 1993) but most geographically widespread wader in Australia seen throughout Australasia except New Guinea. Mainly sedentary, many remain on or near breeding site, most birds remain within 1-2km, lack of marked seasonal changes implies no large-scale movements (Marchant and Higgins 1993). 451 records since 1990 within study area (BDBSA 2010). Considered 'near-threatened' or 'rare' and in probable decline in DENR Murraylands region and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *A geographically widespread species in Australia. BDBSA records indicate high abundance and widespread distribution in the SA MDB compared to other birds assessed in this study. Regional and sub-regional rare or near threatened status. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change? Species that raise young quickly are less at risk as chick is vulnerable for less time and parental investment is reduced allowing subsequent broods to be raised (P. Wainwright 2010, pers. comm.).	Average of 2.2 eggs per clutch, usually 2-3, is capable of double-brooding and producing replacement broods. Young take around 8 weeks to fledge and become independent (Marchant and Higgins 1993). *Species has moderate fecundity potential and is capable of multiple and replacement broods. Young take a relatively moderate time to reach independence increasing the chance for subsequent broods to be raised in a single season if conditions allow. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	In Australia breed broadly from Sep to Feb. Average clutch of 2-3 eggs and is capable of double-brooding and producing replacement broods. High fledgling success (NZ studies) up to 67% in good season. Age at first breeding not known but adult plumage attained at 1 year. One recaptured bird was at least 5 years old (Marchant and Higgins 1993). 451 records since 1990 within study area (BDBSA 2010). Considered 'near-threatened' or 'rare' and in probable decline in DENR Murraylands region and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Good potential for high recruitment as species shows indication of short generation times (ready to breed after 1 year judging by plumage development) and moderate longevity. Good fledging success rates have also been recorded for the species and probably a good population base. Species should be considered at low risk.*	**H**	**L**

Scientific Name:	*Erythrogonys cinctus*	Common Name:	Red-kneed Dotterel (Plover)

	Question	Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>Prefers open wetlands with low, scattered fringing vegetation and no over-story. Eucalypts tend to exclude growth of vegetation beneath (light starvation and toxins from tree). Species will probably suffer a reduction in optimal habitat within the study area and may encounter increased competition. More research required into species ability to adapt to brackish environments (P. Wainwright 2010, pers. Comm.).</u>	Inhabits margins of terrestrial wetlands, prefers temporary or permanent freshwater wetlands particularly those inundated by rain or floodwaters including swamps, lakes, waterholes, inundated claypans, billabongs and creeks. Often use artificial freshwater habitats such as dams, reservoirs, bore drains and sewage ponds. Often found foraging and nesting in open areas among scattered fringing or emergent vegetation such as short grass tussocks, reeds and rushes or dense clumps of bushes such as canegrass, lignum, and salt marsh. Generally avoid tree-lined wetlands, and rarely at brackish or saline wetlands (Marchant and Higgins 1993). Drought refuge areas important to the conservation of this species (Lane 1987 as cited in SAAB 2001). *Associated with fringing aquatic vegetation for foraging and nesting and tends to avoid tall riparian woodland habitat. Shows a preference to freshwater wetlands and generally avoids saline environments. Could be considered a freshwater specialist but may use brackish and saline types if forced. Drought refuge is also identified as an important factor. A lack of research into adaptation to brackish conditions however reduces confidence. Species should be considered at moderate risk but with medium confidence*	**M**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Field atlas suggests no pattern of movement but reporting rates were lower in winter than summer, presumably because birds disperse to filled water-bodies and become less conspicuous (Blakers et al 1984 as cited in SAAB 2001). Probably move in response to availability of fresh water, moving to coastal areas when inland areas are dry, and moving to inland areas after the wet season or flooding replenishes wetlands (Marchant and Higgins 1993). *A dispersive and mobile species able to move in response to seasonal habitat availability. Species should be considered at low risk*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Colonially breeding species are less at risk of predation and nest losses through protection in numbers (lower predation probability) (P. Wainwright 2010, pers. Comm.).</u>	Omnivorous, feeds on seeds, molluscs (bivalves, gastropods, freshwater snails), annelids, spiders and insects (diverse range of aquatic and terrestrial taxa) (Ecological Associates 2010). Breed as territorial pairs solitarily or in looses colonies of up to 30 pairs. Aggressive conspecific interactions in feeding flocks and aggressive displays to other species recorded e.g. Crakes and Sandpipers (Marchant and Higgins 1993). High rate of egg losses attributed to predation by Ravens (Maclean 1976 as cited in Marchant and Higgins 1993). *As an omnivorous forager, food is unlikely to be limiting unless very sparse and/or in high competition with other waders. Some aggressive behaviour toward conspecifics and other birds, motivation unclear but presumably defending feeding territory and implies species is a strong competitor. High losses of eggs to predation noted in one study and may be more vulnerable when nesting solitarily. Species should be considered at low risk*	**H**	**L**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? Red-kneed Dotterels generally prefer freshwater habitats if they have a choice. However they also commonly use brackish or saline wetlands (e.g. Barker Inlet). Why they choose one over the other is unclear. At the very least it suggests that this species shows some adaptability to alternative habitats and to that extent, may tolerate a changing environment reasonably well (P. Wainwright 2010, pers. Comm.).	Omnivorous, feeds on seeds, molluscs (bivalves, gastropods, freshwater snails), annelids, spiders and insects (diverse range of aquatic and terrestrial taxa) (Ecological Associates 2010). Capacity to move in response to availability of fresh water, moving to coastal areas when inland areas are dry, and moving to inland areas after the wet season or flooding replenishes wetlands (Marchant and Higgins 1993). Part of group of waders that has wide environmental tolerances (Halse et al 1993). Prefers temporary or permanent freshwater wetlands but rarely occurs at brackish or saline wetlands. (Marchant and Higgins 1993). Halse et al (1993) identify it as preferring saline (total dissolved solids 10-25ppt), alkaline (pH > 7.4) wetlands. Kingsford and Porter (1994) showed the mean abundance of small waders, including Red-kneed Dotterels, was significantly higher on the saline Lake Wyara than on the adjacent fresh Lake Numalla and this was related to significantly larger numbers of planktonic invertebrates in the salt lake. *Relatively wide diet requirements unlikely to be limiting. Preferred freshwater wetlands with fringing and/or emergent vegetation may be under threat through salinsation and could reduce geographical range although species shows tolerance to wide range of environmental conditions and reported using brackish and saline wetlands. Species should be considered at moderate risk*	**H**	**M**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? Species that fledge quicker have an advantage through reduced parental investment and young being less dependent and vulnerable for a shorter time (P. Wainwright 2010, pers. Comm.).	Nest at freshwater wetlands, on shores or small islets, often where dense or dead shrubs conceal nests (Ecological Associates 2010). High rate of egg losses attributed to predation by Ravens (Maclean 1976). Often found foraging and nesting in open areas among scattered fringing or emergent vegetation such as short grass tussocks, reeds and rushes or dense clumps of bushes such as canegrass, lignum, and salt marsh, nestlings use as cover from predators. Young can swim from hatching, leave nest early as 2 days, pre-juvenile moult at 3-4 weeks (Marchant and Higgins 1993). Part of group of waders that has wide environmental tolerances (Halse et al 1993). Documented using and sometimes preferring saline over freshwater lake habitats (Halse et al 1993; Kingsford and Porter 1994). *Relies on availability of dense foliage in nesting sites for concealment from predators to avoid high mortalities. Loss of dense riparian and fringing habitats is expected through salinity problems, drought and wetland drying effects of climate change. Risks are moderated as young leave nest early thus reducing parental care of nestlings and young are more able to avoid predation. Species can also use saline and brackish wetlands. Species should be considered at moderate risk*	**H**	**M**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? Species is known to breed reliably in the study area. Those species dependent on permanent freshwater wetlands for breeding will be less affected through recruitment. Frequency of flooding events will limit recruitment in species relying on temporary wetlands for breeding unless river management is carefully applied (inundation timing, duration and magnitude is considered in relation to breeding requirements) (P. Wainwright 2010, pers. Comm.).	Nest at freshwater wetlands, on shores or small islets, often where dense or dead shrubs conceal nests (Ecological Associates 2010). Breed as territorial pairs solitarily or in looses colonies of up to 30 pairs. Usually breed August to December or January, but will nest anytime in summer, autumn or winter after heavy rain. Timing of laying highly correlated with peak rainfall +3 months (Marchant and Higgins 1993). Breeding recorded in Lower Darling (Marchant and Higgins 1993) and Lower Lakes host breeding sites for moderate numbers (Ecological Associates 2010). *Availability (duration and frequency) of breeding sites may decline due to reduced water flow and rainfall and flood events. Species shows high dependence on rainfall/high flows to trigger breeding implying a reliance on temporary wetlands that raises threat to species under climate change. Species should be considered at high risk but with medium confidence due to lack of research into species adaptability to brackish and saline conditions for breeding and uncertainty over management of flows with respect to breeding cycle*	**M**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? Species with high abundance, wide distribution and high mobility are less at risk than sedentary species with small and fragmented populations as they have more chance of being geographically and genetically isolated and feature restricted gene pools and flow. When large breeding colonies form in response in flood/high flow events, gene pool is likely to be diverse as individuals from different populations can mix (P. Wainwright 2010, pers. Comm.).	Moderate Australian population numbers estimated conservatively at approximately 26000 (Watkins 1993). IBRA sub-regionally listed as rare in South Olary Plain and Murray Scroll Belt and vulnerable and in definite decline in the Murray Mallee (Gillam and Urban 2010). No large scale movements known but probably move in response to availability of fresh water, moving to coastal areas when inland areas are dry, and moving to inland areas after the wet season or flooding replenishes wetlands. Large post breeding and breeding flocks occur in flooded sites but concentrate on SA coast in summer (Marchant and Higgins 1993). Known to breed in Coongie Lakes District, where at times at least 1 % of the national population of birds may occur at times (e.g. 15000 birds in 1997 (Reid 2000 as cited in SAAB 2001). *When large breeding colonies form in response in flood/high flow events, gene pool is likely to be diverse as individuals from different populations can mix. Species shows high distribution, high capacity for mobility and is known to breed in very large flocks but is only moderately abundant compared to similar waders (e.g. Black-winged Stilt). Species should be considered at moderate risk*	**H**	**M**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? Species with high abundance, wide distribution and high mobility are at lower risk as they have less chance of being geographically and genetically isolated and feature restricted flow. Formation of breeding colonies improves chances of good gene flow between individuals from different regional populations (P. Wainwright 2010, pers. Comm.).	No specific studies. No large scale movements known but probably move in response to availability of fresh water, moving to coastal areas when inland areas are dry, and moving to inland areas after the wet season or flooding replenishes wetlands. Large post breeding and breeding flocks occur in flooded sites but concentrate on SA coast in summer (Marchant and Higgins 1993). Known to breed in Coongie Lakes District, where at times at least 1 % of the national population of birds may occur at times (e.g. 15000 birds in 1997 (Reid 2000 as cited in SAAB 2001). *Formation of large breeding colonies improves chances of good gene flow between individuals from different regional populations. Species also show wide distribution and high capacity for movement so should be considered at low risk*	**H**	**L**

	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change? Species with high abundance, wide distribution and high mobility have a greater potential capacity for genetic flexibility even if this does not translate directly into obvious expressions of different phenotypes e.g. significant geographic variation in morphologies (P. Wainwright 2010, pers. Comm.).	Monotypic. No subspecies or geographic variation recorded (Marchant and Higgins 1993). Moderate Australian population estimated conservatively at approximately 26000 (Watkins 1993). Large post breeding and breeding flocks occur in flooded sites but concentrate on SA coast in summer. Probably move in response to availability of fresh water, moving to coastal areas when inland areas are dry, and moving to inland areas after the wet season or flooding replenishes wetlands (Marchant and Higgins 1993). *No indication of species capacity to express obvious differences in phenotype in response to geographic position, environmental conditions or any other cues. Species is highly distributed and mobile but population is only of moderate size compared to similar waders. Lack of documented phenotypic variation reduces confidence but likely species has a degree of resilience due to its mobility, distribution and abundance. Species should be considered at moderate risk but with medium confidence*	**M**	**M**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Moderate Australian population numbers estimated conservatively at approximately 26000 (Watkins 1993). Declining in Murray Estuary and Lake Alexandrina (now zero), variable in Lake Albert, uncommon in Coorong (Ecological Associates 2010). No large scale movements known but probably move in response to availability of fresh water, moving to coastal areas when inland areas are dry, and moving to inland areas after the wet season or flooding replenishes wetlands. 369 records since 1990 within floodplain, majority (211) in Lower Lakes and Coorong, 60 in Murray Mallee and 98 in Murray Scroll Belt (BDBSA 2010). IBRA sub-regionally listed as 'rare' in South Olary Plain and Murray Scroll Belt and 'vulnerable' and in 'definite decline' in the Murray Mallee (Gillam and Urban 2010). *Moderate population size compared to other water dependent birds and capacity for dispersal across majority of SA MDB. Mobility of species means regional populations unlikely to be permanently isolated. Sub-regionally threat listed as vulnerable or rare and in definite decline within study area . Species should be considered at moderate risk*	**H**	**M**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Little information. Usually lays 4 eggs, average of 3.4 (Maclean 1976). Usually breed August to December or January, but will nest anytime in summer autumn or winter after heavy rain. Number of broods per season unknown (Marchant and Higgins 1993). *Moderate fecundity potential but unclear whether able to breed opportunistically in response to rainfall/flow events species. Species should be considered at moderate risk but with moderate confidence due to lack of information on multiple or replacement brood capacity*	**M**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? Frequency of flooding events will limit recruitment in species relying on temporary wetlands for breeding unless river management is carefully applied (inundation timing, duration and magnitude is considered in relation to breeding requirements). Species is known to breed reliably in the study area (P. Wainwright 2010, pers. Comm.).	Age at first breeding, fledging success rates, number of broods per season and longevity are unknown. Usually breed Aug to Dec-Jan in simple pairs with often many pairs in same locality or in colonies. Lower Lakes host breeding sites for moderate numbers (Ecological Associates 2010). Will nest anytime in summer, autumn or winter after heavy rain, timing of laying is highly correlated with peak rainfall +3 months (Marchant and Higgins 1993). *Recruitment may be limited due to altered flows to breeding sites and predicted declines in rainfall under climate change. Species should be considered at high risk but with medium confidence as generation times and fledging success rates are undefined as is the species' capacity for multiple brooding and opportunistic breeding.*	**M**	**H**

Scientific Name:	*Haliaeetus leucogaster*	**Common Name:**	White-bellied Sea-Eagle

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? Open water tracts with tall riparian trees or other perching structures are critical habitat requirements. The issue for the sea-eagle in SA is habitat refuge i.e. human disturbance. ~80% of the SA population is now found on offshore islands (T. Dennis pers. Comm. 2010).	Maritime and large open terrestrial wetlands, particularly deep freshwater swamps, lakes, reservoirs and billabongs. Also meadows, deep channels, coastal lagoons, salt marsh and inland ephemeral wetlands when filled by floodwaters. Nature of shoreline or emergent vegetation apparently unimportant providing open water remains. Critical breeding habitat includes tall open forest and woodland, inland near water bodies and on coastal cliffs and escarpments. Local extinctions in NSW and Vic attributed to clearing of optimal breeding habitat in coastal forests, remaining isolated trees used but with low breeding success (Marchant and Higgins 1993). Structure of vegetation is more important than composition for raptors but destruction, degradation and alteration of habitat is the most critical factor in raptor conservation (Olsen 1998; Dennis and Baxter 2006). Recognised as an indicator species of ecosystem health in pristine coastlines (Dennis and Baxter 2006). Artificial habitats, e.g. agricultural land, sewage farms, also have great conservation value for breeding and wintering for resident and transient raptors. However nest sites, roosts and hunting perches must be conserved or provided to make them effective (Olsen 1998). Habitat protection provisions akin to the large buffer areas (1.5-3km in diameter) around nest sites of threatened raptors in parts of the USA are a recommended to ensure breeding and foraging habitats are considered by land use planning and management and avoids displacements resulting in further decline of numbers (Dennis and Baxter 2006). *Widely recognised as having critical habitat requirements with success largely dependent on quality of undisturbed sites particularly when breeding but also foraging. While species is able to use utilise marine, estuarine and freshwater environments, clearing or loss of structural vegetation near water bodies poses a threat under climate change and has been associated with localised extinctions. Species should be considered at high risk*	**H**	**H**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change? <u>The river wetlands, Lakes and upper Coorong are significant foraging and maturation area for sub-ad sea-eagles and the river an important corridor for genetic exchange between SA's isolated population the eastern States (T. Dennis pers. Comm. 2010).</u>	Resident, established pairs mostly sedentary but have a large home range of 62-100km^2 (Marchant and Higgins 1993; Dennis and Baxter 2005). Immature birds and some adults are more dispersive. Birds occupying territories on inland water bodies possibly more dispersive than birds along coast as forced to move as water disappears, juveniles reported to move to 3000km from natal sites (Marchant and Higgins 1993). Shephard et al (2005b), in a study of long-term variation in occupancy distribution across Australia from 1901-2001, showed considerable differences in range and frequency between defined regions (i.e. inland and coastal blocks). A clear increase in the use of coastal blocks was accompanied by a decrease in use of inland blocks from 1977-1981. This was attributed to drought conditions during the El Nino period from 1977 to 1981 where presumably birds moved to the coast when inland habitats dried up or became unsuitable (Shephard et al 2005b). *Highly mobile and dispersive species are generally at less risk under climate change. Drought frequency and magnitude is expected to increase under climate change and this has been shown to affect the dispersal and lower the frequency of the species in inland habitats. This is applicable to the study area as birds would be expected to move to coast. Species should be considered at low risk but with medium confidence as it is able to move if regions become unsuitable but net effects of this forced redistribution to the population are unknown.*	**M**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Breeding season in SA commences with courtship and nest repair in early May. As with all *Haliaeetus spp*. this is most sensitive period as they will abort the nest or eggs if disturbed. The issue for the sea-eagle in SA is habitat refuge i.e. human disturbance. ~80% of the SA population is now found on offshore islands (T. Dennis pers. Comm. 2010).</u>	Territorial breeding behaviour against conspecifics, other eagles, kites, gannets and other coastal bird species, violent interactions with Wedge-Tailed Eagle usually losing, parental nest defence is not strong. Other raptors also attempt to steal prey and in turn it tries to steal from conspecifics and other birds Marchant and Higgins 1993). Threatened by control measures (through secondary poisoning) of 'pest' species e.g. rabbits, mice. Any broad-scale control of 'pest' species however may have a significant effect on dependent raptor populations through removal of prey sources. Species is also particularly sensitive to disturbance when nesting, failures attributed to various human activities e.g. land development (Olsen 1998). *Competition is a factor affecting the breeding cycle of the species, nest site and territorial disputes are common with conspecifics and other birds, apparent competition for food evidenced by prey stealing. Violent interactions with more common and larger Wedge-tailed eagles over hunting and breeding territory are another significant competitive pressure. Human interactions are widely cited as a major influence and could be considered competition for space and resources. This is mainly associated with disturbance of breeding and foraging sites but also effects of pest species control. Species should be considered at high risk*	**H**	**H**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	A carnivorous, opportunistic feeder taking birds, reptiles, fish, mammals, crustaceans, echinoderms and carrion. Hunting habitat (open tracts of water or land often with nearby trees) is critical for availability of prey items (Marchant and Higgins 1993). Artificial habitats, e.g. agricultural land, sewage farms, also have great conservation value for breeding and wintering for resident and transient raptors. However nest sites, roosts and hunting perches must be conserved or provided to make them effective (Olsen 1998). Shows ability to cope with or avoid toxic compounds found in some fish, will also eat carrion until highly decomposed (Marchant and Higgins 1993). As an apex predator, can be limited by prey availability and also threatened by control measures (through secondary poisoning) of 'pest' species e.g. rabbits, mice. Any broad-scale control of 'pest' species however may have a significant effect on dependent raptor populations through removal of prey sources (Olsen 1998). A clear increase in the use of coastal blocks was accompanied by a decrease in use of inland blocks from 1977-1981. This was attributed to drought conditions during the El Nino period from 1977 to 1981 where presumably birds moved to the coast when inland habitats dried up or became unsuitable (Shephard et al 2005b). *Survival of species appears to rely firstly on suitable foraging habitat (refuges, hunting perches, open tracts of water etc.), and secondly on the availability of prey items. As an apex predator it is more susceptible to food limitations. Also threatened by secondary poisoning through consumption of contaminated prey and also through eradication of 'pest' species that may provide a substantial food source. The net effect of pest control under climate change is difficult to assess and reduces confidence in assessment as it could be either an advantage (more pest species) or disadvantage (poisoning through control of pest outbreaks). Increased drought frequency and magnitude is expected under climate change and may limit availability of habitat and food availability within the study area. Species should be considered at moderate risk but with medium confidence*	**M**	**M**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>The river wetlands, Lakes and upper Coorong are significant foraging and maturation area for sub-ad sea-eagles and the river an important corridor for genetic exchange between SA's isolated population the eastern States (T. Dennis pers. Comm. 2010).</u>	Poorly understood, chicks rely on parental care including fed piecemeal up until at least 5 weeks old and still in nest after 11 weeks. Fledging takes 65-70 days and young fed by adults up to 3 months after fledging, driven out of territory by adults after 4 months (Marchant and Higgins 1993). *Young take a long time to leave nest and even longer to become independent and this increasing risk to species significantly as parental investment is high and young are more vulnerable for longer. Food availability (abundance and foraging distance) may also be affected by climate change and could potentially disrupt early growth stages if chick is not fed adequately. As information is lacking on feeding requirements and growth rates of young confidence in assessment is reduced. Lack of knowledge of knowledge of breeding sites within the study area further reduces confidence. Species should be considered at high risk but with low confidence*	**L**	**H**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? Recently completed statewide survey found only one currently occupied territory in the River Murray system and another long-term site taken over by Wedge-tailed Eagles after the sea-eagle pair possibly relocated to the Chowilla floodplain. All occupied, recently abandoned and long abandoned nest sites along the Murray are/were all constructed over water. Use river red gums as nest sites. Breeding season in SA commences with courtship and nest repair in early May (as with all *Haliaeetus spp*. this is most sensitive period as they will abort the nest or eggs if disturbed) and late fledging events occur in early January i.e. it is an elongated season, May to January in SA (T. Dennis pers. Comm. 2010). Breeding pair known to nest in Moorook and another pair thought to nest in Chowilla floodplain area (P. Wainwright pers. comm. 2011).	Breed on coast and offshore islands and inland beside large rivers, lakes and swamps, usually in tall trees in or near water but also on cliffs, rock pinnacles and escarpments. Breeding season Jun-Dec although varying in some areas e.g. Hunter Island possibly due to food availability, SA studies timed to coincide with incubation and brooding form Sep to Oct (Dennis and Baxter 2006). Uses a variety of nesting sites, display site fidelity to one or two sites but not influenced by success of previous broods, location or proximity to water. Eggs failure or loss to predation triggers replacement broods within about 4 weeks but not if later on in incubation stage (Marchant and Higgins 1993). Species use the same nest structure over long periods of time and are renowned as being sensitive to disturbance during the breeding season. Studies from Kangaroo Island and elsewhere show that disturbed nests produce significantly fewer young than those remote from human interactions (various studies cited in Dennis et al 2005; Dennis and Baxter 2006). Dennis and Lashmar (1996), in a comprehensive survey and assessment of nest sites throughout SA found that the majority (67%) of the breeding population was found on offshore islands including Kangaroo Island. 33% of nesting territories were found on the mainland including only 3 from river systems on Coopers Creek and Murray River (Dennis and Lashmar 1996). *Diverse range of potential nesting sites but site selection based on traditional sites in a breeding territory. Nesting sites are very scarce in study area and may only be 1 or 2. Replacement broods are possible but only upon failure in early incubation stages. Species may display some capacity to adjust breeding to food availability in some areas. Species is likely to be limited by availability of suitable traditional nesting sites in established breeding territories as it shows strong site fidelity and is highly susceptible to nest disturbance that significantly reduces breeding success. Species should be considered at moderate risk but with medium confidence*	**M**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Shephard et al (2005a) found low haplotyoe and nucleotide diversity in populations sampled across Australia and concluded population in Australia likely of genetic bottleneck origin and suggests contiguous range expansion was founded by relatively small number of individuals. Small Australia wide population roughly estimated at more than 500 pairs (Ferguson-Leesand Christie 2001 as cited in DEHWA 2010a). Nationally listed as endangered and sub-regionally listed as critically endangered with definite declines noted in Murray Scroll Belt and Murray Mallee (DENR 2010 Listed as endangered under NPW Act 1972, sub-regionally listed as critically endangered with definite declines noted in Murray Scroll Belt and Murray Mallee (Gillam and Urban 2010). SA populations are physically isolated from rest of Australia as nearest occupied territories were 860km and 700km to the west and east respectively (Dennis and Lashmar 1996). *Genetic diversity likely to be highly restricted given current abundance and declining trend and the fact that SA populations are geographically isolated from other populations in Australia. This is supported by cladistics showing low genetic diversity across Australian populations generally. Species should be considered at high risk*	**H**	**H**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? The river wetlands, Lakes and upper Coorong are significant foraging and maturation area for sub-ad sea-eagles and the river an important corridor for genetic exchange between SA's isolated population the eastern States (T. Dennis pers. Comm. 2010).	Observed lack of equilibrium in some populations could be interpreted as current gene flow however given relatively small number of generations since colonization and small and uneven sample sizes in study this may only represent historical distribution patterns that may not have had enough time to become established at high enough frequency within other regions to be discernible within the study, alternatively intermediates may have been lost over time due to rarity (Shephard et al 2005a). Species forms lifelong monogamous bonds and only replace partners upon death (Marchant and Higgins 1993). *Genetic structure and gene flow is potentially limited given sparse population. Indications of gene flow may be marred by sample size and use of only MtDNA (maternal lineage). Species is also monogamous further restricting gene flow across populations. Species should be considered at high risk as any gene flow that does occur is likely to originate from a homogenous pool and involve the same pairs season after season*	**H**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	No known geographic variation in species (Marchant and Higgins 1993). Genetic homogeneity of individuals found in populations across Australia. Insufficient evidence to suggest division of the Australian populations into different units for management (Shephard et al 2005a). Shephard et al (2005a) pointed out that additional studies were required into secondary markers and recombinant DNA to describe population structure of both sexes. Small regional populations and monogamous breeding (Marchant and Higgins 1993). *Species does not show any signs of plasticity, geographic variation or expressions of different phenotypes. Rarity of species and monogamous bonds further reduce potential for evolution of different phenotypes. Species should be considered at high risk*	**H**	**H**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Occurs along most of Australian coastline and occasionally far inland along rivers. Limited population statistics for SA but thought to be absent from SE and occur mainly from Upper Murray to Coorong and along coast to Eyre Peninsula. No data on population in Coorong and Lower Lakes. State (SA) and nationally listed as endangered, also listed under the Chinese Australian Migratory Bird Agreement (CAMBA) (Marchant and Higgins 1993). Victorian population is currently considered restricted with only 100 pairs estimated as remaining (Clunie 1994 as cited in Marchant and Higgins 1993). Small Australia wide population roughly estimated at more than 500 pairs (Ferguson-Leesand Christie 2001 as cited in DEHWA 2010a). Very few records (25) since 1990 within floodplain and widely distributed from Murray Mouth to Vic border (BDBSA 2010). Listed as endangered under NPW Act 1972, sub-regionally listed as critically endangered with definite declines noted in Murray Scroll Belt and Murray Mallee (Gillam and Urban 2010). *Widely recognized as a very rare species and is threat listed at national, state and regional levels in severe categories. BDBSA records support literature citing major population depressions and declines. Drought, lowered river height and increased river regulation under climate change is expected to increase pressure on recruitment and survival within the study area. Species should be considered at high risk*	**H**	**H**

	Question	Comments/ Reference	Confid	Vul Rating
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Clutch size is small, usually 2 eggs, sometimes 1 but rarely 3. No information on number of broods per season but replacement broods are possible if losses are early in incubation period. (Marchant and Higgins 1993). Studies from Kangaroo Island and elsewhere show that disturbed nests produce significantly fewer young than those remote from human interactions (various studies cited in Dennis et al 2005; Dennis and Baxter 2006). *Species has a very low reproductive capacity and is highly susceptible to disturbance and subsequent nest failure. Species should be considered at high risk*	**H**	**H**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? One-two eggs, and usually one will fledge NB long-lived eagles at the top of their food chain don't necessarily breed every year (T. Dennis pers. Comm. 2010).	In general raptors tens to be long-lived with slow reproduction rates and low population densities (Olsen 1998). Does not reach breeding maturity until 6-7 years of age (Marchant and Higgins 1993). Of nests with 2 eggs, 1 is sometimes infertile or second chick dies before fledgling. 1983 study in SE Vic found rates for successful nests of 34% producing 2 young, and 66% producing 1 young and an average of 1.1 chicks raised successfully from all active nests. Nest success in this study was better in tall open woodland compared to farmland (Marchant and Higgins 1993). *The species has a very low reproductive capacity, very long generation time (comparatively old age at first breeding) and a rate of mortality of young before fledgling at around 50%. Species should be considered at high risk*	**H**	**H**

Scientific Name:	*Himantopus himantopus*	**Common Name:**	Black-winged (Pied) Stilt

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? Use of fresh, brackish and saline wetlands is an advantage for species. Can use permanent or temporary systems because not exclusively dependent on infauna (feed on pelagic organisms). Do not need deep water for foraging and will use artificial and modified habitats e.g. irrigation channels in farms. May benefit through range extensions from increased river management and transition to more temporary and saline wetlands (P. Wainwright, pers. comm. 2010).	Prefer shallow, open freshwater wetlands, especially those with dense growth of short grass or similar emergent vegetation, but generally occur on a range of wetlands including swamps, marshy ponds, billabongs, lakes, lagoons, saltmarsh, closed tidal wetlands, waterholes, and also artificial wetlands such as saltworks, sewage farms and flooded paddocks. Also on intertidal mudflats or sandflats in sheltered tidal inlets including estuaries and river deltas and on receding floodwaters. Reportedly benefited from clearing and salinisation of woodlands taking advantage of pastoral and irrigated lands (Marchant and Higgins 1993). *Use of fresh, brackish and saline wetlands is an advantage for species as it can use temporary or permanent systems. Has benefited from some woodland clearing and salinisation and may further expand range under climate change. Also uses modified and artificial habitats. Species should be considered at moderate risk*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Apparently dispersive in Australia. Movements correlated with seasonal and annual fluctuations in rainfall and availability of wetlands. Probably opportunistic moving to wetlands with suitable conditions. Known to travel long distances across seas e.g. PNG, NZ. Show seasonal movements to coastal sites in late summer and autumn, and leaving from the coast in mid-winter to early spring, concurrent with an increase in numbers inland (Marchant and Higgins 1993). *A highly dispersive and mobile species that opportunistically colonises suitable wetland habitats and can travel long distances to reach them. This species should be considered at low risk*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Omnivorous. Takes molluscs, annelids, crustaceans, arachnids and diverse range of aquatic and terrestrial insects, occasionally seeds. Usually breed in colonies, on islets or hummocks surrounded by shallow fresh, brackish or saline water. Breed colonially but sometimes solitarily in swamps, streams, rivers, flooded saltmarsh and in mangroves. Nests on ground, but also on loose platforms with up to 500 nests in a colony. Ground nests susceptible to egg predation by feral animals and losses to trampling e.g. by stock and vehicles but not thought a major threat (Marchant and Higgins 1993). *Competition for nesting space is not identified in the literature although colonial and can be in high numbers. Ground nests may be subject to some damage and/or predation and this may be higher where birds breed in solitary pairs but net effects are thought minor. Wide diet means food is unlikely to be limiting unless particularly scarce through habitat degradation or in high competition similar waders. Species should be considered at low risk*	**H**	**L**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Use of fresh, brackish and saline wetlands is an advantage for species. Can use permanent or temporary systems because not exclusively dependent on infauna (feed on pelagic organisms). Do not need deep water for foraging and will use artificial and modified habitats e.g. irrigation channels in farms (P. Wainwright, pers. comm. 2010).</u>	Feeds on aquatic and terrestrial invertebrates, molluscs, crustaceans, insects, small fish and occasionally seeds (Ecological Associates 2010). Forage in shallow water or saturated mud in fresh or non-tidal saline wetlands, often close to emergent vegetation (Marchant and Higgins 1993). Studies in south-western Australia found bird prefers brackish, alkaline (pH > 7.4) wetlands (Halse et al 1993). Salinity range of wetlands used by 11 broods in south-western Australia 0.127 – 21.520ppt, and pH ranging from 6.8 – 10.1 (Goodsell 1990). Studies from arid south-western Queensland found the mean abundance of Black-winged Stilt was significantly higher on the saline Lake Wyara than on the adjacent fresh Lake Numalla. There were significantly larger numbers of planktonic invertebrates in the salt lake than in the freshwater lake (Kingsford and Porter 1994). *Species shows a high tolerance to salinity including hyper-saline environments. Some studies indicate a preference for brackish and saline wetlands possibly due to increased food availability. Species may not tolerate acid conditions as appears to occur in neutral to alkaline waters. Foraging usually near dense aquatic vegetation that may be at risk through habitat degradation under climate change. A transition to more temporary, saline wetlands through increased river management may benefit species if systems are managed correctly and are highly productive. Species should be considered at moderate risk*	**H**	**M**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Species with young that are dependent for less time are at an advantage as parental investment is less and young spend less time as vulnerable nestlings (P. Wainwright, pers. comm. 2010).</u>	No data on juvenile intake but assumed similar to adult diet (i.e. omnivorous). Takes molluscs, annelids, crustaceans, arachnids and diverse range of aquatic and terrestrial insects, occasionally seeds. Chicks are brooded but not fed, independently forage few meters away from nest from 1-2 days old. Prefers freshwater, though also occurs on brackish and saline to hypersaline water-bodies. Recorded in waters with salinities between 10 and 145 ppt (Jessop 1987 as cited in Marchant and Higgins 1993). Recorded occurring in brackish and saline wetlands with neutral to slightly alkaline pH (Goodsell 1990; Halse et al 1993; Kingsford and Porter 1994). *Diet of juveniles not described but assumed to forage for similar food as adults so therefore not immediately limiting due to wide preferences though confidence is limited. Foraging usually near dense aquatic vegetation that may be at risk through habitat degradation under climate change. Limited parental care with no feeding benefits species as parental investment is reduced and young spend less time in a vulnerable state. Wide tolerance to salinity but may be sensitive to acidity. Species should be considered at moderate risk but with medium confidence due to lack of specific knowledge of juvenile growth tolerance and requirements*	**M**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Species with young that are dependent for less time are at an advantage as parental investment is less and young spend less time as vulnerable nestlings (P. Wainwright pers. comm. 2010).</u>	Breed usually in colonies, on islets or hummocks surrounded by shallow fresh, brackish or saline water. Nests on ground, but also on loose platform in or near swamps, streams, rivers, flooded saltmarsh and in mangroves. Breeding is seasonal and opportunistic. In southern and eastern Australia, generally August to December, but also at any time if conditions are suitable. Display low site fidelity but occasionally use old nests of other species e.g. Black Swan. Chicks are brooded but not fed, independently forage few meters away from nest from 1-2 days old (Marchant and Higgins 1993). Breeding records somewhat restricted to coastal and sub-coastal regions from the South East to southern Eyre Peninsula, parts of the lower Murray River and the Lake Eyre drainage basin (Blakers et al 1984 as cited in SAAB 2001). *Wide nesting preferences but must be near water as chicks forage independently from 1-2 days of age only meters away. Known breeding sites in Lower Murray where increased acidification and drought (drying of wetlands) under climate change may render some currently used areas unsuitable. Species is highly mobile and dispersive and this may mitigate this threat. Species should be considered at moderate risk*	**H**	**M**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Cosmopolitan species, widespread throughout Australia, population estimated at 266000. Apparently dispersive in Australia, movements are correlated with seasonal and annual fluctuations in rainfall and availability of wetlands. Seasonal and opportunistic breeding in colonies and occasionally solitarily (Marchant and Higgins 1993). 2547 records since 1990 within floodplain, majority in Lower Lakes and Coorong, 298 records widely distributed across Murray Scroll Belt and Murray Mallee sub-regions within study area (BDBSA 2011). IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). *Widespread and highly abundant throughout Australia according to literature and supported by BDBSA records in the SA MDB floodplain region. Regional clusters of records in BDBSA may represent regional populations and sub-regionally listed as vulnerable but unlikely that they are genetically isolated due to high dispersive and mobility capacity of bird. Species should be considered at low risk*	**H**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Cosmopolitan species, widespread throughout Australia and apparently dispersive. Movements correlated with seasonal and annual fluctuations in rainfall and availability of wetlands. Paring occurs at or en route to breeding grounds (Marchant and Higgins 1993). Breeding records somewhat restricted to coastal and subcoastal regions from the South East to southern Eyre Peninsula, parts of the lower Murray River, and the Lake Eyre drainage basin (Blakers et al 1984 as cited in SAAB 2001). *Regional populations are unlikely to be isolated, genetic diversity not limiting as species is abundant and widespread. Good dispersal capacity of species and mixing of individuals from different populations likely especially when colonially breeding. Species should be considered at low risk*	**H**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic with marked geographic variation with up to 5 subspecies all having been recognized as full species previously. All have different plumage and vary in size compared to nominate *H. himantopus*. Known to hybridize with Black Stilt. Some authors encourage treatment of birds in complex as one species due to the amount of geographic variation shown (Marchant and Higgins 1993). *Species shows a high capacity for expressing a variety of phenotypes. It is also abundant, widespread and highly mobile and likely to contain a diverse gene pool, feature good gene flow and have the capacity for genetic flexibility. Species should be considered at low risk*	**H**	**L**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Cosmopolitan species, widespread throughout Australia (Marchant and Higgins 1993). Australian population estimated at 266000 (Watkins 1993). Trend stable to variable in Coorong, Lower Lakes and Murray Estuary except Lake Alexandrina where a decline to 4% has occurred over the last 5 years (Ecological Associates 2010). 2547 records since 1990 within floodplain, majority in Lower Lakes and Coorong, 298 records widely distributed across Murray Scroll Belt and Murray Mallee sub-regions within study area (BDBSA 2011). IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). *Widespread and highly abundant according to literature and verified by pattern of BDBSA data. Regional populations unlikely to be isolated along Murray due to dispersive capacity. Species should be considered at low risk*	**H**	**L**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Lays 3-6 eggs (average around 3.7); first clutch will be replaced if failure occurs, no information on multiple brooding capacities. Breeding is seasonal and opportunistic. In southern and eastern Australia, generally August to December, but also at any time if conditions are suitable (Marchant and Higgins 1993). At Bool Lagoon in south-east South Australia abundance was negatively correlated with water levels. This was mainly due to a response to habitat availability, with numbers increasing in response to the availability of shallow water habitat (Harper 1990 as cited in SAAB 2001). *Moderate fecundity potential and replaces brood upon failure but no indication of multiple brooding capacity. Seasonal and opportunistic breeding is an advantage provided conditions are suitable. Climate change may benefit species by providing more temporary, saline and shallower wetlands through drought and reduced/managed flows. Species should be considered at moderate risk*	**H**	**M**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	No information on longevity of species. Breeding is seasonal and opportunistic. In southern and eastern Australia, generally August to December, but also at any time if conditions are suitable.Usually breed from 2 years of age. Highly variable success rates for hatching and fledgling but reportedly very low; hatching <50%; fledging <10%) (Marchant and Higgins 1993). At Bool Lagoon in south-east South Australia abundance was negatively correlated with water levels. This was mainly due to a response to habitat availability, with numbers increasing in response to the availability of shallow water habitat (Harper 1990 as cited in SAAB 2001). IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). *Moderate clutch sizes but potential for successful recruitment is low due to high egg failure and nestling mortality rates and very low fledging success. Species also takes a relatively long time (2 years) to reach breeding maturity. Opportunistic breeding is an advantage provided conditions are suitable. Climate change may provide more temporary, saline and shallower wetlands through drought and reduced/managed flows. Probably moderate population base from which to recruit from. Species should be considered at high risk but with medium confidence as unknown if range extension through climate change that may improve recruitment.*	**M**	**H**

Scientific Name:	*Gallirallus philippensis*	**Common Name:**	Buff-banded Rail

FAMILY: Rallidae

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	Inhabit both permanent and ephemeral wetlands of salinity ranging from fresh to saline terrestrial, estuarine and littoral wetlands. Will also use artificial impoundments e.g. sewage farms, farm dams, channels and ditches. Also occur on non-wetland habitats e.g. grasslands, pastures, crops, woodland and forests. Breed around wetlands or in pastures and crops among dense clumps of grass, sedges, rushes or samphire and shrubs. Forage around vegetated margins of wetlands on mud near tall grass reeds and rushes or other concealing vegetation and roost in similar. Feed on ground, in mud and shallow margins of wetlands and beaches and occasionally pastures. Available habitat reduced through wetland reclamation for development, stock trampling/grazing in farmed areas. This may be offset by widespread use or artificial habitats and disturbed land e.g. rubbish dumps and mine heaps (Marchant and Higgins 1993). *Species can use range of wetlands with salinities ranging from fresh to saline with good vegetative cover and also uses artificial impoundments, crops and pastures. Uses shallow wetlands and margins as opposed to deeper bodies. A transition from permanent, freshwater wetlands to more temporary and saline wetlands is expected through increased flow regulation to mitigate effects of climate change and drought and may increase this species' range. Species that do not need deep water for foraging are less at risk. Salinity problems may however reduce available fringing vegetation in some areas. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Movement poorly studied, resident and dispersive and possibly migratory. In northern Australia maintain year-round presence but in parts of SA disappear from some areas over winter. Possibly move to areas of high rainfall from drought-stricken regions (Marchant and Higgins 1993). In southern Australia, generally considered a visitor in spring-summer (various studies cited in Marchant and Higgins 1993) and suggested that move in response to water availability (Schodde and de Naurois 1982 as cited in Marchant and Higgins 1993). *Movement in species is poorly known but reasonable evidence for good dispersion and possible seasonal migrations particularly in SA. Suggested irruptions in response to water availability from drought stricken areas to areas of high rainfall. Species should be considered at low risk but with medium confidence due to lack of conclusive studies of mobility.*	**M**	**L**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Abundance and reproductive success is probably driven mainly by effects of predation (P. Wainwright pers. comm. 2011).</u>	Medium size bird to around 230g, often described as quarrelsome and non-breeding birds often squabble over feeding territories. A secretive, skulking species as is typical of the Rallidae family (Marchant and Higgins 1993). Eats mostly crustaceans, molluscs, worms and insects but also some plant matter, seeds and fruits frogs, eggs, carrion and refuse. Can be quite aggressive to other species and known to kill other rails with single peck (Serventy 1959 as cited in Marchant and Higgins 1993). Also known to attack magpies, lapwings, doves and honeyeaters and young known to chase the former two species (Coates 1985; Dunlop 1970 both as cited in Marchant and Higgins 1993). Recorded displacing other birds on feeding territories. One parent usually adopts role of defense of young against intruders usually through distraction displays but also direct threat of intruder. Nest is flimsy construction on or near ground level but only needed for 1 day, if disturbed will pick up eggs and move them to a hastily constructed new nest (Marchant and Higgins 1993). Predation by feral cats and rats (along with human factors) has probably caused the extinction of the subspecies on the main atoll of the Cocos-Keeling Islands. The greatest threat is now the possible, accidental introduction of predators to North Keeling Island (Stokes et al. 1984; Reid 2000 as cited in Garnet and Crowley 2000). *A medium size and apparently rather aggressive bird especially around feeding territories against other bird species. Can displace and kill other birds and even young will chase small birds. Some nest defense but young are nidifugous and leave nest within a day of hatching. Introduced animals (but also native raptors etc.) pose a major threat with noted population extinctions attributed to predation on remote islands (but outside study area). Abundance and reproductive success is probably driven mainly by effects of predation although is a somewhat cryptic species. Species should be considered at moderate risk.*	**H**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Inhabit both permanent and ephemeral wetlands of salinity ranging from fresh to saline terrestrial, estuarine and littoral wetlands. Will also use artificial impoundments e.g. sewage farms, farm dams, channels and ditches. Also occur on non-wetland habitats e.g. grasslands, pastures, crops, woodland and forests. Forage around vegetated margins of wetlands on mud near tall grass reeds and rushes or other concealing vegetation and roost in similar. Eats mostly crustaceans, molluscs, worms and insects but also some plant matter, seeds and fruits frogs, eggs, carrion and refuse (Marchant and Higgins 1993). *Broad habitat and diet requirements and tolerant of a range of salinities reduces risk under climate change. Use of artificial environments is also an advantage. Uses shallow wetlands and margins as opposed to deeper bodies. Species that do not need deep water for foraging are less at risk as river regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation. Species should be considered at low risk.*	**H**	**L**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Inhabit both permanent and ephemeral wetlands of salinity ranging from fresh to saline terrestrial, estuarine and littoral wetlands. Will also use artificial impoundments e.g. sewage farms, farm dams, channels and ditches. Also occur on non-wetland habitats e.g. grasslands, pastures, crops, woodland and forests. Breed around wetlands or in pastures and crops among dense clumps of grass, sedges, rushes or samphire and shrubs. Forage around vegetated margins of wetlands on mud near tall grass reeds and rushes or other concealing vegetation and roost in similar. Eats mostly crustaceans, molluscs, worms and insects but also some plant matter, seeds and fruits frogs, eggs, carrion and refuse (Marchant and Higgins 1993). Young leave nest within 24hrs and can feed themselves after 1 week. Young are fully grown and able to fly at 2 months (Dunlop 1970 as cited in Marchant and Higgins 1993). *Broad habitat and diet requirements and tolerant of a range of salinities reduces risk under climate change. Young hatch quite well developed, grow quickly and are independent rapidly meaning they are less vulnerable for shorter time and also reduces load on parents. Use of artificial environments is also an advantage. Uses shallow wetlands and margins as opposed to deeper bodies. Species that do not need deep water for foraging are less at risk as river regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation.*	**H**	**L**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Poorly studied in Australia, some work in NZ in early 1980's. Australian information based on Dunlop (1970) and Australian Nest Record Scheme both as cited in Marchant and Higgins (1993). Breeding is typically in simple pairs in breeding territories and can raise up to 3 broods per year. Breeding season in southern Australia is roughly from Aug/Sep to Feb. Breed around wetlands or in pastures and crops among dense clumps of grass, sedges, rushes or samphire, saltmarshes and shrubs. Nests on or near ground level usually near water but also up to 60m away and does not re-use sites. Nest is a flimsy construction but if disturbed will pick up eggs and move them to a hastily constructed new nest (Marchant and Higgins 1993). Clutch size reduced during droughts (Gilbert 1936 as cited in Marchant and Higgins 1993). Young leave nest within 24hrs of hatching and can feed themselves after 1 week. Young are fully grown and able to fly at 2 months (Dunlop 1970 as cited in Marchant and Higgins 1993). *Breeding season is relatively long compared to other birds assessed in this study and does not rely on presence of water beneath or immediately adjacent to nest for breeding success. Though not specified, may use saline wetlands in typical salt-tolerant/halophytic vegetation. If nest is disturbed during incubation, will move to a new nest. Can still breed through droughts though clutches are generally smaller. Young hatch quite well developed, grow quickly and are independent rapidly meaning they are less vulnerable for shorter time and also reduces load on parents. Species should be considered at low risk but with medium confidence due to lack of studies specific to SA and the MDB region.*	**M**	**L**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? Relatively rare so probably a limited gene pool (P. Wainwright pers. comm. 2011).	No specific or recent population estimates for Australia. Cocos Island subspecies (*andrewsi*) listed as endangered under the Environment Protection and Biodiversity Conservation Act 1999 (DSEWPC 2010). Most other subspecies are secure, and global status of species is 'Least Concern' (Garnet and Crowley 2000). Movements not well known but resident, dispersive and possibly migratory. May move to areas of high rainfall from drought-stricken regions (Marchant and Higgins 1993). In southern Australia, generally considered a visitor in spring-summer (various studies cited in Marchant and Higgins 1993) and suggested that move in response to water availability (Schodde and de Naurois 1982 as cited in Marchant and Higgins 1993).Very sparse records within SA MDB floodplain since 1990 (25) and fewer (18) in study area above Wellington (BDBSA 2010). Listed as 'endangered' and in 'probable decline' in DENR Murraylands region and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Species does not form breeding colonies and generally breeds in solitary pairs in breeding territories reducing potential diversity of available gene pool. Low abundance and patchy distribution is likely given sparseness of records especially within study area and sub-regional threat listing. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? Relatively rare so probably a limited gene pool (P. Wainwright pers. comm. 2011).	Movement poorly studied but thought resident and dispersive and possibly migratory. In southern Australia, generally considered a visitor in spring-summer (various studies cited in Marchant and Higgins 1993). Breeding is typically in simple pairs, solitary nesting in breeding territories and can raise up to 3 broods per year. Pair-bonding is poorly studied. Probably sustained monogamous but duration of bond is unclear (Dunlop 1970 as cited in Marchant and Higgins 1993). *Species does not form breeding colonies and generally breeds in solitary pairs in breeding territories reducing potential for gene flow. Also may sustain long-term monogamous pair- bonds that would limit gene flow in regional populations although duration of bond is not defined. Low abundance and patchy distribution is likely given sparseness of records especially within study area and sub-regional threat listing. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic species with complex geographic variation on global scale and 26 recognised subspecies though conjecture exists as to validity of some. Australian mainland and Tasmanian population once divided into 3 subspecies but now followed as a single subspecies. Morphological differences between regional populations are similar to variation within populations (Marchant and Higgins 1993), i.e. geographic variation at regional scale is difficult to determine conclusively. *Low abundance in SA MDB and suggested that birds undergo migrations to breed so increased chance of mixing with small gene pool is not conducive to producing geographic variation. Any variation is likely to occur at scales much larger than study area. Species should be considered at high risk with medium confidence as the genetic structure of populations within the SA MDB is unknown.*	**M**	**H**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Very low reporting rates in Atlas surveys and a low proportion of sightings within the Murray-Darling Depression (MDD) bioregion estimated to host a moderate percentage of the national population (ANRA 2010b). Conspicuousness varies throughout year and may be harder to detect when not breeding in winter (Marchant and Higgins 1993). Very sparse records within SA MDB floodplain since 1990 (25) and fewer (18) in study area above Wellington (BDBSA 2010). Listed as 'endangered' and in 'probable decline' in DENR Murraylands region and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Low abundance and patchy distribution is likely given sparseness of records especially within study area and according to Atlas survey data from the MDD bioregion. Regional and sub-regional threat listed as 'endangered'. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Clutch size usually 5-8 and less (4-5) during drought (Gilbert 1936 as cited in Marchant and Higgins 1993). Clutches of 3 and 2 also recorded by Dunlop (1975) and Storr (1980) both as cited in (Marchant and Higgins 1993). Clutch size reduced during droughts (Gilbert 1936 as cited in Marchant and Higgins 1993). Can raise up to 3 broods per year (Marchant and Higgins 1993). Very sparse records within SA MDB floodplain since 1990 (21) and fewer (14) in study area above Wellington (BDBSA 2010). *Good clutch size compared to other birds assessed in this study and can also have multiple broods in a season. Species will reduce clutch size during droughts presumably increasing chances of success in limiting environment. Probably small population base to recruit from. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Breeding is typically in simple pairs and can raise up to 3 broods per year. Clutch size usually 5-8 and less (4-5) during drought (Gilbert 1936 as cited in Marchant and Higgins 1993). Clutches of 3 and 2 also recorded by Dunlop (1975) and Storr (1980) both as cited in (Marchant and Higgins 1993). Breeding is typically in simple pairs in breeding territories and can raise up to 3 broods per year. Breeding season in southern Australia is roughly from Aug/Sep to Feb and species can breed as early as 11 months (Dunlop 1970 as cited in Marchant and Higgins 1993). Very low reporting rates in Atlas surveys and a low proportion of sightings within the Murray-Darling Depression (MDD) bioregion estimated to host a moderate percentage of the national population (ANRA 2010b). Listed as 'endangered' and in 'probable decline' in DENR Murraylands region and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Good clutch size, long breeding season and capacity for multiple broods in a season reduces potential for recruitment limitations. Can begin breeding in first year but longevity is unknown. Probably has a small population base from which to recruit from. Species should be considered at moderate risk.*	**H**	**M**

Scientific Name:	*Phalacrocorax (Microcarbo) melanoleucos*	Common Name:	Little Pied Cormorant

FAMILY: Phalarcrocoracidae

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	Occurs in terrestrial wetlands and sheltered coastal waters, uses a variety of natural and artificial inland wetlands, swamps, billabongs, pools and channels. In an aerial survey of eastern Australia, 93 % of the estimated population occurred on artificial impoundments, while > 99 % occurred on waters larger than 100 hectares (Marchant and Higgins 1990). Able to use smaller wetlands and open water with vegetation compared to other cormorants. Prey caught in a succession of brief dives (Marchant and Higgins 1990b), which is best suited to taking more sedentary prey in shallow waters (Schodde and Tidemann 1986 as cited in SAAB 2001). Also recorded in saltpans, saline swamps and wetlands with sedge, mangrove and salt marsh vegetation. Roost in trees and bushes near water but also artificial perches e.g. fences, stumps, navigation beacons. Breed mainly in freshwater environments on trees and bushes in or near water. In Booligal (NSW), tend to breed in swamps with high organic matter with diverse flora and invertebrates and in early succession stages of drying and wetting cycles (Marchant and Higgins 1990b). Continued destruction of natural freshwater wetlands, which are more diverse than artificial wetlands and water impoundments and are more important breeding habitats is a major threat as is increased salinity of naturally freshwater habitats used for breeding (SAAB 2001). *Flexible salinity tolerances ranging from fresh to saline (but not hypersaline) and also extensively uses artificial impoundments. Fringing vegetation is required but nature is unimportant as long as perches are available and prefers open water for foraging. Shallow water foraging and fishing means less reliance on deep, permanent systems and may benefit species under climate change. Uses permanent and ephemeral freshwater systems preferring latter for breeding as wetting and drying cycles encourage diverse flora and fauna. River regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation and this may benefit species. This is offset by risk of salinity and drying in ephemeral wetlands under climate change. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Dispersive species, banding studies indicate capacity for long distance movements (100km's), overseas (to NZ). Inland dispersal much more significant than in coastal populations. Seasonal abundance patterns do not always correlate with water availability (flow, rainfall) but is seen in some areas e.g. SE Qld (positive correlation with rainfall and negative with falling water level and temperature). Few recoveries of banded young after 10 months but some individuals do return to natal colony (Marchant and Higgins 1990b). *Good evidence for significant dispersal and mobility capacity particularly post-breeding and in inland areas. Patterns of movement in response to water availability and/or temperature. Species unlikely to be limited by movement capacities and should be considered at low risk.*	**H**	**L**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Medium size aquatic bird to around 880g and appears to be less aggressive than Great or Little Black Cormorants. Colonial nesters of between a few and hundreds of nests often mixed with other cormorants e.g. Little Black, rarely nest singly. Rarely form feeding flocks but will if food is plentiful and include Little Black Cormorants and occasionally feeding egrets (*Ardea spp*). Feed extensively on 'pest' fish species e.g. carp and redfin, eradication efforts may be detrimental if not replaced by suitable native prey. Diet mainly of crustaceans as opposed to Little Black Cormorant that is primarily piscivorous. Alarm call made by adults in colonies upon sighting aerial predators e.g. Marsh Harrier, Kelp Gull, spreading throughout colony but only when nestlings are present. No other overt anti-predator behaviour and adults in colony typically fly away silently (Marchant and Higgins 1990b). *Smaller and less aggressive than other cormorants assessed in this study. Smaller prey than other cormorants consisting of more invertebrate items so competition for food is presumably less. Proliferation of pest species under climate change may be a benefit but eradication measures e.g. of carp, must be considered. Nest defense is weak, uses some threat displays to intruders and gives alarm calls when predators are spotted but no aggressive territoriality mentioned in literature usually choosing to fly away if challenged. Colonial nesting is a competitive advantage but usually solitary in non-breeding dispersion. Species should be considered at moderate risk.*	**H**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Generally feed singly but seen cooperating in groups of up to 200 sometimes with Little Black Cormorants presumably when food is abundant. Feed extensively on 'pest' fish species e.g. carp and redfin, eradication efforts may be detrimental if not replaced by suitable native prey. Diet mainly of crustaceans as opposed to Little Black Cormorant that is primarily piscivorous (Marchant and Higgins 1990b). Also take insects e.g. crickets, grasshoppers, bugs, beetles, weevils, dragonfly larvae and caddis flies (Barker and Vestjens 1989 as cited in SAAB 2001). Prey caught in a succession of brief dives (Marchant and Higgins 1990b), which is best suited to taking more sedentary prey in shallow waters (Schodde and Tidemann 1986 as cited in SAAB 2001). In south-western Australia between July 1981 and May 1985, preferred brackish TDS < 10 ppt), alkaline (pH > 7.4) wetlands (Halse et al. 1993). In September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al 1993). In arid south-western Queensland between 1987-1989, the mean abundance was significantly more on the fresh Lake Numalla possibly related to better food availability e.g. freshwater fish and shrimp (Kingsford and Porter 1994) and possibly breeding site preferences. *Salinity is not likely to limit survival except at extremely high levels. Vegetation can be either freshwater or saline and even dead as long as perches exist along with open tracts of water, preferably shallow for foraging. Smaller size and more diverse diet than other cormorants although may prefer freshwater systems due to better availability of some prey. Proliferation of pest species under climate change may be a benefit but eradication measures e.g. of carp, must be considered. Species should be considered at low risk.*	**H**	**L**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	No information specific information on growth, parental care or fledging to maturity (Marchant and Higgins 1990b). Parental care probably similar to Great Cormorant, shading and watering of young by adults in hot weather and fed by regurgitation. Birds in this family probably have both parents incubate and tend young until a few weeks after fledging and hatchling period is around 50 days. Hatchlings are born altricial and are nidiculous (require care for a time) but nestling/fledging period for species is undefined. Recorded preference to feeding in saline waters and also use coastal and marine systems but prefer fresh environments particularly for breeding (Marchant and Higgins 1990b) possibly due to reliance on freshwater vegetation for nesting. For their young to fledge, water needs to remain under nest trees for at least 5 and up to 10 months following flooding (Briggs and Thornton 1999). In Booligal (NSW), tend to breed in swamps with high organic matter with diverse flora and invertebrates and in early succession stages of drying and wetting cycles (Marchant and Higgins 1990b). *Preference to breeding in more productive freshwater wetlands and presumably raises young in similar environment. These habitats are under threat through climate change and raise risk to growth of young. Changes to hydrological regimes e.g. more flow regulation, may threaten growth of young to fledging if wetland below nests dry. Will use fresh to saline wetlands for feeding but tend to prefer ephemeral fresh wetlands. Transition from permanent to temporary wetlands is expected under climate change but flow regulation and salinity issues must be considered. Lack of specific information on growth and fledging limits confidence. Species should be considered at high risk but with medium confidence.*	**M**	**H**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Breed mainly in freshwater environments on trees and bushes in or near water. In Booligal (NSW), tend to breed in swamps with high organic matter with diverse flora and invertebrates and in early succession stages of drying and wetting cycles. Lowering of water levels during breeding may cause failures however temporary drainage may stimulate breeding through increased food availability (Marchant and Higgins 1990b). Miller (1976) showed that increase in food availability, water level and temperature induced an increase in gonadal activity in little pied cormorants and little black cormorants in inland NSW. Adequate nesting sites were also necessary for gonads to mature fully and for egg-laying. Keast and Marshall (1954-55) suggested that desert birds were physiologically adapted in such a way that their sexual cycles could respond quickly to environmental cues such as rainfall or its effects; cormorants respond rapidly to increasing water level (Llewelyn 1983). Wetlands in the southern Murray-Darling Basin should be flooded in winter/spring to allow breeding of Pelacaniformes such as Cormorants. For Cormorants to initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least 5 and up to 10 months following flooding (Briggs and Thornton 1999). At Bool Lagoon in south-east SA between July 1983 and June 1987, the abundance of Little Pied Cormorants was positively correlated with water levels and numbers were greatest during higher water levels (Harper 1990 as cited in SAAB 2001). Continued destruction of natural freshwater wetlands, which are more diverse than artificial wetlands and water impoundments and more important breeding habitats are a major threat as is increased salinity of naturally freshwater habitats used for breeding (SAAB 2001). Mean salinity of wetlands used by 14 broods in south-western Australia 5.766 g/L (range 0.708 – 17.2), mean pH 7.9 (range 5.7 – 10.0) (Goodsell 1990 as cited in SAAB 2001). *Breeding mainly in freshwater wetlands and also requires water be present under nesting sites for long term while raising young although wetting/drying cycle also important and must be carefully managed. Opportunistic breeding may be advantage but also relies on favourable conditions that may be more infrequent under climate change. Species should be considered at high risk.*	**H**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Have become more widespread only where previously forested areas have been cleared and dams constructed, however natural wetlands are better habitats especially for breeding (Marchant and Higgins 1990b). No recent population estimates (SAAB 2001). High number of records within SA MDB floodplain and since 1990 (2137, 344 within study area above Wellington) (BDBSA 2010) compared to other birds assessed in this study. Listed under IUCN threat listing as 'near threatened' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions (Gillam and Urban 2010). Colonial nesters of between a few and hundreds of nests often mixed with other cormorants e.g. Little Black, rarely nest singly. Probably sustained monogamous bonding though not verified through banding studies. Dispersive species, banding studies indicate capacity for long distance movements (100km's) and inland dispersal much more significant than in coastal populations (Marchant and Higgins 1990b). At Bool Lagoon in south-east SA between July 1983 and June 1987, the abundance of Little Pied Cormorants was positively correlated with water levels and numbers were greatest during higher water levels (Harper 1990 as cited in SAAB 2001). *Good abundance and wide distribution according to records and literature reduces risk. Colonial breeding in large groups and widespread dispersion also a benefit. Sustained monogamous pair-bonds may limit genetic diversity across population at regional scale but lacking quantitative data confirming extent and duration of bond lowers confidence. Species should be considered at low risk but with medium confidence.*	**M**	**L**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? <u>Highly dispersive, gene flow is probably good at population level (P. Wainwright pers. comm. 2011).</u>	Colonial nesters of between a few and hundreds of nests often mixed with other cormorants e.g. Little Black, rarely nest singly. Probably sustain monogamous pair bonds but not verified through banding studies. Dispersive species, banding studies indicate capacity for long distance movements (100km's) and inland dispersal much more significant than in coastal populations (Marchant and Higgins 1990b). At Bool Lagoon in south-east SA between July 1983 and June 1987, the abundance of Little Pied Cormorants was positively correlated with water levels and numbers were greatest during higher water levels (Harper 1990 as cited in SAAB 2001). Have become more widespread only where previously forested areas have been cleared and dams constructed, however natural wetlands are better habitats especially for breeding (Marchant and Higgins 1990b). No recent population estimates (SAAB 2001). High number of records within SA MDB floodplain and since 1990 (2137, 344 within study area above Wellington) (BDBSA 2010) compared to other birds assessed in this study. *Good abundance and wide distribution according to records and literature reduces risk. Colonial breeding in large groups and widespread dispersion also a benefit. Sustained monogamous pair-bonds can limit gene flow but is probably good at population level given relative abundance. Species should be considered at low risk but with medium confidence.*	**M**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change? <u>If population size and recruitment is high this will increase chance of diversity (P. Wainwright pers. comm. 2011).</u>	A polytypic species with up to 3 recognised sub-species. Nominate *P. melanoleucos* is not identified specifically as displaying different phenotypic expressions however polymorphism has been recorded in the NZ sub-species *P. m. brevirostris*. Dowding and Taylor (1987) discuss the appearance of pied, black, white-throated and intermediate polymorphs e.g. smudgy, across a north-south gradient in NZ. These differences are linked to allele frequencies and supported by predictive genetic modeling. Galbreath (1989) refutes some of this evidence proposing optional and/or more complex genetic models also explain results but at least concurs in identifying the occurrence of these polymorphs. It is unclear whether these observations translate to Australian populations of *P. melanoleucos* and early work suggests that the NZ sub-species should in fact be considered as a separate species due to distinct morphological and behavioural differences (van Tets 1976 as cited in Marchant and Higgins 1990b). *Good abundance and wide distribution according to records and literature increases chance of diversity. Likely that Aust. populations consist of only 1 subspecies but unclear from literature if shared with NZ and lowers confidence. Abundance is relatively high and recruitment is thought to be good so diversity may be high. Species should be considered at moderate risk but with low confidence due to lack of regionally specific studies.*	**L**	**M**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Have become more widespread only where previously forested areas have been cleared and dams constructed, however natural wetlands are better habitats especially for breeding (Marchant and Higgins 1990b). Atlas survey sightings suggest a moderate number within the Murray-Darling Depression bioregion estimated to represent a moderate proportion of the national population (ANRA 2010b). High number of records (629) within study area since 1990 compared to other birds assessed in this study and 3925 records in SA MDB floodplain (BDBSA 2010). Listed under IUCN threat listing as 'near threatened' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions (Gillam and Urban 2010). *Current records, survey sightings and the literature suggest a moderate population base relevant to the study area. Proposed 'near threatened' status in Murray Scroll Belt and may be over-represented by BDBSA records. Species should be considered at low risk but with medium confidence.*	**M**	**L**

	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Lays 3-5 eggs per clutch, with 4 being most common but no records of replacement or multiple brooding. Cormorant and shag family are typically single brooding but will lay replacement eggs. Breeding season not well defined but claimed as spring-summer in southern Australia and probably continuous throughout the year if conditions favour (Marchant and Higgins 1990b). *Moderate clutch size compared with other birds assessed in this study but single brooding. Opportunistic breeding may be an advantage but relies on favourable conditions that may become more infrequent under climate change. Breeding cold be continuous throughout the year at a population scale so raises reproductive potential. Lack of specific information and reliance on family level data lowers confidence. Species should be considered at low risk but with medium confidence.*	**M**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>Probably breed in 2nd year so little lag time between generations and good recruitment from year to year (P. Wainwright pers. comm. 2011).</u>	Breeding season not well defined but claimed as spring-summer in southern Australia and probably continuous throughout the year if conditions favour. Cormorant and shag family are typically single brooding but will lay replacement eggs. Hatching/fledging success rates vary from 58-88% but this is based on few studies. Age at first breeding unknown but adult plumage attained by end of first year (Marchant and Higgins 1990b). Longevity unknown. Atlas survey sightings suggest a moderate number within the Murray-Darling Depression bioregion estimated to represent a moderate proportion of the national population (ANRA 2010b). High number of records (629) within study area since 1990 compared to other birds assessed in this study and 3925 records in SA MDB floodplain suggesting high abundance in Lower Lakes (BDBSA 2010). Listed under IUCN threat listing as 'near threatened' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions (Gillam and Urban 2010). *Moderate clutch size and single brooding but may lay replacement clutches upon failure. Opportunistic breeding may be an advantage but relies on suitable conditions that may become more infrequent under climate change. Good hatching/fledging success rate but based on little data and limits confidence. Probably breeds in second year and has a moderate life span but not documented. Probably a strong population base from which to recruit from and little lag time between generations at population scale. Species should be considered at low risk but with medium confidence.*	**M**	**L**

Scientific Name:	*Nycticorax caledonicus*	Common Name:	Nankeen (or Rufous) Night-Heron

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change. Nocturnal, more tolerant of brackish/saline conditions, e.g. feed in Goolwa Channel and Coorong, breed on Pelican Point. Use temporary wetlands around Lower Lakes and Coorong and other places along River Murray. Roost in trees during day (need tall dense trees e.g. pines preferred over gums). Not as specialized feeding requirement as in Australasian Bittern (P. Wainwright 2010, pers. Comm.).	Mainly nocturnal, usually seen hunching in trees over water, common near permanent water (Slater et al 2001). Forage in deep or shallow water; inland prefer permanent water bodies on floodplains especially those with woody edges and swamps with tall emergent vegetation. Saline habitats are used less often, but birds regularly found on mangrove lined coasts, estuaries, tidal reaches of water courses, and salt marshes (Ecological Associates 2010). Nesting habitat in natural freshwater wetlands and floodwaters has been destroyed or modified by drainage, clearing, grazing, burning, increased salinity, groundwater extraction and flood mitigation schemes (Marchant and Higgins 1990). *Evidence of relatively broad habitat preferences and requirements that reduce risk to species, however roosting and nesting requires dense cover and tall riparian vegetation and freshwater wetlands that under threat through habitat degradation (e.g. salinisation) expected to worsen under climate change. Species should be considered at moderate risk.*	**H**	**H**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change? Area of uncertainty, not known if current residents will become nomadic if habitat becomes unsuitable (P. Wainwright 2010, pers. Comm.).	Poorly understood, generally considered nomadic depending on availability of food but some birds probably sedentary in favourable habitat. In general a northern movement of at least part of southern population in winter. Some dispersive movement from drying swamps in Murray-Darling river system (Ecological Associates 2010) *Evidence of birds prepared to move when conditions become unsuitable but probably prefer residential habits. Dispersal and mobility is generally poorly understood. As information is limited species should be treated conservatively and placed at high risk but with low confidence.*	**L**	**H**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? Can be a colonial breeder in small or large colonies and potentially out-competed by larger wader e.g. egrets and spoonbill in mixed colonies. Colonial breeding can be an advantage for species through protection in numbers with conspecifics and other species (P. Wainwright 2010, pers. Comm.).	Feeds on diverse range of aquatic and terrestrial animals, principally fish but also frogs, freshwater crayfish and insects. Opportunist that takes any suitable prey when available including newly hatched sea-turtles, nestlings, house mice and human refuse. Also molluscs, freshwater mussels, centipedes, spiders, and crabs (Ecological Associates 2010). Very few detailed records of social behaviour. Agonistic interactions between males during courtship (Marchant and Higgins 1990) *Lack of information and observations of interactions between conspecifics and other fauna perhaps due to cryptic nocturnal nature of species. Competition for food limited as is nocturnal. Roosts and breeding sites are similar to many other waders so some competition is possible. Cryptic and nocturnal nature means competition is probably limited so should be considered at low risk.*	**H**	**L**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Nocturnal, tolerant of brackish/saline conditions, e.g. feed in Goolwa Channel and Coorong, breed on Pelican Point. Use temporary wetlands around Lower Lakes and Coorong and other places along River Murray. Roost in trees during day (need tall dense trees e.g. pines preferred over gums). Not as specialized feeding requirement as in Australasian Bittern (P. Wainwright 2010, pers. Comm.).</u>	Feeds on diverse range of aquatic and terrestrial animals, principally fish but also frogs, freshwater crayfish and insects. Opportunist that takes any suitable prey when available including newly hatched sea-turtles, nestlings, house mice and human refuse. Also molluscs, freshwater mussels, centipedes, spiders, and crabs (Ecological Associates 2010). Will tolerate raised salinity (mean of 2.9ppt but up to 10.2 ppt) (Goodsell 1990 as cited in Marchant and Higgins 1990) but prefers low salinity (< 10ppt) and high phosphorus levels (> 0.25mgL^{-1}) (Halse et al 1993). *Gleans food primarily from water bodies so relies on health of wetlands raising threat to species. Reliance on dense, riparian woodland habitat for roosting during the day increases risk as loss of these habitats is expected to increase under climate change. Species should be considered at moderate risk.*	**H**	**M**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>The quicker a species can fledge its young the better. Less stress on parents, young are vulnerable for shorter time and allows multiple clutches e.g. in response to flooding (P. Wainwright 2010, pers. Comm.).</u>	Almost no specific information on growth of nestlings and fledglings. Age of independence not known, nestling supposed to be fed regurgitate by both parents for 6-7. Heat waves (>42^0 C) may cause mortalities, deaths and deformities of chicks recorded at Geelong in early 1970s (Marchant and Higgins 1990). *Lack of information on growth rates and requirements, potential for food availability/quality to be affected by variations in salinity and hydrological regime. Increased regularity and magnitude of heat waves may also affect growth of young birds. Relatively moderate time to independence but not quantified. Conservatively the species should be considered at moderate risk*	**M**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Shown in one heron species that birds foraging far from a colony site rear smaller broods than locally foraging birds. This is attributed to changes in the distribution and abundance of key food resources associated with hyper-salinisation (Ecological Associates 2010). Nest in dense cover of trees or shrubs in saline or fresh wetlands. Also breed in treeless offshore islands on ground among shrubs. Breed colonially, usually in central parts of swamps and flooded areas. Breeding broadly in spring and summer, but probably more influenced by rainfall, flooding and water conditions (Marchant and Higgins 1990). Nesting habitat in natural freshwater wetlands and floodwaters has been destroyed or modified by drainage, clearing, grazing, burning, increased salinity, groundwater extraction and flood mitigation schemes (Marchant and Higgins 1990). *Breeding sites in tall, riparian emergent vegetation and woody edges and freshwater wetlands are under threat through climate change. Reproductive success potentially affected by food availability/ foraging distance. Species should be considered at high risk.*	**H**	**H**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? <u>Colonial breeder in Channel country. Lack of understanding of breeding and migratory behaviour (P. Wainwright 2010, pers. Comm.).</u>	Some populations have been recorded as regularly moving north-south across Australia according to seasonal shifts but other populations are considered sedentary and hardly move at all (Marchant and Higgins 1990). IBRA sub-regionally listed as endangered and in probable decline in Murray Mallee and Murray Scroll Belt and rare in the South Olary Plain (Gillam and Urban 2010). *While large scale migrations and colonial breeding are recorded that would strengthen the gene pool through mixing, confidence is limited as studies are lacking. Thought to breed colonially in Channel country within study area. Current distribution and abundance in SA MDB appears patchy and fragmented and regional ratings reflect this pattern but this may be influenced by the cryptic nature of the species. Species should be considered at low risk but with medium confidence.*	**M**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? <u>Colonial breeder in Channel country. Lack of understanding of breeding and migratory behaviour (P. Wainwright 2010, pers. Comm.).</u>	Some evidence of north-south seasonal movements and dispersal though scale not described and generally poorly understood (Ecological Associates 2010) *While large scale migrations and colonial breeding are recorded that would strengthen the gene pool through mixing, confidence is limited as studies are lacking. Widely distributed records across SA MDB floodplain with very low abundance implies highly fragmented populations potentially limiting gene flow between populations but may be artifact of sampling regime or cryptic nature of species. Species should be considered at low risk but with reduced confidence.*	**M**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic, 6 subspecies identified differing mainly in colour of underparts but also some size differences. Subspecies shared with Micronesia and NZ, intermediates also recorded. Some evidence for interbreeding with *N. nycticorax* (Marchant and Higgins 1990). *Species shows high capacity of subspeciation and geographic variation, driving mechanisms behind differences unclear so difficult to determine whether is advantage but is unlikely to be detrimental. Species should be considered at low risk.*	**H**	**L**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change? Colonial breeder in Channel country. Lack of understanding of breeding and migratory behaviour (P. Wainwright 2010, pers. Comm.).	Distributed throughout Micronesia, Philippines, north Borneo and Java to New Caledonia, Australia and New Zealand. In Australia, widespread in northern, eastern and south western Australia (SAAB 2001). Trend is rare or not recorded in Coorong and Lower Lakes (Ecological Associates 2010). BDBSA records indicate wide distribution but very low abundance, 45 records since 1990 within floodplain, 6 records in Lower Lakes, 23 in Murray Mallee and 16 in Murray Scroll Belt (BDBSA 2010). Listed as 'vulnerable' in DENR Murraylands and 'endangered' in in Murray Mallee and Murray Scroll Belt and in probale decline and rare in the South Olary Plain (Gillam and Urban 2010). *Sub-regionally listed as endangered or rare within study area and very few recent records within study area. Lack of understanding of migratory and breeding behaviour also limits interpretation of what is the effective population size but potentially includes birds from around Australia. Conservatively the species should be considered at high risk but with moderate confidence due to knowledge gaps on migratory behaviour and effective population sizes.*	**M**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change? Will re-nest if disturbed or eggs are predated on (P. Wainwright 2010, pers. Comm.).	No quantified data, authors report moderate clutch sizes of 2-5 eggs and one report of one pair having one brood in winter and one in summer (Marchant and Higgins 1990). *Good clutch sizes but probably only one brood per season however details poorly known. May re-nest upon egg failure or predation. Limited capacity compared to multiple brooding species. Species should conservatively be considered at high risk but with low confidence.*	**L**	**H**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? Recruits well, good clutch size and moderate length of parental care. Will also re-nest if disturbed or eggs are predated on. Frequency of flooding events (lack of) will limit recruitment. Species dependent on permanent water bodies will be less affected through recruitment (P. Wainwright 2010, pers. Comm.).	Recruitment success rates are not known, heat waves thought to cause nestling mortalities and deformities. Breeding season broadly in spring and summer, but nests recorded from August to June and timing probably much influenced by rainfall, flooding and water conditions. Inland prefer permanent water bodies on floodplains especially those with woody edges and swamps with tall emergent vegetation. Nesting habitat in natural freshwater wetlands and floodwaters has been destroyed or modified by drainage, clearing, grazing, burning, increased salinity, groundwater extraction and flood mitigation schemes (Marchant and Higgins 1990). *Thought to recruit well (reasonable success rate) and will re-nest and lay replacement broods if disturbed but infrequency of flood events and loss of nesting sites under climate change potentially limits recruitment. Appears to prefer using permanent water bodies and tolerates marine conditions, this is thought to reduce risk under climate change. Reliance on tall riparian vegetation and woodland for nesting and cover however raises threat. Species should be considered at moderate risk but with low confidence as recruitment is poorly studied*	**L**	**M**

Scientific Name:	*Oxyura australis*	Common Name:	Blue Billed Duck

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent do habitat preference limit the ability of the regional population of the species to tolerate climate change?	'Other waterfowl, e.g. musk duck, blue-billed duck, and freckled duck, are restricted to the more permanent types of habitat, and their numbers do not fluctuate greatly from year to year as these habitats are largely invulnerable to failures of river flooding (Braithwaite & Frith 1969)'. Almost wholly aquatic, preferring deep water in large, permanent wetlands, where conditions are stable and aquatic flora abundant (Marchant & Higgins 1990, Frith 1969; Scott 1997); temperate, fresh to saline, terrestrial wetlands, including sewerage ponds, rivers, salt lakes and salt pans (Marchant and Higgins 1990). When breeding, dispersed on deep fresh swamps and lakes, densely vegetated with rushes or sedges providing soft vegetation for nest-building (Marchant and Higgins 1990). Cumbungi choked swamps, provide good habitat for the species (Scott 1997) – some increases in this habitat under reduced flows in the Murray River. Seeds of *Myriophyllum sp*. and *Chara sp.* described to consistently form an important part of the diet of blue-billed ducks (Braithwaite & Frith 1969). 'Size of population depends on retention of permanent deep water lakes (Jaensche et al 1988 [in Marchant & Higgins 1990])'. ***Preferred permanent wetlands dominated by emergent vegetation within the study region are expected to be maintained under climate change conditions though with decline in water quality and productivity. However, deep temporary wetlands providing a productive food source and abundant submerged vegetation, are expected to decrease. Utilises both fresh and saline habitats, but fresh sites appear to support largest concentrations and are selected for breeding. 'Habitat' preference is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Short-distance movements occur between breeding swamps and overwintering lakes with some long distance dispersal in exceptional years. Longest regular movement probably between breeding swamps in w NSW and lakes along Murray River, though numbers involved correlated positively with local rainfall and not all birds participate (Marchant & Higgins 1990). Irruptions inland do occur, probably based on the availability of large expanses of inland water. They have bred in Lake Eyre when water was available (Marchant and Higgins 1990). Their movement is more complete and regular and more like true migration than movements of any other Australian duck (Frith 1982 [in Marchant & Higgins 1990]). ***Though species has capacity for long distance movements, short distance dispersal appears more common and movements more regular than for other ducks, e.g. some limitation to altering dispersal patterns expected . 'Mobility & Dispersal' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	H	M
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	'In such a sociable, demonstrative and competitive species….(Marchant & Higgins 1990)'. Feeds on a range of plant material and benthic invertebrates (Frith et al 1969). 'The hardhead, musk duck, and blue-billed duck are adept at diving to the bottom of deep water, and so have food resources that are not available to the surface-feeding waterfowl (Frith et al 1969)'. ***Species is described as 'competitive' and able to source a wide range of food resources not available to other waterfowl due to its diving ability. 'Competition' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'…numbers of Blue-billed Duck demonstrated no correlation with either season or water levels (Harper 1990)'. 'Occur on saline and freshwater wetlands though largest concentrations and breeding occurs on fresh wetlands (Halse et al 1993 [in SAAB 2001]; Marchant & Higgins 1990)'. Cumbungi choked swamps, provide good habitat for the species (Scott 1997) – some increases in this habitat under reduced flows in the Murray River. ***Species does not require specific water regime (preferring permanent wetlands with abundant emergent vegetation), is a generalist feeder and can inhabit both fresh and saline habitats. 'Survival tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Growth tolerances are not specifically documented, and although it is documented that species occurs on saline wetlands, largest concentrations and breeding is on freshwater wetlands (Goodsell 1990; Marchant & Higgins 1990) an indication that better conditions for juvenile growth, and possibly adult growth may occur in freshwater habitats. ***Not enough information to determine if 'Growth tolerances' would limit the ability of the regional population of the species to tolerate climate change.***	L	M
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Breeds entirely seasonally and is largely unaffected by water level and wetland inundation (Briggs 1990 [in Scott 1997]; Harper 1990). When breeding, dispersed on deep fresh swamps and lakes, densely vegetated with rushes or sedges (e.g. Typha, Eleocharis) providing soft vegetation for nest-building (Marchant and Higgins 1990). Mean salinity of wetlands used by 9 broods in Western Australia was 1.722g/L (Goodsell 1990). In study region recently bred on Lake Littra, a large temporary freshwater wetland following an environmental watering event (Harper pers. Com.). ***Breeding documented as not limited by water regime and aentirely seasonal but species has largely been recorded breeding on temporary wetlands within study region and requires largely freshwater vegetated wetlands to breed, expected to decline with increasing salinity and reduced flood events. 'Reproductive tolerances' are expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	' Extent of occurrence believed stable, area of occupancy thought decreasing, and number of breeding birds, estimated at 12 000, believed to be stable (Garnett and Crowley 2000 [in SAAB 2001])'. Species listed as 'Rare' in SA (NPW 1972). Distribution limited to south-east and south-west Australia, recorded as vagrant elsewhere (Marchant & Higgins 1990). ***Extent of gene pool not documented but national distribution is relatively limited and population is listed as 'Rare' in SA . 'Gene Pool' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	L	H

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Short-distance movements occur between breeding swamps and overwintering lakes with some long distance dispersal in exceptional years. Longest regular movement probably between breeding swamps in w NSW and lakes along Murray River, though numbers involved correlated positively with local rainfall and not all birds participate (Marchant & Higgins 1990). Their movement is more complete and regular and more like true migration than movements of any other Australian duck (Frith 1982 [in Marchant & Higgins 1990]). 'Blue billed ducks have only an ephemeral pair bond during copulation (Marchant & Higgins 1990)'. Range expands and contracts according to rainfall (Marchant & Higgins 1990) – decline in gene flow may occur with reduced rainfall. ***Extent of gene flow within population not documented but is expected to be moderate, with variable distances dispersed by individuals and between years often to regular sites and correlated with rainfall which is expected to decline under climate change. Some increase in gene flow due to lack of monogamous pair bonding within species. 'Gene Flow' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	***Unknown: no information found on the extent that 'phenotypic plasticity' limits the ability of the regional population of the species to tolerate climate change.***	L	M
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Species listed as 'Rare' in SA (NPW 1972). Large numbers of Blue-billed Duck regularly gather in winter-flocks on permanent swamps of Murray River System (Frith 1982; Marchant and Higgins 1990). ' Extent of occurrence believed stable, area of occupancy thought decreasing, and number of breeding birds, estimated at 12 000, believed to be stable (Garnett and Crowley 2000 [in SAAB 2001])'. ***Small population size: 'Population size' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	H	H
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Usually 5 or 6 eggs per clutch (Frith 1982 [in Marchant & Higgins 1990]). Relatively small clutch size and few records of large breeding events but unclear what the capacity for the population to increase under ideal breeding conditions would be.	L	M
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	'Mean survival rate estimated at 3 per clutch. Appears to survive better than dabbling ducks…Water rats *Hydromys chrysogster* apparently do much damage (Marchant & Higgins 1990)'. Sexually mature at 1 year and captive male bred at 16 years (Marchant & Higgins 1990). ***Moderate survival rate of young indicated: 'Recruitment' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M

Scientific Name:	*Phalacrocorax carbo*	Common Name:	Great Cormorant

FAMILY: Phalarcrocoracidae

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	Widespread, in terrestrial wetlands and coastal waters. Occur inland on lakes, reservoirs, swamps, rivers, pools, billabongs. Favours deep permanent lakes, major rivers (Hobbs 1961 as cited in Marchant and Higgins 1990b) or open water in deep marshes (Marchant and Higgins 1990b). Less common on small waterbodies or shallow vegetated waters. Restricted to fresh and brackish wetlands with extensive sedges and live trees and secondary saline wetlands with dead trees, avoids hypersaline and species poor freshwater wetlands (Halse et al. 1993). Birds unaffected by fluctuations in salinity and turbidity, nature of shoreline vegetation unimportant, provided trunks, branches, posts or islands in or by water for perching (Fjeldsa 1985 as cited in SAAB 2001). Along coast, abundant in estuaries and deep coastal lagoons, also occur in saltpans, mangrove swamps, saltfields and on rock platforms and beaches on exposed coasts. Construction of water storages has provided additional foraging and breeding habitat. Estuaries and deep open lakes and lagoons have been less affected by drainage than most other types of wetlands (Marchant and Higgins 1990b). *Flexible salinity tolerances ranging from fresh to saline (but not hypersaline) and also uses artificial impoundments. Fringing vegetation is required but nature is insignificant as long as perches are available. Major threat due to reliance on permanent, deep water bodies required for diving/swimming foraging and fishing activities. While deep water bodies suffer less from drainage, increased pressure on water resources under climate change may mean more extractions for irrigation, higher evaporation and lower recharge and may lead to problems with salinity that could affect food supply. River regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Nomadic with wide dispersal following successful inland breeding. Large scale breeding usually follows flood in south east Australian river systems or of those associated with Lake Eyre (Marchant and Higgins 1990b). This is followed by wide dispersal of juveniles and adults as lakes dry up (van Tets et al. 1976 as cited in Marchant and Higgins 1990b). Most movements occurred along river systems or to wetlands adjacent to the coast from wetlands to the south east and some north east up the Murray Darling (van Tets et al. 1976 as cited in SAAB 2001). *Strong evidence of high mobility and dispersal capacity of species including large scale migrations to breeding areas triggered by flood waters. Species should be considered at low risk.*	**H**	**L**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Very large aquatic bird (wingspan over 1.5m and weighs to 2.5kg) (Marchant and Higgins 1990b) compared to other birds assessed in this study. More aggressive than Little Pied Cormorant. Consumes predominantly fish in most habitats, species taken depend largely on availability and in Australia, carp and goldfish taken in large numbers in because of their abundance. Can feed extensively on introduced fish, particularly common carp and redfin (Marchant and Higgins 1990b) and presumably eradication may be detrimental unless replaced by native prey. Nests colonially, usually associated with other species of cormorants, herons, spoonbills, ibises and occasionally solitarily. Both sexes defend nest sites with threat and nest-worrying displays. Little Ravens and Whistling Kites known to take eggs and chicks. Parents guard young until able to ward off against other adults and predators (Marchant and Higgins 1990b). *As a very large and aggressive bird it has competitive advantages compared to smaller birds and is unlikely to suffer much predation pressure except possibly when young. Colonial nesting also provides competitive advantages. As an apex predator in its habitat, it may suffer some competition for food with other large water birds and fish e.g. Murray Cod but this is not mentioned in the literature and may not be significant. Replacement of native prey items must be considered in the event of large scale pest eradication, climate change may also favour the proliferation of introduced species benefiting bird. Species should be considered at low risk.*	**H**	**L**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Birds unaffected by fluctuations in salinity and turbidity, nature of shoreline vegetation unimportant, provided trunks, branches, posts or islands in or by water for perching (Fjeldsa 1985 as cited in SAAB 2001). Restricted to fresh and brackish wetlands with extensive sedges and live trees and secondary saline wetlands with dead trees, avoids hypersaline and species poor freshwater wetlands (Halse et al. 1993). Consume predominantly fish in most habitats and species taken depends largely on availability. In Australia, carp and goldfish taken in large numbers in because of their abundance (Marchant and Higgins 1990b). Can feed extensively on introduced fish, particularly common carp and redfin (Marchant and Higgins 1990b) and presumably eradication may be detrimental unless replaced by native prey. Also take a large number of crustaceans (including shrimps, freshwater crayfish and also insects in freshwater habitats. Ducklings of black duck *Anas superciliosa* also recorded taken (Barker and Vestjens 1989 as cited in SAAB 2001). *Flexible salinity tolerances ranging from fresh to saline but not hypersaline and uses artificial impoundments. Fringing vegetation is required but nature is insignificant as evidenced by use of dead trees as perches in secondary saline wetlands. Major threat due to reliance on permanent, deep water bodies required for diving/swimming foraging and fishing activities. While deep water bodies suffer less from drainage, increased pressure on water resources under climate change may mean more extractions for irrigation, higher evaporation and lower recharge and may lead to problems with salinity that could affect food supply. River regulation also aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation. Problems with habitat and water quality may also affect food supply and pest eradication may remove critical food sources in some areas unless carefully managed. Species should be considered at moderate risk.*	**H**	**M**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Nests colonially, usually associated with other species of cormorants, herons, spoonbills, ibises and occasionally solitarily. Large scale breeding usually follows flood in south east Australian river systems or of those associated with Lake Eyre. Nest site typically in trees, bushes, reeds or on ground, rocks and man-made platforms and structures in inland lakes, swamps and billabongs but also estuaries and shallow coastal lagoons (Marchant and Higgins 1990b). Birds unaffected by fluctuations in salinity and turbidity, nature of shoreline vegetation unimportant, provided trunks, branches, posts or islands in or by water for perching (Fjeldsa 1985 as cited in SAAB 2001). Restricted to fresh and brackish wetlands with extensive sedges and live trees and secondary saline wetlands with dead trees, avoids hypersaline and species poor freshwater wetlands (Halse et al. 1993). Consume predominantly fish in most habitats and species taken depends largely on availability. Size of prey of young probably smaller consisting of more invertebrates. Breeding probably occurs at any time of year depending on conditions of water, food and shelter, mainly in MDB south of 20°S in Australia. Young are altricial and nidiculous. Nestling food items usually smaller than adult diet consisting mainly of invertebrate but also small fish and insects, seeds and worms. Young leave nest at about 4 weeks and fledge at 7 weeks, parents continue to feed until around 11 weeks (Marchant and Higgins 1990b). *Breeding is opportunistic and timed to coincide with flood peaks and abundance of vegetation and food especially in inland systems. Climate change is expected to affect flood timing and reduce frequency and magnitude of events and may increase risk to opportunistic and successful growth of species in natal areas. Young hatch poorly developed and spend considerable time in vulnerable nestling stage which also increases load on parents (feeding, shading and watering). Nesting and growth of young in fresh to saline environments. Climate change may increase pressure on nestling growth and parental investment through changes to hydrological and temperature regimes, water quality and food availability. Small invertebrate prey of young are susceptible to water and habitat quality degradation. Species should be considered at moderate risk but with medium confidence due to lack of studies of breeding biology and tolerances of juveniles.*	**M**	**M**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Breeding not well studied in Australia and lacks quantifiable data. Breeding probably occurs at any time of year depending on conditions of water, food and shelter, mainly in MDB south of 20°S in Australia. Large scale breeding usually follows flood in south east Australian river systems or of those associated with Lake Eyre. Nest site typically in trees, bushes, reeds or on ground, rocks and man-made platforms and structures in inland lakes, swamps and billabongs but also estuaries and shallow coastal lagoons (Marchant and Higgins 1990b). Birds unaffected by fluctuations in salinity and turbidity, nature of shoreline vegetation unimportant, provided trunks, branches, posts or islands in or by water for perching (Fjeldsa 1985 as cited in SAAB 2001) and this probably applies to breeding territories as well as foraging and roosting habitats. Colonial nester with conspecifics and other birds. High tides recorded destroying nests in Derwent River (Tasmania) (Marchant and Higgins 1990b). Security of nest sites better in trees when can nest at height, generally around 1-3m above water but up to 7m, thought to be limited by height of available trees (Aust. NRS as cited in Marchant and Higgins 1990b). Young are altricial and nidiculous, fed up to 4 weeks after fledging (at 7 weeks) and so may be independent after about 11 weeks (Marchant and Higgins 1990b). *No strict breading season and is dependent on favourable environmental conditions. Opportunistic breeding timed to coincide with flood peaks and presumably abundance of vegetation and food. Climate change is expected to affect flood timing and reduce frequency and magnitude of events and may pose risk. Nature of vegetation for nest sites is unimportant, presence of structure is key e.g. may be in live or dead trees. Salinity and temperature not identified as direct limiting factors for breeding, hydrological regime is probably the major variable. A transition from permanent, freshwater wetlands to more temporary and saline wetlands is expected through increased flow regulation to mitigate effects of climate change and drought with a loss of preferred deep, permanent sites and tall riparian vegetation. Species should be considered at moderate risk but with medium confidence due to lack of specific studies into breeding biology and reliance on family level information.*	**M**	**M**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? Nomadic and mobile over large spatial scales so probably extensive genetic mixing. Probably not limited at population level despite monogamous pair-bonds given relative abundance (P. Wainwright pers. comm. 2011).	Nomadic with wide dispersal following successful inland breeding. Large scale breeding usually follows flood in south east Australian river systems or of those associated with Lake Eyre (Marchant and Higgins 1990b). This is followed by wide dispersal of juveniles and adults as lakes dry up (van Tets et al. 1976 as cited in Marchant and Higgins 1990b). Up to 1000 birds can occur when conditions suitable in Coongie Lakes District (Reid 2000 as cited in SAAB 2001) and up to 500 nests have been recorded in Goyders Lagoon (J. Reid pers. comm. as cited in SAAB 2001). Atlas surveys suggest a low to moderate number in the Murray-Darling Depression bioregion estimated to represent a moderate proportion of the national population (ANRA 2010b). High number of records within study area since 1990 (523), and 3573 records across SA MDB floodplain compared to other birds assessed in this study (BDBSA 2010). Pair bonding is sustained monogamous, bonding can occur toward end of first year but no effective breeding until second year though actual age at first breeding is unknown (Marchant and Higgins 1990b). Listed as 'rare' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions under IUCN criteria (Gillam and Urban 2010). *Widespread distribution and low to moderate abundance indicated in literature and current data. Likely to have a reasonable population base shared throughout SA MDB as is nomadic and mobile with contractions to breeding areas. Colonial breeding and large-scale influxes to breeding areas upon flooding of inland systems increases chance of mixing. Species is probably at low risk in terms of genetic diversity.*	**H**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? Nomadic and mobile over large spatial scales so probably extensive genetic mixing. Probably not limited at population level despite monogamous pair-bonds given relative abundance (P. Wainwright pers. comm. 2011).	Typically breed colonially, nests often densely spaced in association with other species e.g. herons, ibises and spoonbills. Nomadic with wide dispersal following successful inland breeding. Large scale breeding usually follows flood in south east Australian river systems or of those associated with Lake Eyre (Marchant and Higgins 1990b). Up to 1000 birds can occur when conditions suitable in Coongie Lakes District (Reid 2000 as cited in SAAB 2001) and up to 500 nests have been recorded in Goyders Lagoon (J. Reid pers. comm. as cited in SAAB 2001). This is followed by wide dispersal of juveniles and adults as lakes dry up (van Tets et al. 1976 as cited in Marchant and Higgins 1990b). Pair bonding is sustained monogamous, bonding can occur toward end of first year but no effective breeding until end of second year and commonly not until several years old (though actual age at first breeding is unknown) (Marchant and Higgins 1990b). Atlas surveys suggest a low to moderate number in the Murray-Darling Depression bioregion estimated to represent a moderate proportion of the national population (ANRA 2010b). High number of records within SA MDB floodplain since 1990 (2104), mostly from Lower Lakes area and 393 records in study area above Wellington (BDBSA 2010) compared to other birds assessed in this study. Listed as 'rare' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions under IUCN criteria (Gillam and Urban 2010). *Widespread distribution and relatively high abundance indicated in literature and current data. Likely to have a reasonably large population base that would be advantageous but no recent population estimates limits confidence. Colonial breeding and large-scale influxes to breeding areas upon flooding of inland systems increase chance of mixing. Sustained monogamous bonds probably not limiting at population scale due to relative abundance. Species is probably at low risk in terms of gene flow at the regional population scale due to high abundance and distribution of species and formation of large breeding colonies.*	**H**	**L**

	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic and almost completely cosmopolitan species with distribution across Aust., NZ, Europe, Africa and North America. 6 subspecies recognized world-wide by one author but only one subspecies (*novaehollandiae*) occurs in Australasia (Peters as cited in Marchant and Higgins 1990b). Siegel-Causey (1988) as cited in Marchant and Higgins (1990b) recommends treatment of all as one super-species due to superficial morphological similarities but also states that subspecies *novaehollandiae* may represent a single species but gives no details. Widespread in Australia in coastal and permanent inland waters mainly east of line from Adelaide to Darwin and south west W.A., using ephemeral floodwaters elsewhere including deserts (Marchant and Higgins 1990b). No recent population estimates but Atlas surveys suggest a low to moderate number in the Murray-Darling Depression bioregion (ANRA 2010b). High number of records within SA MDB floodplain since 1990 (2104) compared to other birds assessed in this study mostly from Lower Lakes area and high number (393) of records in study area above Wellington (BDBSA 2010). *Although polytypic, only one subspecies identified in Aust. Suggested they may represent a single species as all seem morphologically similar. Widespread distribution and moderate to high abundance indicated throughout study area may reduce threat of genetic limitations. Species should be considered at moderate risk but with low confidence due to lack of genetic profiles of regional populations.*	**L**	**M**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	No recent population estimates. Widespread in Australia in coastal and permanent inland waters mainly east of line from Adelaide to Darwin and south west W.A., using ephemeral floodwaters elsewhere including deserts (Marchant and Higgins 1990b). Up to 1000 birds can occur when conditions suitable in Coongie Lakes District (Reid 2000 as cited in SAAB 2001) and up to 500 nests have been recorded in Goyders Lagoon (J. Reid pers. comm. as cited in SAAB 2001). Atlas surveys suggest a low to moderate number in the Murray-Darling Depression bioregion estimated to represent a moderate proportion of the national population (ANRA 2010b). High number of records within SA MDB floodplain since 1990 (3573), mostly from Lower Lakes area with 523 records in study area above Wellington (BDBSA 2010). Listed as 'rare' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions under IUCN criteria (Gillam and Urban 2010). *Atlas surveys indicating a moderate population in the SA MDB and BDBSA data suggest a higher abundance compared to other birds assessed in this study. 'Rare' regional and sub-regional status listing and declining trend suggests population is already struggling. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Generally 3-5 eggs per clutch and up to 6, average of 4.1 from 30 clutches (Aust. NRS as cited in Marchant and Higgins 1990b). Breeding probably occurs at any time of year depending on conditions of water, food and shelter. May have up to 2 broods per year but replacement clutches are not known (Marchant and Higgins 1990b). *Moderate mean clutch size and able to double-brood means species shows a moderate reproductive capacity compared to other birds assessed in this study. Opportunistic breeding mat be an advantage but relies on favourable conditions that may be detrimentally affected under climate change. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Breeding not well known in Australia lacking detailed studies but probably occurs at any time of year depending on conditions of water, food and shelter (Marchant and Higgins 1990b). Generally 3-5 eggs per clutch and up to 6, average of 4.1 from 30 clutches and may have 2 broods per year but no information on replacement laying (Aust. NRS as cited in Marchant and Higgins 1990b). No recent population estimates but up to 1000 birds can occur when conditions are suitable in Coongie Lakes District (Reid 2000 as cited in SAAB 2001) and up to 500 nests have been recorded in Goyders Lagoon (J. Reid pers. comm. as cited in SAAB 2001). Very large aquatic bird to 2.5kg, may breed at end of second year but many not until several years old (Marchant and Higgins 1990b). Listed as 'rare' and in 'probable decline' in the Murray Scroll Belt and Murray Mallee IBRA sub-regions under IUCN criteria (Gillam and Urban 2010). *Moderate clutch size and double-brooding but replacement clutches are not known. No specific information on triggers for opportunistic breeding but presumably involves water and food availability. Timing and duration of breeding opportunities may be detrimentally affected under climate change. Large bird probably has long generation time and commonly do not breed until relatively old (several years). Species should be considered at high risk but with medium confidence due to lack of data on opportunistic breeding tolerances.*	**M**	**H**

Scientific Name:	*Phalacrocorax sulcirostris*	Common Name:	Little Black Cormorant

FAMILY: Phalarcrocoracidae

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change?	Construction of reservoirs and farm dams has provided additional foraging and breeding habitat. Deep open waters and estuaries which are favoured by Little Black Cormorants are less affected by drainage than most other types of wetlands. Some breeding swamps and lakes are threatened by increased salinity and various detrimental land management practices (Marchant and Higgins 1990b). Consume 'mostly fish particularly smelt, carp and perch with smaller numbers of freshwater crayfish and other crustaceans' (Marchant & Higgins 1990b). Feed extensively on introduced fish, particularly common carp and redfin. Extensive eradiaction may be detrimental (Miller 1979), particularly if native fish populations do not replace eradicated fish (SAAB 2001). Widespread in many types of waterbodies in Australia. On the Australian mainland most common on inland waters, feeding mainly in open water > 1 m deep (Miller 1979; Dostine and Morton 1988). Occur on large lakes with abundant carp and redfin sheltering in deep submerged beds of ribbonweed, also rivers, billabongs and pools with flooded or fringing trees, in deep dams and channels, and in permanent and semi-permanent swamps with open water (Marchant and Higgins 1990 as cited in SAAB 2001)'. Breed in vegetated swamps and lakes, mainly freshwater, and favour flooded trees well away from land in remote parts of large wetlands. High in stems or forks of trees over water, sometimes up to 30 m above water in the deeper parts of swamps (Marchant and Higgins 1990b). In Australia, widespread in coastal and inland waters, including ephemeral waters in desert regions (Marchant and Higgins 1990b). A NSW study found numbers of little black cormorant were related to Murray River discharge, an index of inland wetland availability (Gosper et al 1983). 'The dispersal of cormorants is very much dependent upon the presence of aquatic habitat, since they feed solely by swimming underwater to catch their food. They also require suitable perches where they can dry themselves after prolonged periods of fishing, and where they can safely roost at night (Llewelyn 1983)'. *Species shows reasonably flexible habitat requirements and can make use of artificial systems and prey on introduced pest species that may be favoured by climate change. Seem to prefer large, deep, permanent wetlands that will be less affected by changes to water regimes but salinity may threaten breeding in some areas. Require fringing or emergent tall vegetation e.g. trees, for breeding and refuge. These habitats are threatened under climate change through salinity and changes to flow and water availability. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change	Dispersive in Australia, with large numbers of birds dispersing from inland waterbodies after drought following wet periods (Marchant and Higgins 1990b). 'The mean straight-line distance travelled from the natal colony to the recovery site increases for the first 5 months after banding (Fig. 9), being 110 km at 2 months, 175 km at 3 months and peaking at 290 km at 5 months (Llewelyn 1983)'. 'This study also shows that great cormorants disperse further and more often than little pied and little black cormorants…The dispersal of little black cormorants from the South Australian colonies was not as marked as that of great cormorants, and most stayed close to the coast...The apparently lesser need and capacity for dispersal (distance moved and rate of movement) in the little black and little pied cormorants as compared with great cormorants, would reduce the chance of large local increases in numbers (Llewelyn 1983)'. *A reasonably dispersive species with long distance movements from an early age and known to*	**H**	**L**

		move in response to water availability. Not as mobile as Great Cormorant. Species should be considered at low risk.		
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Medium to large size aquatic bird to around 1200g, highly gregarious and nest colonially often densely spaced and associated with other species e.g. herons, ibises and spoonbills. Defend small nest territories with threat and nest-worrying displays, appears more aggressive than Little Pied Cormorant (Marchant and Higgins 1990b). Little Black Cormorants feed extensively on introduced fish, particularly common carp and redfin, and extensive campaigns to eradicate fish may be detrimental, particularly if native fish populations do not replace eradicated fish (SAAB 2001). Cooperative feeding flocks surround schools of fish in open water but only when food is abundant and enough birds congregate (Marchant and Higgins 1990b). 'Van Tets et al. (1976) examined the dispersion of the five species of Australian cormorants in South Australia and suggested differences in size helped to reduce interspecific competition for food, but where sizes are similar, as with the great and pied cormorants, the former avoided competition by dispersing inland (Llewelyn 1983)'. *Competition unlikely to factor in species ability to cope with climate change. Known to feed extensively on introduced fish e.g. carp, redfin that are expected to remain or increase in abundance under climate change through competitive advantages compared to native fish. Reduced interspecific competition (other cormorants) through different prey selection (size related). A medium to large bird and probably competes well against other water birds. Species should be considered at low risk.*	**H**	**L**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	In arid south-western Queensland between 1987-1989, the mean abundance of Little Black Cormorants was significantly more on the fresh Lake Numalla (max. 310 birds, mean conductivity at August 1989 was 2239.5 microS/cm), than on the adjacent (3 km apart) saline Lake Wyara (max. 14 birds, mean conductivity at August 1989 was 37210 microS/cm), this could be related to food availability e.g. shrimp (Kingsford and Porter 1994). Little Black Cormorants feed extensively on introduced fish, particularly common carp and redfin, and extensive campaigns to eradicate fish may be detrimental (Miller 1979), particularly if native fish populations do not replace eradicated fish (SAAB 2001). *Survival of species not likely to be affected by food availability under climate change due to broad diet including pest species. Can use either fresh or saline wetlands for feeding (recorded extensively in both) but require emergent vegetation near or in water for refuge and may be at risk of degradation under climate change. Species should be considered at low risk.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	No specific information on parental care, growth of young or fledging and breeding is generally poorly studied. Parental care thought same as in Great Cormorant, shading and watering of young by adults in hot weather. Both parents are thought to incubate and tend young until a few weeks after fledging (fledging period unknown). Birds in this family have a nestling period around 70 days (more commonly 48-53 days) and (Marchant and Higgins 1990b). Recorded preference to feeding in saline waters (Kingsford and Porter 1994) and also use coastal and marine systems but prefer fresh environments particularly for breeding (Marchant and Higgins 1990b) possibly due to reliance on freshwater vegetation for nesting. Seem to be able to delay or adjust breeding to coincide with climax of vegetation e.g. ribbon weed, and food availability in swamps that dry and re-fill (Marchant and Higgins 1990b). *Some parental care suggested, timing of breeding coinciding with food and habitat availability increases chance of young having adequate resources for growth. Species known to use fresh to saline wetlands for feeding although require freshwater systems for breeding probably die to provision of suitable nesting and roosting sites and refuge for young. Climate change threatens to alter flow regimes and flood magnitude and frequency and could affect habitat availability (feeding and shelter) particularly in early life stages of species living in freshwater systems. Species*	**M**	**M**

		should be considered at moderate risk.		
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Lacking detailed studies and generally poorly known. Breeding season not clearly known but thought to occur mainly in spring-summer in southern Australia but also continuously or at any time of year depending on favourable conditions (Marchant and Higgins 1990b). At Booligal in NSW, breeds in swamps with climax vegetation of ribbon weed and abundant fish, and when swamps dry and then refill, breeding is inhibited until the flooding climax is reached (Crome 1988). Lowering of water-levels in breeding places may lead to breeding failure, as in Little Pied Cormorants (Miller 1979). Wetlands in the southern Murray-Darling Basin should be flooded in winter/spring to allow breeding of Pelacaniformes such as Cormorants (Briggs and Thornton 1999). Deeper open areas associated with River Red Gum wetlands which are managed for Cormorants and other Pelecaniformes should not necessarily dry out between floods. For Cormorants to initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least 5 and up to 10 months following flooding (Briggs and Thornton 1999). Nests almost always on freshwaters (Marchant and Higgins 1990b) except some instances, e.g. Pt. Pirie where nests in mangroves (G. F. van Tets as cited in Marchant and Higgins 1990b). 'Examination of flood regimes in inland south-east Australia showed that natural flooding was an important factor in initiating breeding of cormorants, as were small localized artificial floods (Llewelyn 1983)'. 'The relatively short-term flooding followed by a drop in water level is essential, so that the flooding stimulus can be repeated, river red gums can survive, and birds can continue to use these trees for nesting (Llewelyn 1983)'. *Availability of freshwater wetlands that are either permanent or seasonally flooded is critical for breeding success. Species breeding triggered by large natural flood events but also through small artificial flows. While species appears to be able to adjust timing of breeding, managed and/or reduced flows under climate change may affect success. Wetland and flow management needs to consider breeding requirements of species particularly in light of climate change. Climate change threatens to alter natural flow and salinity regimes and poses major risk to suitability of freshwater sites and associated vegetation. Species should be considered at high risk.*	**M**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Population size in Australia, SA and regionally is not documented. Widespread and dispersive in coastal and inland waters in Australia including ephemeral waters in desert regions. Breeding is poorly known, generally thought to occasionally breed solitarily but more commonly in medium to large mixed colonies with other cormorants, herons and spoonbills. Species possibly features sustained monogamous pairs and display some philopatry and formation of discrete breeding flocks. Colonies range in size from small to large consisting of between 5-1000 nests (Marchant and Higgins 1990b). Significant breeding occurs in far north-east of SA, with a minimum of 500 nests recorded in Coongie Lakes District in the summer of 1990/1991 (Reid 2000) and up to 3000 nests near Koonchera waterhole in April 2000 and 2001, and close to 1000 nests in Goyders Lagoon in 2001 (J. Reid, unpublished data) [in SAAB 2001]). *Gene pool is likely to be diverse in larger regional populations particularly when large breeding colonies form. Specific information on population sizes is lacking reducing confidence in assessment. Sustained monogamous breeding may restrict gene pool although this is not quantified e.g. by banding studies. Majority of studies describe colonial breeding with large flocks of birds implying a good population base and high potential for gene mixing. Species should be considered at low risk but with low confidence due lack of genetic studies and conclusive banding study results to confirm nature and extent of pair bonding.*	**M**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Possibly sustained monogamous pairs (Marchant & Higgins 1990)'. In Australia widespread in coastal and inland waters, including ephemeral waters in desert regions (Marchant and Higgins 1990b). In SA widespread except desert areas North and SW of Lake Eyre (Marchant and Higgins 1990b). Dispersive in Australia, with large numbers of birds dispersing from inland waterbodies after drought	**M**	**L**

		following wet periods (Marchant and Higgins 1990b). Breeding colonies range in size from small to large consisting of between 5-1000 nests (Marchant and Higgins 1990b). Significant breeding occurs in far north-east of state, with a minimum of 500 nests recorded in Coongie Lakes District in the summer of 1990/1991 (Reid 2000) and up to 3000 nests near Koonchera waterhole in April 2000 and 2001, and close to 1000 nests in Goyders Lagoon in 2001 (J. Reid, unpublished data as cited in SAAB 2001). *Gene flow is likely to be high in regional populations particularly when large breeding colonies form. Specific information on population sizes is lacking reducing confidence in assessment. Sustained monogamous breeding may restrict gene flow across populations although this is not quantified e.g. by banding studies. Majority of studies describe colonial breeding with large flocks of birds implying a good population base and high potential for gene flow. Species should be considered at low risk but with low confidence due lack of genetic studies and conclusive banding study results to confirm nature and extent of pair bonding.*		
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic, no geographic variation is known (Marchant and Higgins 1990b). Miller (1976) showed that increase in food availability, water level and temperature induced an increase in gonadal activity in little pied cormorants and little black cormorants in inland NSW. Adequate nesting sites were also necessary for gonads to mature fully and for egg-laying. Keast and Marshall (1954-55) suggested that desert birds were physiologically adapted in such a way that their sexual cycles could respond quickly to environmental cues such as rainfall or its effects; cormorants respond rapidly to increasing water level (Llewelyn 1983). *Species shows some capacity for adjustment of sexual cycles around environmental cues but is unclear whether this is a physiological adaptation or an example of phenotypic plasticity manifested in inland populations specifically. No geographic variation is recorded for species and is considered monotypic. A lack of specific genetic profiles of regional populations limits confidence in assessment. Species should be considered at moderate risk but with low confidence.*	**L**	**M**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Widespread in Australia in coastal and inland waters, including ephemeral waters in desert regions (Marchant and Higgins 1990b). 'In NSW nesting colonies of little black cormorants are not as common as those of little pied cormorants and great cormorants, so that numbers of this species in this State are smaller. Furthermore, these numbers seem to be little influenced by the large breeding colonies and aggregations of birds in the lower Murray… Local breeding as a result of favourable environmental conditions is the only factor likely to affect their numbers (Llewelyn 1983)'. Significant breeding occurs in far north-east of SA, with a minimum of 500 nests recorded in Coongie Lakes District in the summer of 1990/1991 (Reid 2000) and up to 3000 nests near Koonchera waterhole in April 2000 and 2001, and close to 1000 nests in Goyders Lagoon in 2001 (J. Reid, unpublished data) [in SAAB 2001]). High number of records within SA MDB floodplain since 1990 (1310) and in study area above Wellington (411) (BDBSA 2010) compared to other birds in this study. Listed as 'near threatened' in DENR Murraylands and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Reportedly a widespread species across Australia with large colonies recorded breeding in north of SA. Unclear as to whether these colonies are analogous to regional populations in the study area but likely due to dispersive nature of species. Generally referred to in literature as reasonably common but not as abundant as Great Cormorant and 'near threatened' status in IBRA subregions. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	No quantified data on clutch size but studies suggest 3-6 eggs. No information on multiple or replacement broods and breeding season is not strictly defined. Breeding thought to occur mainly in spring-summer in southern Australia but also continuously or at any time of year depending on favourable conditions (Marchant and Higgins 1990b).	**M**	**L**

		Poorly studied, data deficient area of species life history that reduces confidence in assessment. Moderate to high estimated clutch size compared to other birds assessed in this study. Indication of opportunistic breeding when conditions are favourable could reduce risk to species but only if flows and flooding is managed appropriately. Species should be considered at low risk but with low confidence due to lack of studies.		
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Significant breeding occurs in far north-east of state, with a minimum of 500 nests recorded in Coongie Lakes District in the summer of 1990/1991 (Reid 2000) and up to 3000 nests near Koonchera waterhole in April 2000 and 2001, and close to 1000 nests in Goyders Lagoon in 2001 (J. Reid, unpublished data) [in SAAB 2001]). No specific information on multiple or replacement broods but birds in this family will replace lost eggs although not known as multiple brooding. Breeding season is not strictly defined but thought to occur mainly in spring-summer in southern Australia but also continuously or at any time of year if conditions are favourable. Age at first breeding and success rates are not documented however adult plumage attained by end of first year (Marchant and Higgins 1990b). High number of records within SA MDB floodplain since 1990 (1310) and in study area above Wellington (411) (BDBSA 2010) compared to other birds in this study. Listed as 'near threatened' in DENR Murraylands and IBRA sub-regions throughout study area under IUCN criteria (Gillam and Urban 2010). *Species is probably a good breeder as it is recorded in large numbers in mixed colonies where mortalities are reduced through territorial nest protection and reduction of predation pressure (colonial breeding advantage). Indication of opportunistic or continuous breeding in favourable conditions would benefit recruitment and species likely reaches breeding maturity by end of first year. Species should be considered at low risk but with medium confidence due to lack of quantifiable evidence and specific studies into recruitment success.*	**M**	**L**

Scientific Name:	*Platalea flavipes*	**Common Name:**	Yellow-billed Spoonbill

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>Needs water deep enough to sift in like great egret i.e. deep, pool level permanent wetlands. Prefers fresh or brackish wetlands, avoids saline environments. Less adaptable than egret. Transition from permanent to temporary wetlands under increased management of climate change must be careful, vegetation monitoring diagnostic of water and habitat quality for prey (P. Wainwright 2010, pers. Comm.).</u>	Ranges throughout mainland on suitable waterways (Slater et al 2001). Mainly inland at fresh or brackish wetlands with sparse or low vegetation. Prefer shallow swamps with abundant aquatic flora, pools, watercourses, billabongs, also on pastures flooded by rain or irrigation, shallow parts of lakes or deeper swamps, either in open water or among emergent vegetation. Rarely found on coasts or in estuaries. Structure of bill limits feeding to depths of <0.4m over soft substrates of mud, sand or clay (Marchant and Higgins 1990). *Moderate range of suitable habitats but seemingly avoid saline environments and prefers fresh and brackish systems with low or sparse aquatic vegetation. Requires shallow water over soft substrates but deep enough to sift for food. River regulation to mitigate climate change is expected to create more temporary wetlands and maintain less deep permanent systems (efficiency gains through less evaporation). Flow reductions may also increase available habitats through silting but only if water quality is maintained within tolerance. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change? <u>Area of uncertainty, not known if current residents will become nomadic if habitat becomes unsuitable (P. Wainwright 2010, pers. Comm.).</u>	Little known. Probably no regular seasonal movement in southern Australia (Ecological Associates 2010). Endemic to Australia, suggestion of regular movements from breeding sites in Qld but this pattern does not transfer to other regions e.g. Vic and WA where they may be sedentary. Wide foraging range reported up to 500m from nesting sites (Marchant and Higgins 1990). *Some indication of species ability to relocate should conditions become unfavourable but not supported by quantitative evidence. Foraging widely improves chances of species but scale is still small. Indication that some populations are sedentary. As little information exists, this species should be treated conservatively and be considered moderately at risk with low confidence.*	**L**	**M**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Colonially breeding species are less a risk as protection offered by numbers in colony (reduced probability of predation) (P. Wainwright 2010, pers. Comm.).</u>	Moderately varied diet consisting mainly of aquatic insects with smaller numbers fresh water crustaceans and fish. Breeding sites are varied and species is colonial breeder often with herons, egrets, ibises and other spoonbills. Some nestling losses attributed to attacks by crows and Whistling Kites in studies from northern Australia (Marchant and Higgins 1990). *Some limited diet switching possible in reaction to competition but less adaptable than other large waders e.g. egret, that are able to utilize saline habitats. While breeding sites are variable, colonial breeding and site fidelity could lead to inter/intra specific competition for space and resources. Colonies however are more protected from predation and attacks from aggressive species e.g. crows. Species should be considered moderately at risk.*	**M**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Needs water deep enough to sift in like great egret i.e. deep, pool level permanent wetlands. Prefers fresh or brackish wetlands, avoids saline environments. Less adaptable than egret. Transition from permanent to temporary wetlands under increased management of climate change must be careful, vegetation monitoring diagnostic of water and habitat quality for prey (P. Wainwright 2010, pers. Comm.).</u>	Can only tolerate minor increases in salinity in foraging sites. Consumes mainly aquatic insects, particularly backswimmers, with small numbers of fresh water crayfish, fresh water shrimp and fish (Ecological Associates 2010). *Reasonably narrow diet of small aquatic prey and intolerance of slight salinity increases in foraging sites probably due to lack of specific prey items through unsuitable water quality. Requires water deep enough to sift for food in and can only tolerate minor salinity increases implying reliance on permanent freshwater wetlands and deeper pools. River regulation to mitigate climate change is expected to create more temporary saline wetlands and less permanent systems (efficiency gains through less evaporation). These management efforts may affect availability of suitable habitats. Species should be considered at moderate risk.*	**H**	**M**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? Young are less dependent for a shorter period of time e.g. compared to ibis or egret, this is an advantage for the species as less parental investment and young are vulnerable for less time (P. Wainwright 2010, pers. Comm.).	Young fed regurgitate by both parents, fledging at around 5 weeks but continue to be fed for several weeks. Can only tolerate minor increases in salinity in foraging sites and consumes mainly aquatic insects, crustaceans and fish. Nest mortalities attributed mainly to starvation but limited studies (Marchant and Higgins 1990). For spoonbills to initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least 5 and up to 10 months following flooding (Briggs and Thornton 1999). At Bool Lagoon in south-east South Australia between July 1983 and June 1987, numbers of Yellow-billed Spoonbills were negatively correlated with water levels. This was mainly due to a response to habitat availability, with numbers increasing in response to the availability of shallow water habitat (Harper 1990). *Reasonably narrow diet of small aquatic prey and intolerant of salinity increases in foraging sites. Relatively short time to independence means young are less vulnerable earlier in life and parental investment is reduced. Reliance on significant flood events and duration of flood water for successful fledging of young raises risk considerably as the frequency and magnitude of such events is expected to decrease under climate change. This species should be considered at high risk.*	**H**	**H**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? Young are less dependent for a shorter period of time e.g. compared to ibis or egret, this is an advantage for the species as less parental investment and young are vulnerable for less time (P. Wainwright 2010, pers. Comm.).	Yellow-billed Spoonbills favour breeding sites that have not dried out completely before reflooding. Breeding is mainly in southern part of range usually inland at freshwater wetlands vegetated with trees, lignum or reeds in which nests are built (Ecological Associates 2010). River red gums, Casuarina and Melaleuca woodland are used as nesting sites and site fidelity (revisiting) is a feature (Marchant and Higgins 1990). Particularly responsive to large floods on our rivers, only breed when certain thresholds of overbank flows are exceeded, over last 50 years frequency and extent of such flows and breeding events have declined considerably in the MDB (Olsen and Weston 2004). For spoonbills to initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least 5 and up to 10 months following flooding (Briggs and Thornton 1999). At Bool Lagoon in south-east South Australia between July 1983 and June 1987, numbers of Yellow-billed Spoonbills were negatively correlated with water levels. This was mainly due to a response to habitat availability, with numbers increasing in response to the availability of shallow water habitat (Harper 1990). *Relatively short time to independence means young are less vulnerable earlier in life and parental investment is reduced. Reliance on significant flood events and duration of flood water for successful fledging of young raises risk considerably as the frequency and magnitude of such events is expected to decrease under climate change. Degradation of riparian woodland nesting habitats is likely through increased drought and salinisation brought about through climate change. Species should be considered at high risk*	**H**	**H**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	No specific studies. Likely to be mainly sedentary in southern Australia (Ecological Associates 2010). Thought to be in decline and listed as a species of concern in Atlas of Australian Birds (Olsen and Weston 2004). Moderate number of widely distributed records within SA MDB floodplain since 1990 (666) suggests low abundance and patchy distribution throughout the SA MDB (BDBSA 2010). IBRA sub-regionally listed as endangered and in probable decline in Murray Mallee and Murray Scroll Belt and rare and in probable decline in the South Olary Plain (Gillam and Urban 2010). *Some conservative measures are appropriate for this species given the number of reports listing it as being of conservation concern. If the SA MDB populations are sedentary then their patchy abundance and distribution means effective regional population sizes and available genetic pool may be limiting. Species should be considered at high risk with medium confidence as species mobility is an area of uncertainty affecting size of effective populations.*	**M**	**H**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	No specific studies. Eurasian Spoonbill studies suggest gene flow between regional populations through banding studies that recorded individuals breeding in different colonies around Europe (De le Court and Aguilera 1997). Regional populations thought sedentary in southern Australia (Ecological Associates 2010). IBRA sub-regionally listed as endangered and in probable decline in Murray Mallee and Murray Scroll Belt and rare and in probable decline in the South Olary Plain (Gillam and Urban 2010). *Given that populations in SA are likely to be sedentary unlike the Eurasian species, gene flow is likely to be restricted particularly if current records represent realistic abundance and distribution. The species should be treated conservatively and be considered at high risk with medium confidence as species mobility is an area of uncertainty*	**M**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	No subspecies or geographic variations recorded. No specific studies on phylogenetics. Regional populations thought sedentary in southern Australia (Ecological Associates 2010). Moderate number of widely distributed records within SA MDB floodplain since 1990 (666) suggests low abundance and patchy distribution throughout the SA MDB (BDBSA 2010). *No records of variations in morphology or other traits in literature however studies are lacking. Patchy distribution of BDBSA records combined with sedentary nature in southern Australia suggests some geographic isolation but fact that no geographic variation is observed indicates species does not possess capacity for evolution of different phenotypes. Species should be considered at high risk but with medium confidence due to lack of specific information*	**M**	**H**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Endemic to Australia and vagrant to NZ, population statistics are patchy and variable since the 1960s (Marchant and Higgins 1990). Trend is recently increasing in Lake Albert, still uncommon in the Murray Estuary, rare in the Coorong and stable in Lake Alexandrina in 2004. Regional populations thought sedentary in southern Australia (Ecological Associates 2010). Still common but appear to be in decline over recent years, identified as a species of concern in Atlas of Australian Birds (Olsen and Weston 2004). Moderate number of widely distributed records within SA MDB floodplain since 1990 (666) suggests low abundance and patchy distribution throughout the SA MDB (BDBSA 2010). IBRA sub-regionally listed as endangered and in probable decline in Murray Mallee and Murray Scroll Belt and rare and in probable decline in the South Olary Plain (Gillam and Urban 2010). *Abundance in SA appears to be moderate compared to other species assessed in this study according to BDBSA records but may be confounded by survey effort and method (e.g. peak in 2004/5 surveys immediately followed by very few records in subsequent years). Most reports including IBRA sub-regional work, list it as species of concern due to noted declines and if the SA MDB populations are sedentary then their patchy abundance and distribution means effective regional population sizes may be highly limiting. Species should be considered at high risk but with medium confidence as species mobility is an area of uncertainty.*	**M**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Clutch sizes are small and average around 3 eggs in previous studies, no information on number of broods per year or capacity for replacement broods (Marchant and Higgins 1990). *This species lacks the ability to produce large clutch sizes and specific information on brooding is lacking. Reproductive capacity likely to be limiting based on clutch size and the species should be considered at high risk but with low confidence.*	**L**	**H**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Breeding season not well known, usual breeding season probably Oct to Apr (Ecological Associates 2010), may be from Jul-Nov in southern Australia (Marchant and Higgins 1990). Success rates of fledglings is documented at between 0.75 and 1.37 chicks raised per breeding pair, losses attributed mainly to starvation but nest falls and attacks from crows and Whistling Kites are also blamed (Marchant and Higgins 1990). For Spoonbills to initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least 5and up to 10 months following flooding (Briggs and Thornton 1999). Longevity and age at sexual maturity are unknown. *Small clutch sizes and fledgling success rates below 50% means recruitment capacity is potentially highly limited. Flood timing, duration and magnitude is expected to reduce under climate change putting further pressure on the species to recruit successfully. Generation time is not known but likely to be medium to long given size of bird but this limits confidence. Species should be considered at high risk with medium confidence.*	**M**	**H**

Scientific Name:	*Platycercus elegans flaveolus (NC)*	Common Name:	Yellow Rosella

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>Salinisation presents biggest risk to health of River Red Gums along Murray River corridor (P. Wainwright pers. comm. 2011).</u>	Mostly restricted to riparian or littoral River Red Gum woodland, occasionally in other Eucalypt species and Casuarina mallee shrubland where populations have probably been displaced by death of nearby Red Gums. Prefer Eucalypt hollows for nesting in forested areas, will occupy nest boxes in pines but not in open areas (Higgins 1999). Habitat alteration is the main threat to all parrots in continental Australia (Snyder et al 2000). Uses gallery forest with *Eucalyptus camaldulensis* groves along banks of Darling, Murrumbidgee and Lachlan Rivers as well as tributaries; also seen foraging in adjoining farmland and in Mallee vegetation (Lexicon of Parrots 2010). *Relatively narrow habitat requirements particularly for nesting relying on certain species of native trees and shrubs and reasonable proximity to water source or riparian zone but is not a water bird. These woodland riparian habitats are under severe threat of degradation and loss under climate change mainly associated with salinisation of soil and water bodies but can use mallee and other Eucalypt forest. Does not actively forage or breed in water like the waders and will disperse away from riparian areas when not breeding. Species should be considered at low risk in terms of habitat limitations.*	**H**	**L**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change? <u>Rosellas are able to move 10km's and are fast flyers so mobility is probably not limiting (P. Wainwright pers. comm. 2011).</u>	All subspecies of Crimson Rosella are considered either sedentary or resident however some populations considered nomadic and occasional/seasonal visitors in some areas of Australia. Seasonal patterns may reflect seasonal use of different habitats. When not breeding, Yellow Rosella moves from Eucalyptus woodland to surrounding lands, wide dispersal of young in some populations e.g. ACT (Higgins 1999). *Sedentary and residential patterns of some populations may be broken by deterioration of habitat but species shows capacity to relocate and does disperse widely. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Varied diet consisting of range of seeds, grasses, weeds, also fruit, nuts, flowers, nectar and some insects and their larvae. Will feed alongside other Rosellas and parrots. Agonistic interactions ritual of early breeding season. Will defend nest holes by displacing intruders, pairs will also defend small territories around nest. May compete for hollows with other taxa including Galahs, Kookaburras, Starlings, Mynas (aggressive native Noisy Mynas and introduced Indian Mynas), possums, gliders and feral bees (Higgins 1999). *Broad diet means unlikely food limitation through competition and no noted predation pressure. Competition for nest hollows likely to increase through further loss of suitable habitat and increased competition with other taxa including exotic species e.g. feral bees and Indian mynas, which often have competitive advantages in limiting environments but will defend territories. Species should be considered at moderate risk.*	**H**	**M**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Varied diet consisting of range of seeds, grasses, weeds, also fruit, nuts, flowers, nectar and some insects and their larvae. Roosting in tall trees and dense foliage required to avoid heat when loafing in middle of day in summer closely linked to riparian woodlands dominated by river red gums (Higgins 1999). Uses gallery forest with *Eucalyptus camaldulensis* groves along banks of Darling, Murrumbidgee and Lachlan Rivers as well as tributaries; also seen foraging in adjoining farmland and in Mallee vegetation (Lexicon of Parrots 2010). *Does not rely exclusively on water bodies to glean food and can use adjoining lands near riparian areas to forage. Food limitation unlikely due to generalist diet. Increased habitat fragmentation, degradation and loss of riparian woodlands is expected under climate change but may be offset by use of other habitats eg mallee shrubland. Species should be considered at low risk.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Nestlings fed by regurgitation often at first tapering off as chick gets older, fledging around 33 days and continuing to be fed for up to 4 weeks, independent sub-adults then form post-breeding flocks (Higgins 1999). *Moderate length of time to independence of young compared to other species assessed in this study. This raises threat to species as parental investment is high and young are more vulnerable for longer. Habitat fragmentation may force parents to travel further for foraging sites and this may affect the growth of very young birds that need to be fed at short intervals. Species should be considered at moderate risk.*	**H**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	All subspecies of *P. elegans* are solitary breeders and nest in natural hollows in large trees (commonly Eucalyptus but also in Lilly Pilly). Will also use artificial nest holes e.g. nest boxes, fence posts, holes in brick walls, under roofs and in chimneys. Availability of suitable nesting sites, particularly previously used hollows (shown to host larger clutch sizes), and frequency and magnitude of rainfall or flooding events seem to most affect reproduction in the species (Higgins 1999). *Birds that do not build nests but rely on provision of nest holes are more at risk. Nesting habitat degradation (tall woodland forests), increased competition for nesting holes especially with feral animals (e.g. bees) provide risks. Degradation of riparian breeding habitats may affect reproductive success. Hydrological regimes affect breeding and this may be altered under climate change. Species should be considered at moderate risk.*	**H**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	All subspecies of Crimson Rosella are considered either sedentary or resident however some populations considered nomadic and occasional/seasonal visitors in some areas of Australia. Very few records (37) within floodplain since 1990, none in Lower Lakes and Coorong, all records north of Mannum, Crimson Rosellas more abundant and more widely distributed (BDBSA 2010). *Current records of Yellow Rosella in BDBSA are sparse and widely distributed suggesting a fragmented population. As most populations are thought to be sedentary/residential, the gene pool is likely to be restricted to a large extent however its capacity to interbreed with other subspecies of the Crimson Rosella complex may offset this but at the cost of maintaining subspecies integrity. Subspecies should be considered at moderate risk but with low confidence as geographic variation at species level and uncertain over validity of considering the occurrence of hybrids with more abundant species.*	**H**	**H**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? Mixing is somewhat limited by patchy distribution and mobility (P. Wainwright pers. comm. 2011).	Genetic discontinuity was noted in studies by Joseph et al (2008) suggesting that while the discontinuities do not totally impede gene flow, they are of sufficient magnitude to effectively isolate the clusters they define. Joseph et al (2008) suggest that a population expansion was accompanied by geographical range expansion, secondary contact and hybridization in eastern and western populations. Pleistocene landscape and sea-level and habitat changes then established current distributions and range disjunctions. Populations now show idiosyncratic patterns suggesting selection and drift now drive evolution in different populations (Joseph et al 2008). A range of phenotypic intermediates and hybrids are noted for the Crimson Rosella species complex (Joseph et al 2008). At the species level, the Crimson Rosella is a monogamous breeder and keeps the same partner for several years or for life (Higgins 1999). *Some degree of gene flow at the species level is apparent as several intermediate and hybrid examples are noted. Confidence that this represents the subspecies is limited. The extent to which flow takes place probably varies and is likely to reflect the degree of mobility (sedentary vs. nomadic) of individuals within a given population. Gene flow limitations in regional populations helped define clusters and current mechanisms for divergence are thought to be selection and drift. Probably moderately limited gene flow but low confidence.*	**L**	**M**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic species, geographical variation in plumage is great and classification varies. Yellow Rosella is part of Crimson Rosella complex containing several (up to 7) subspecies whose geographic ranges are known to overlap. A range of phenotypic intermediates and hybrids are also noted (Higgins 1999; Joseph et al 2008). Selection and genetic drift are suggested as current drivers of the variation (Joseph et al 2008). *Species shows a high degree of phenotypic plasticity and geographic variation. Yellow Rosella able to breed with other Crimson Rosellas and produce viable intermediate/hybrid offspring, and also show a variety of different plumage. Species should be considered at low risk*	**H**	**L**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Crimson Rosella population estimated at above 200000 and Yellow Rosella subspecies above 50000 world-wide but consists of several isolated populations (Parrots.org 2010). Very few Yellow Rosella records (37) within floodplain since 1990, none in Lower Lakes and Coorong, all records north of Mannum. Crimson rosella are more abundant (847 records since 1990) and are more widely distributed. Also less abundant than Regent Parrot (281 records since 1990) in SA MDB floodplain (BDBSA 2010). *Population size likely to be a limiting factor in maintaining the integrity of the Yellow Rosella as a separate subspecies. Literature suggests world-wide population is relatively small containing isolated populations. BDBSA records verify this pattern of very patchy abundance and distribution across the study area. Species should be considered at high risk*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Other Rosella species lay 3-8 eggs (Slater et al 2001), and reports of 3-6 per brood are not uncommon (Higgins 1999). Clutch size significantly larger in nest holes used in successive years, 4 year study in ACT found significantly larger clutches in wettest year of study. Species will also double-brood (Higgins 1999). *Moderate fecundity potential increased by fact species can have multiple broods per season. The availability of previous nest sites is a strong influencing factor as may be rainfall and hydrological conditions. Habitat degradation, increased competition for nesting holes and alteration of hydrological and climatic regimes are expected outcomes of climate change and is likely to limit reproductive capacity. Species should be considered at high risk*	**H**	**H**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	No information on age at first breeding or generation time. High fecundity potential as species can have multiple broods per season and apparent trend for better success where clutch size is larger (> 5 eggs). Larger clutches recorded during wetter years. Fledgling success rates have been recorded between 15% and 39% and majority of fledgling populations originate from successively used nest holes (Higgins 1999). Very few Yellow Rosella records (37) within floodplain since 1990, none in Lower Lakes and Coorong, all records north of Mannum. Crimson rosella are more abundant (847 records since 1990) and are more widely distributed (BDBSA 2010). *While the species has reasonable fecundity potential, its recruitment success (survivorship) is relatively poor. Success is heavily influenced by availability of suitable nest holes (preferably successively used) and high rainfall seasons. Population base is also relatively small in study area. These may be limiting factors through climate change so species should be considered at high risk*	**H**	**H**

Scientific Name:	*Poliocephalus poliocephalus*	**Common Name:**	Hoary headed Grebe

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change? <u>Do not explicitly require riparian or emergent vegetation and is comfortable in deep, open water tracts. Will usually dive if alarmed so much less need for vegetative cover. Could be a low-moderate rating (P. Wainwright pers. comm. 2011).</u>	Utilises range of terrestrial to estuarine wetlands, apparently prefer large open waterbodies, permanent or semi permanent, and also frequent small (< 1 ha) waters and temporary waters after flooding. However prefer large (100 – 500 m wide) sheets of open water, 0.5 – 3 m deep, with submerged vegetation (Marchant and Higgins 1990). Avoid water covered by dense weed, and sharp divisions of distribution of birds on waters occur because of presence of dense waterweeds. Common at times on brackish to saline coastal, estuarine and even marine waters (Marchant and Higgins 1990). 'If small invertebrates plentiful clarity of water rather unimportant (Marchant & Higgins 1990)'. For breeding, prefer permanent waters or climax stages of semi-permanent floodwaters with open marsh and swamp vegetation and widespread waterweed. Assemblies of a few too many hundreds occur on productive floodwater swamps (Marchant & Higgins 1990). 'Unable, due to its bill type, to take zooplankton with the same efficiency as the filter feeding ducks, it probably requires presence of some larger aquatic insects or shrimps, before it has sufficient food surplus to breed (Fjeldsa 1983)'. *Although a wide range of habitats are utilized, reduced flooding and a reduction in large semi-permanent and productive temporary wetlands with submerged vegetation are expected to moderately reduce habitat for the species within the study region. Permanent pool level wetlands within region often dominated by floating surface vegetation due to lack of flow likely to be avoided by species as unsuitable habitat. 'Habitat' preference is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Poorly known, highly dispersive in drier parts of range. Flocks arrive at some inland swamps shortly after rise in water level (Marchant & Higgins 1990). 'Longest recorded movement of a banded bird 572km (ABBBS [Marchant & Higgins 1990])'. *Species capable of regular long distance movements. 'Mobility & dispersal' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Primary feeding mechanism is deep diving (Marchant & Higgins 1990). 'Data suggests preference for foliage-gleaning arthropods when food plentiful and efficient use of Daphnia and other tiny prey when food scarce (SAAB 2001)'. In January 2009 reasonable numbers of hoary headed grebes *Poliocephalus poliocephalus* were present in the South lagoon [of Lower Lakes] having switched to foraging extensively on brine shrimps (Paton *et al* 2009)'. 'Mosquito fish, on the other hand, are carnivores and may compete directly with waterfowl for invertebrates. They are very effective predators and can greatly reduce plankton and insect populations (Crome 1986). *Though competition from introduced fish such as Gambusia is expected with an overlapping primary food source of invertebrates, the species diving ability and utilization of a wide variety of prey sizes is expected to reduce the impact of competition. 'Competition' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Utilise range of terrestrial to estuarine wetlands, permanent and temporary habitats and including salt pans, saline & hypersaline lakes and coastal inlets (Marchant & Higgins 1990). In January 2009 reasonable numbers of hoary headed grebes *Poliocephalus poliocephalus* were present in the South lagoon [of Lower Lakes] having switched to foraging extensively on brine shrimps (Paton *et al* 2009)' – salinities in the south lagoon between 2006 and 2009 have been as high as 5-6 times seawater (Paton *et al* 2009). '…it probably survives periods with only zooplankton blooms available as food and this may be a main reason for its abundance in parts of Australia (Fjeldsa 1983)'. *Its ability to utilize range of habitat types with differing water regimes, tolerance of high salinity and its efficient use of available food source provides this species with good survival tolerances. 'Survival tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	*Although information on growth tolerances not found specifically documented, due to the species high salinity tolerance and efficient use of available food sources 'growth tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	For breeding, prefer permanent waters or climax stages of semi-permanent floodwaters with open marsh and swamp vegetation and widespread waterweed (Marchant and Higgins 1990). Flooding is main breeding stimulus (Briggs 1990 [in Scott 1997]). Artificial regulation on floodwaters may prevent breeding in some areas (Marchant & Higgins 1990). 'Up to 1000 nests have been recorded on individual lakes of the Coongie Lakes District, although this was an unusual event (Reid 2000 [in SAAB 2001])'. In south-western Australia between July 1981 and May 1985, preferred brackish (total dissolved solids < 10 ppt), alkaline (pH > 7.4) wetlands (Halse et al. 1993). Mean salinity of wetlands used by 17 broods in south-western Australia 4.567 gL-1 (range 0.728 – 9.870) (Goodsell 1990). *Though described to breed also on permanent waters, flooding is documented to be the main stimulus for breeding and largest breeding events are documented to occur on temporary/ semi-permanent wetlands after flooding. Tolerates brackish waters for breeding. 'Reproductive tolerances' are expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**H**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	The Hoary-headed Grebe *Poliocephalus poliocephalus* is abundant in many parts of Australia (Fjeldsa 1983). Common and widely distributed in eastern half of South Australia (Marchant and Higgins 1990). Highly nomadic (Fjeldsa 1983). Highly dispersive in drier parts of range. Flocks arrive at some inland swamps shortly after rise in water level (Marchant & Higgins 1990). *Though specific information on gene pool of species was not found documented species is described as common and widespread. 'Gene pool' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Common and widely distributed in eastern half of state (Marchant and Higgins 1990). Highly nomadic (Fjeldsa 183). Highly dispersive in drier parts of range. Flocks arrive at some inland swamps shortly after rise in water level (Marchant & Higgins 1990). 'Longest recorded movement of a banded bird 572km (ABBBS [Marchant & Higgins 1990])'. *Though specific information on gene flow within the species was not found documented species is described as common, widespread and highly dispersive. 'Gene flow' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change? Very nomadic and highly dispersive, will mix quite well at certain times e.g. big colonies following flooding (P. Wainwright pers. comm. 2011).	Common and widely distributed in eastern half of state (Marchant and Higgins 1990). Highly nomadic (Fjeldsa 183). Highly dispersive in drier parts of range. Flocks arrive at some inland swamps shortly after rise in water level (Marchant & Higgins 1990). 'Longest recorded movement of a banded bird 572km (ABBBS [Marchant & Higgins 1990])'. *No specific information found. Probably good population base and large breeding contractions increase chances of mixing.*	**M**	**L**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change? BDBSA records probably under-represent numbers, commonly mis-identified due to confusion with Australian (Little) Grebe especially when out of breeding plumage (P. Wainwright pers. comm. 2011).	Common and widely distributed in eastern half of state (Marchant and Higgins 1990). The Hoary-headed Grebe *Poliocephalus poliocephalus* is abundant in many parts of Australia (Fjeldsa 1983). Generally absent from driest arid regions but will occur wherever surface water persists after rain (Marchant and Higgins 1990). Species not listed as conservation significant with SA (NPW Act 1972). Moderatley abundant records within study area since 1990 (254) (BDBSA 2011). Listed as 'near threatened' in DENR Murraylands region and 'least concern' in Murray Malle and Murray Scroll Belt IBRA sub-regions under IUCN criteria (Gillam and Urban 2010). *Though population size within the study region is variable depending on resource availability, species is considered to be secure. 'Population' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change?	'Up to 1000 nests have been recorded on individual lakes of the Coongie Lakes District, although this was an unusual event (Reid 2000 [in SAAB 2001])'. Four to five eggs per clutch usually recorded in nests, three to six occasional (Marchant and Higgins 1990). From Australian Nest record Scheme, mostly 3-4, average 3.4. Replacements after failure of first clutch recorded (Marchant and Higgins 1990). Breed in simple pairs, often colonially or semi-colonially, colonies up to 300 pairs (Marchant and Higgins 1990). *Relatively large reproductive events documented under ideal breeding conditions, e.g. temporary wetlands flooded, and species documented to replace failed clutches. 'Reproductive capacity' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.*	**M**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? BDBSA records probably under-represent numbers, commonly mis-identified due to confusion with Australian (Little) Grebe especially when out of breeding plumage (P. Wainwright pers. comm. 2011).	Common and widely distributed in eastern half of state (Marchant and Higgins 1990). The Hoary-headed Grebe *Poliocephalus poliocephalus* is abundant in many parts of Australia (Fjeldsa 1983). Generally absent from driest arid regions but will occur wherever surface water persists after rain (Marchant and Higgins 1990). Species not listed as conservation significant with SA (NPW Act 1972). Reasonably abundant records within study area since 1990 (254) (BDBSA 2010). *No specific information on reproductive success or recruitment rate found documented lowers confidence. Probably good population base and known to form decent sized breeding colonies. Recruitment is probably not a major limiting factor.*	**M**	**L**

Scientific Name:	*Polytelis anthopeplus*	Common Name:	Regent Parrot

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? Salinisation presents biggest risk to health of River Red Gums along Murray River corridor (P. Wainwright pers. comm. 2011).	Common resident or nomad in woodland near agricultural clearings in south-west and locally common partial nomad in riverine forests in south-east (Slater et al 2001). Much remaining feeding habitat has been separated from breeding habitat and continues to be grazed, which may reduce its value (Gannet and Crowley 2000). Commonly associated with Eucalyptus trees e.g. River Red Gums, Black Box etc. and grasses, in riverine or littoral environments. Seem to prefer tall Red Gum forests near water for roosting and nesting in mature, senescent or dead trees. No large scale seasonal movement although do disperse from riparian breeding sites to mallee regions. Preference for large trees means that breeding sites must be within 60m of either permanent or temporary water (where largest trees occur). *Clear reliance on tall woodland forest environments that are only found in close proximity to water within the study site but not explicitly a water bird. Habitat degradation is likely particularly in north of SA across floodplain wetland complexes but can use other woodland habitats and range away form riverine areas after breeding. Does not actively forage or breed in water like the waders. Species should be considered at moderate risk in terms of habitat limitations.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change? Able to move 10km's, is a fast flyer so is probably not limited in this respect (P. Wainwright pers. comm. 2011).	Poorly understood but thought to be mainly nomadic but resident and sedentary in some areas. Mostly feed on ground or in tree canopies of Eucalypt woodland usually within about 20km of breeding sites. No large scale seasonal movement although do disperse from riparian breeding sites to mallee regions. Foraging movements during breeding season possibly more extensive (Higgins 1999). Travel more widely during the non-breeding season (Gannet and Crowley 2000). Foraging sites required to be in proximity to nests in breeding season, species may travel long distances for food in non-breeding season (Higgins 1999). *Species has some mobility and dispersive capacity but shows a tendency to reside in certain areas but presumably only when conditions are favourable. Shows ability to move over large enough scales if needed though movement reduced when breeding. Should be considered at moderate risk as can probably move if conditions become unsuitable but habitat fragmentation as uses Murray corridor as an avenue throughout study area and may limit species especially when breeding.*	**H**	**M**

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Feral honey bees have excluded Regent Parrots from many hollows around Lake Albacutya and occupy some suitable hollows that are for Regent Parrots in Wyperfeld National Park, although overall hollow availability may not be limiting (Gannet and Crowley 2000). Agonistic interactions with other Regent Parrots in competition for nesting space but not overly aggressive. Interspecies interactions are more aggressive e.g. Crimson Rosellas driving off Regent Parrots in Rosella's nest trees, competition with galahs for nesting holes (Higgins 1999). *Main competitive forces surround competition for space and nesting sites with other species, availability of suitable nesting sites in Eucalypt forests and especially riverine red gum forests. Suggested that hollow availability is not necessarily limiting in some areas but not referenced to study area reducing confidence. Species should be considered at moderate risk.*	**M**	**M**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	It forages for seeds of grasses and herbaceous plants in mallee within 20 km of the nesting site, particularly where Christmas Mallee or Yellow Mallee dominate. It will also take berries, blossom, other pant material and lerp, as well as fallen grain and fruit in orchards and vineyards Use of agricultural and horticultural crops by the Regent Parrots has exposed a proportion of the population to poison, shooting, and, when feeding on spilt grain, traffic accidents (Gannet and Crowley 2000). *Suitable natural foraging habitat may be reduced through climate change but reasonably long range foraging and not gleaning food from water bodies exclusively. Also has a generalist diet unlikely to be limiting. Species should be considered at low risk.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Diet relies on variety of grasses and herbaceous plants including cereal crops, also fruit, flowers and occasionally insect larvae and psyllids/lerp. Preference for large trees means that breeding sites must be within 60m of either permanent or temporary water (where largest trees occur). Foraging sites required to be in proximity to nests in breeding season, species may travel long distances for food in non-breeding season (Higgins 1999). *Relatively broad herbaceous diet is unlikely to be limiting. Increased habitat fragmentation and foraging distances could potentially threaten health of nestlings during breeding season as feeding intervals may be lengthened. Species should be considered at moderate risk.*	**H**	**M**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	In the SA MDB, breeding from Renmark to Morgan with nests in riverine River Red Gums and Black Box woodlands, using hollows in large dead or living eucalypts that have a minimum girth of 25 cm. Nesting habitat has also been destroyed, and its regeneration prevented through logging for timber, firewood collection, ringbarking on agricultural land, salinisation and waterlogging (Gannet and Crowley 2000). In SA nest mostly in dead trees (up to 94% of nests) that have been drowned due to lock and weir construction on River Murray, likely that bird simply continued to nest in trees that have since died as trend does not follow in other areas. Preference for large trees means that breeding sites must be within 60m of either permanent or temporary water (where largest trees occur). Females are sole incubators and rely on males to feed by regurgitation (Higgins 1999). *Birds that do not build nests but rely on provision of nest holes are more at risk. Nesting habitat degradation (tall woodland forests), increased competition for nesting holes especially with feral animals (e.g. bees) provide risks. Degradation of riparian breeding habitats may affect reproductive success. No apparent reliance on hydrological regimes to trigger or complete breeding as in some water birds. Species should be considered at moderate risk*	**H**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Population status is endangered in NSW and vulnerable in SA and Vic (Higgins 1999). The area of occupancy has decreased to the extent that the population is now fragmented and a continuing decrease in population size is likely (Gannet and Crowley 2000). EPBC listed as 'vulnerable' and IBRA sub-regionally listed as 'endangered' and in 'definite decline' in Murray Mallee, Murray Scroll Belt and South Olary Plain (Gillam and Urban 2010). *Threatened population status in 3 states and nationally listed as vulnerable. IBRA sub-regionally listed as endangered with definite declines within study area. Wide concurrence among literature of ongoing declines and increases in fragmentation. Gene pool is likely to be limited and the species should be considered at high risk*	**H**	**H**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? <u>Mixing is somewhat limited by patchy distribution and mobility (P. Wainwright pers. comm. 2011).</u>	No specific information. The area of occupancy has decreased to the extent that the population is now fragmented and a continuing decrease in population size is likely (Gannet and Crowley 2000). Nationally listed as vulnerable and IBRA sub-regionally listed as endangered and in definite decline in Murray Mallee, Murray Scroll Belt and South Olary Plain (Gillam and Urban 2010). *Threatened population status in 3 states and concurrence among literature of ongoing declines and increasing population fragmentation means that gene flow is likely to be restricted especially where populations are sedentary or resident so the species should be considered at high risk.*	**H**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	No specific information. Species is polytypic and 2 subspecies have been identified reflecting eastern and western Australia populations. Western subspecies is duller and has shorter torso, plumage differs slightly in adult birds (Higgins 1999). Nationally listed as vulnerable and IBRA sub-regionally listed as endangered and in definite decline in Murray Mallee, Murray Scroll Belt and South Olary Plain (Gillam and Urban 2010). *Lack of specific studies however existence of subspecies indicates some degree of genetic flexibility in the species and possibility of adaptive radiation. Population status however suggests limited chance for different phenotypic expression however mixing is probably limited by distribution and mobility. As knowledge is lacking the species should be treated conservatively and considered at moderate risk*	**L**	**M**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change? Probably over-represnted abundance in BDBSA records due to targeted survey efforts and conspicuousness of species (P. Wainwright pers. comm. 2011).	Endemic to Australia, 2 main poulations (1 in NSW/Vic, 1 in Murray Mallee region in SA), population status is endangered in NSW and vulnerable in SA and Vic (Higgins 1999). The area of occupancy has decreased to the extent that the population is now fragmented and a continuing decrease in population size is likely. Small estimated Australian population of eastern Regent Parrot of 1500 individuals (Gannet and Crowley 2000), other authors estimate around 2300 (DEHWA 2010b). 281 records within floodplain since 1990, majority concentrated in Murray Scroll Belt to north of SA near Vic border; only 43 records pre 1990 but likely reflects increased survey efforts of last 10 years. Records suggest more abundant than Yellow Rosella in study area since 1990 (BDBSA 2010). EPBC listed as 'vulnerable' and IBRA sub-regionally listed as 'endangered' and in 'definite decline' in Murray Mallee, Murray Scroll Belt and South Olary Plain (Gillam and Urban 2010). *Threatened population status in 3 states and nationally listed as vulnerable. IBRA sub-regionally listed as endangered with definite declines within study area. Wide concurrence among literature of ongoing declines and increases in fragmentation. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change? May have 2 broods in succession in good years but breeding is purely seasonal over spring-summer (P. Wainwright pers. comm. 2011).	Moderate clutch sizes of 3-6 eggs incubated by female only. No information on number of broods per year or replacement broods (Higgins 1999). *Moderate fecundity potential but due to gaps in knowledge of reproduction species should be treated conservatively and be considered at moderate risk due to low confidence.*	**L**	**M**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? Provision of nesting habitat (red gums) is critical to recruitment success (P. Wainwright pers. comm. 2011).	No information on age at first breeding or generation time. A study from WA population shows a high fledgling success rate of 64-89% equaling 3 young per nest. Hatching takes about 21 days and fledglings are independent after 5-6 weeks (Higgins 1999). *While clutch sizes are not large, high fledgling success rate increases recruitment potential. No information on age at maturity or longevity. Habitat is critical to recruitment. Species should be considered at moderate risk but with low confidence.*	**L**	**M**

Scientific Name:	*Porphyrio porphyrio*	Common Name:	Purple Swamphen

FAMILY: Rallidae

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	Terrestrial wetlands and adjacent grasslands, also estuarine and littoral wetlands. Open habitat next to wetlands such as grasslands, meadows, lawns, parks and gardens. Therefore found in all sorts of wetlands from ponds to swamps to artificial dams and sewage works. Usually on freshwater or brackish water, sometimes at saline, eutrophic and turbid wetlands, permanent, semi-permanent, seasonal or ephemeral (Marchant and Higgins 1993). Tends to prefer small and shallow wetlands but will move to large bodies in times of drought (Harper 1990). Usually in aquatic vegetation at fringes of the wetland, and terrestrial vegetation adjacent to open areas. Consume mainly aquatic vegetation, feeding in dense reed beds where they climb and wade through vegetation over water, gleaning insects and seeds. Also dig for subterranean rhizomes and roots of vegetation, and will immerse head in search of new growth. Numbers reduced by removal of marginal wetland vegetation, recreational developments, drainage of wetlands, silting and grazing (Marchant and Higgins 1993). Grouped by Halse et al. (1993) as a bird restricted to fresh to brackish permanent wetlands with dense cover. Nests in reeds, in swamps and dams, usually in water but occasionally away from water (Marchant and Higgins 1993). Known to breed on inland swamps following flooding (Hobbs 1961 as cited in Marchant and Higgins 1993) but at same time flooding may reduce access to some food plants forcing birds to move to less inundated areas (Norman and Mumford 1985 as cited in Marchant and Higgins 1993). Needs reed beds (Gillam and Urban 2010). *Species inhabits a wide range of wetland environments with salinity ranging from fresh to saline and also uses artificial environments. Seems to prefer fresh to brackish wetlands with dense fringing and riparian vegetation. These habitats are susceptible to degradation through drainage, changes to salinity and hydrological regime and may be detrimental under climate change however may be offset by use of artificial impoundments. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Dispersive, possibly partly migratory and sometimes sedentary. Generally no evidence for large scale seasonal movement (Blakers et al. 1984 as cited in SAAB 2001), however movements may occur across Torres Strait where it is considered to be a regular wet season visitor. Gosper et al. (1983) found strong evidence of seasonal movements to and from inland wetlands. Birds were more abundant in late autumn and winter and decreased over late winter and spring presumably dispersing to coast. This agreed with findings of other studies suggesting that the species is nomadic and coastal populations are also affected by season (Briggs 1977; Norman 1979 as cited in Gosper et al. 1983). Increases in local populations may also occur according to availability of habitat. Movements of birds in South Australia poorly known (SAAB 2001). Harper (1990) in a study on Bool Lagoon SA however, found no relationship between rainfall, season or water height and abundance. Most recoveries from banding studies indicate that the species is largely sedentary with long distance movements restricted to only a few individuals (Marchant and Higgins 1993). Birds may move to less inundated areas following flooding as access to food plants is lost (Norman and Mumford 1985 as cited in Marchant and Higgins 1993) and it is suggested that lack of water is primary trigger for movement (Carroll 1969 as cited in Marchant and Higgins 1993). *Some conflicting evidence as to movement habits of species and mobility probably varies spatially and temporally in different regions. Lack of studies in SA or MDB region limits confidence in assessment but is likely that species will move in response to water, food and habitat availability. Species should be considered at low risk but with medium confidence due to lack of regional studies.*	**M**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Medium to large sized bird to about 1kg fully grown and quite conspicuous in its open habitat. Consume mainly aquatic vegetation, feed in dense reed beds where they climb and wade through vegetation over water, gleaning insects and seeds. Also dig for subterranean rhizomes and roots of vegetation, and will immerse head in search of new growth. Seemingly not overly aggressive but adults will rush to young when Harriers are present and family groups will attack Harriers if young are targeted. Commonly either use alert postures, alarm calls and distraction displays to defend young. Usually fly away under direct threat. Solitary nesting, or in loose groups round margins of wetlands with much aquatic vegetation. At some locations nesting territory is defended year-round. Large flocks of non-territorial birds also occur particularly in non-breeding season before dispersing to breed but small non-territorial groups sometimes remain. Swim infrequently, when disturbed run quickly to cover, or dive and progress underwater partly or fully submerged.. Deaths recorded immediately following rodent baiting and control of other species, local declines in NZ attributed to egg predation by rats (Marchant and Higgins 1993). *Reasonably large bird not noted as being overly aggressive but small groups will defend breeding territories and members of a group are known to attack potential predators in protection of young. Large flocks of non-territorial birds also occur but have competitive advantages in large numbers. Broad, mainly vegetarian diet is unlikely to be limited through competition. Species is likely to be a strong competitor and should be considered at low risk.*	**H**	**L**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Found in all sorts of wetlands from ponds to swamps to artificial dams and sewage works. Usually on freshwater or brackish water, sometimes at saline, eutrophic and turbid wetlands, permanent, semi-permanent, seasonal or ephemeral. Consumes mainly aquatic vegetation, feed in dense reed beds where they climb and wade through vegetation over water, gleaning insects and seeds. Also dig for subterranean rhizomes and roots of vegetation, and will immerse head in search of new growth (Marchant and Higgins 1993). Flooding suspected to reduce accessibility to some food plants, causing birds to move to drier or less inundated areas (Norman and Mumford 1985 as cited in Marchant and Higgins 1993). In south-western Australia between July 1981 and May 1985, preferred fresh (TDS < 3ppt), neutral (pH 6.6-7.4) wetlands with low (< 0.10 mg/L) phosphorus levels (Halse et al. 1993). In September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al. 1993). *Species inhabits a wide range of wetland environments with salinity ranging from fresh to saline and also uses artificial environments. Some studies indicate a preference for fresh, neutral wetlands with low phosphorus but other types including saline, turbid and eutrophic areas are also used and presumably do not affect survival. Fringing and riparian vegetation is susceptible to degradation through drainage, changes to salinity and hydrological regime and may be detrimental under climate change however this may be offset by use of artificial impoundments. Species should be considered at low risk.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Mean salinity of wetlands used by 10 broods in south-western Australia 1.6ppt (but up to 4.1ppt), and mean pH 8.3 (range 6.8 – 10.2) (Goodsell 1990). In south-western Australia between July 1981 and May 1985, preferred fresh (TDS < 3ppt), neutral (pH 6.6-7.4) wetlands with low (< 0.10 mg/L) phosphorus levels (Halse et al. 1993). In September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al. 1993). Young are semi-precocial and nidifugous so leave nest early on, parents lead chicks from nest and chicks can begin to self-feed within 2 days but continue to be fed for around 2 months. Other members of group will also feed chicks and bring food to sitting adult. Chicks of second clutches also cared for by chicks of first brood clutch (Marchant and Higgins 1993). *Species inhabits a wide range of wetland environments with salinity ranging from fresh to saline and also uses artificial environments. Some studies indicate a preference for fresh, neutral wetlands with low phosphorus but other types including saline, turbid and eutrophic areas are also used. One study in SW Australia indicated brooding occurs on fresh and slightly alkaline wetlands but nesting up to 800m from water body is also recorded indicating flexible breeding site requirements. Young develop quickly and are self-feeding and independent relatively quickly reducing parental investment and means young are less vulnerable for a shorter time. Cooperative brooding also increases chances of successful growth to adulthood. Species should be considered at low risk.*	**H**	**L**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	In South Australia breeds in the South East, in the Mt. Lofty Ranges, Kangaroo Island , Adelaide Plains, lower Murray River, and also in southern Lake Eyre basin. Also on Diamantina River and Cooper Creek systems. Can be opportunistic, breeding recorded in every month, but mainly seasonal breeding from August to February (Marchant and Higgins 1993). Laying closely correlated with peak rainfall + 2-3 months, increase in temperature and photoperiod (Halse and Jaensch 1989 as cited in Marchant and Higgins 1993). Nests in reeds in swamps, dams, usually in water but occasionally away from water in pastures, grasslands or crops (up to 800m away). Ground nesting, build nests on a platform of beaten down reeds or rushes (Marchant and Higgins 1993). In NZ, breed in small groups of 3-7 males and 1-2 females and lay eggs in single nest. In Australia, breeding groups consist of 2-5 adults, pairs more common along water courses (Dow 1980 as cited in Marchant and Higgins 1993). Birds known to breed on inland swamps following flooding (Hobbs 1961 as cited in Marchant and Higgins 1993). At Bool Lagoon in south-east South Australia between July 1983 and June 1987, numbers demonstrated no correlation with either season or water levels (Harper 1990). Population increases shown during times of low rainfall highlighting the importance of Bool Lagoon as a drought refuge for the species as smaller, shallower preferred wetlands dry out (Harper 1990). Mean salinity of wetlands used by 10 broods in south-western Australia 1.6ppt (but up to 4.1ppt), and mean pH 8.3 (range 6.8 – 10.2) (Goodsell 1990). *Relatively long breeding season and also noted as opportunistic with recorded breeding in all months. Laying closely correlated with peak rainfall (with lag of 2-3 months) and increase of temperatures and photoperiod. Rainfall and temperature patterns are expected to change under climate change and may affect timing of breeding. Do not need water below nest and will nest some distance away and in crops, pastures etc. Breeding could be triggered by flooding in some areas but birds will move to more permanent wetlands in times of drought leaving smaller preferred bodies. Seems to prefer fresh to mildly brackish wetlands for brooding and no record or indication of breeding in saline inland or coastal estuarine environments. Cooperative breeding in small family groups is also an advantage. Main limiting factor under climate change would be risk of salinisation and/or drying of preferred ephemeral wetlands and changes to rainfall and temperature regimes. Species should be considered at moderate risk.*	**H**	**M**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Mainly long-term monogamous or polygamous pair-bonds but also promiscuous in unstable groups. Population probably increasing. Construction of artificial impoundments and lakes and creation of more open habitat adjacent to water has allowed extension of its range inland (Marchant and Higgins 1993). Atlas surveys record a moderate number of sightings in the Murray-Darling Depression bioregion and estimated to represent a moderate proportion of the national population (ANRA 2010b). A transient and/or nomadic species with some marked seasonal movements (Gosper et al. 1983; Marchant and Higgins 1993).Numerous records (998) since 1990 within SA MDB floodplain, large proportion outside study area in Lower Lakes region but 439 records above Wellington (BDBSA 2010). Not nationally threat listed but regionally listed in DENR Murraylands as 'rare' and improbable decline, IUCN sub-regional status in Murray Scroll Belt is 'rare' with a stable trend, still breeding with low scattered numbers and in definite decline in Murray Mallee (Gillam and Urban 2010). *Reasonable evidence to indicate patchy population base in SA MDB and within study area despite numerous BDBSA records. Declines likely. Species is moderately mobile with some marked seasonal movements and responses to water/habitat availability related to breeding. Available gene pool is probably moderately restricted as species is polygamous and promiscuous breeding habits and is mobile to some degree. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Mainly long-term monogamous or polygamous pair-bonds but also promiscuous in unstable groups. Known to form large flocks (up to300 birds) in non-breeding season, these disperse to breed (Marchant and Higgins 1993). In NZ, breed in small groups of 3-7 males and 1-2 females and lay eggs in single nest. In Australia, breeding groups consist of 2-5 adults, pairs more common along water courses (Dow 1980 as cited in Marchant and Higgins 1993). Not nationally threat listed but regionally listed in DENR Murraylands as 'rare' and improbable decline, IUCN sub-regional status in Murray Scroll Belt is 'rare' with a stable trend, still breeding with low scattered numbers and in definite decline in Murray Mallee (Gillam and Urban 2010). *Gene flow probably varies among different regional populations and family groups. Formation of flocks in non-breeding season may allow pairing/grouping of different individuals. Varied breeding strategy ranging from monogamous to promiscuous polygamy so likely that gene flow occurs quite freely among regional populations. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic species with 6 subspecies and 2 occurring in the HANZAB area. 1 in SW Aust. and another in north and east of Aust. Skins from some different areas suggest a degree of variation within subspecies. Size differences may occur between Australian and NZ populations but other morphological characteristics (e.g. bill shield, colouration) also separate subspecies (Marchant and Higgins 1993). *Considerable geographic variation in species at continental scale and 2 subspecies recognised in Aust. but unclear as to which one or if both occur in study area and if intermediates are recorded. Good capacity for mobility and dispersion coupled with high abundance of species in study area means genetic variation is more likely to occur although confidence is limited due to lack of specific genetic studies in region. Species should be conservatively considered at moderate risk but with medium confidence due to knowledge gaps.*	**M**	**M**

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Atlas surveys record a moderate number of sightings in the Murray-Darling Depression bioregion and estimated to represent a moderate proportion of the national population (ANRA 2010b). Numerous records (1416) since 1990 within SA MDB floodplain, large proportion outside study area in Lower Lakes region (615 records in study area above Wellington) (BDBSA 2011). Not nationally threat listed but regionally listed in DENR Murraylands as 'rare' and in probable decline, IUCN sub-regional status in Murray Scroll Belt is 'rare' with a stable trend, still breeding with low scattered numbers and in definite decline in Murray Mallee (Gillam and Urban 2010). *Reasonable evidence to indicate patchy population base in SA MDB and within study area despite numerous BDBSA records. Declines likely. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Average from Australian Nest Record Scheme 4.2 eggs per clutch (n=51) and range of 2-6 (Marchant and Higgins 1993). May raise 2 broods in a season (Brown and Brwon 1977 as cited in Marchant and Higgins 1993). Can be opportunistic, breeding recorded in every month, but mainly seasonal breeding from August to February (Marchant and Higgins 1993). *Moderate clutch size compared to other birds assessed in this study and capacity for double-brooding. Relatively long breeding season and also opportunistic. Species has a high reproductive capacity and should be considered at low risk.*	**H**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Can be opportunistic, breeding recorded in every month, but mainly seasonal breeding from August to February (Marchant and Higgins 1993). Both sexes can breed in first year but often do not until second or third year unless dominant members of the group are lost. Average from Australian Nest Record Scheme 4.2 eggs per clutch. High hatching success rates in Australia and NZ (up to 90%). Wet summers increase chances of young surviving first 3 months (70% success rate) and almost total recruitment failure in dry summers. Early clutches are generally more successful but early hatching chicks often die in nest, loss of chick is typically high with first 2 months of hatching and even higher in first few days (Marchant and Higgins 1993). Laying closely correlated with peak rainfall + 2-3 months, increase in temperature and photoperiod (Halse and Jaensch 1989 as cited in Marchant and Higgins 1993). Not nationally threat listed but regionally listed in DENR Murraylands as 'rare' and in probable decline, IUCN sub-regional status in Murray Scroll Belt is 'rare' with a stable trend, still breeding with low scattered numbers and in definite decline in Murray Mallee (Gillam and Urban 2010). *Moderate clutch size and able to double-brood. Long breeding season and also opportunistic and typically high hatching success rates but fledging success rate probably much lower. Reaches breeding maturity in first year but usually do not breed until second or third year which is a long time compared to other birds assessed in this study. High recruitment failures in dry summers. Still breeding in study area but with patchy population base. Climate change is expected to increase frequency and duration of hot summer seasons with increased evaporation and reduced rainfall and increased drought frequency and magnitude in the SA MDB region. This increases risk of recruitment failures and may also alter breeding seasons and affect opportunistic breeding. Species should be considered at high risk.*	**H**	**H**

Scientific Name:	*Porzana fluminea*	Common Name:	Australian (Spotted) Crake

FAMILY: Rallidae

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>As a cryptic species, vegetation fragmentation e.g. through salinity, may expose it to increased predation (P. Wainwright pers comm. 2011).</u>	Well vegetated margin of fresh, brackish and saline wetlands and estuaries, often in saline and tidal wetlands. Will also occur in artificial impoundments e.g. sewage ponds and saltworks. Thought to be less dependent on dense vegetation than Spotless Crake. Breeds in clumps of dense riparian vegetation and mainly forage on margins of wetlands in shallow water (<5cm deep) or in peat and mud. Roosting in similar habitats. Habitat under threat from grazing and wetland reclamation (Marchant and Higgins 1993). Crakes are usually restricted to wetlands with dense cover (Jaesnch et al. 1988 as cited in Halse et al. 1993) and species tend to prefer brackish wetlands with dense vegetation cover (Halse et al. 1993). Flood mitigation and irrigation schemes of the inland could prevent filling of inland swamps, waterholes, wetlands and lakes which provide suitable feeding and breeding habitat (SAAB 2001). *Species can use range wetlands with salinities ranging from fresh to saline though more commonly in fresh and brackish systems with good vegetative cover though less so than other crakes. Uses shallow wetlands and margins as opposed to deeper bodies and may rely on more ephemeral wetlands. A transition from permanent, freshwater wetlands to more temporary and saline wetlands is expected through increased flow regulation to mitigate effects of climate change and drought and may increase this species' range. Species that do not need deep water for foraging are less at risk. Salinity problems may however reduce available fringing vegetation in some areas. Species should be considered at moderate risk.*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Movements unknown but possibly dispersive, irruptive movements recorded in several locations possibly in response to rainfall or drying of wetlands. Recorded leaving drying wetlands and influx after flood or heavy rain. No seasonal movements known although may be more conspicuous during summer (Marchant and Higgins 1993). *While movement is not fully understood reasonable evidence for high mobility and dispersion exists in response to changing hydrological and habitat condition. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>As a cryptic species, vegetation fragmentation e.g. through salinity, may expose it to increased predation (P. Wainwright pers comm. 2011).</u>	Primarily solitary, also in pairs or occasionally in groups (SAAB 2001). Secretive like other rails (Schodde and Tidemann 1986 as cited in SAAB 2001) and runs to cover when disturbed although generally bolder in behaviour than other crakes (Blakers et al. 1984 as cited in SAAB 2001). Never far from cover (Marchant and Higgins 1993).Small bird to 65g and seemingly not very aggressive. Small size food items e.g. seeds, mollusks, insects, crustaceans and spiders. Do not attempt to fight or drive other birds from area, one record of nest defense against human intruder but usually just give off alarm call and flee to cover or fly away. Predators include cats and dogs, snakes, and raptors and may also be taken by Great Egrets (Marchant and Higgins 1993). In Australia, predation by foxes, feral cats and rats presumably important (SAAB 2001). *Largely solitary, relatively small and non-aggressive species with noted predation pressure increases potential for limitation through competition. Nest defense is also not strong. Cryptic nature reduces this somewhat as well as broad diet of small prey and vegetable matter. Species should be considered at moderate risk.*	**H**	**M**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Able to use a wide range of salinity wetlands for feeding. Rely on presence of dense vegetation for foraging, cover and roosting. Glean small food items from shallow wetland areas fringed by vegetation or mud and peat flats (Marchant and Higgins 1993). Appears to be more tolerant of saline conditions than other crakes and small rails, but also occurs in brackish and freshwater water-bodies (Blakers et al. 1984 as cited in SAAB 2001). In south-western Australia between July 1981 and May 1985, preferred brackish (TDS < 10 ppt), while in September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al. 1993). *Species can use range wetlands with salinities ranging from fresh to saline though more commonly in fresh and brackish systems with good vegetative cover though less so than other crakes. More tolerant of saline conditions than similar species and broad omnivorous diet further reduces risk. Species should be considered at low risk.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Cover (vegetation) probably most important for survivorship of young (P. Wainwright pers comm. 2011).</u>	No information on growth or development. Both sexes incubate but nestling period is unknown. Breeds in and around wetlands with vegetation, salinity tolerances undefined but recorded nesting in vegetation typical of fresh, brackish and saline waters. Chicks are precocial and nidifugous and probably only spend a short time in the nest and are quick to begin feeding independently (Marchant and Higgins 1993) although this is not quantified. Time to independence is unknown but rails typically fledge at 30-60 days (Marchant and Higgins 1993). Appears to be more tolerant of saline conditions than other crakes and small rails, but also occurs in brackish and freshwater water-bodies (Blakers et al. 1984 as cited in SAAB 2001). In south-western Australia between July 1981 and May 1985, preferred brackish (TDS < 10 ppt), while in September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al. 1993). *Species can use range wetlands with salinities ranging from fresh to saline though more commonly in fresh and brackish systems with good vegetative cover though less so than other crakes. More tolerant of saline conditions than similar species and broad omnivorous diet further reduces risk. Chicks are precocial so require less parental investment and grow quickly to independence reducing risk though this requires validation at the species level. Species should be considered at low risk but with low confidence as specific knowledge of juvenile tolerances, growth and development are not described in the literature.*	**L**	**L**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Poorly known and no major studies. Breed in simple pairs and one report of scattered colony of 30 nests though nest density undefined. Breeds in and around wetlands with vegetation, salinity tolerances undefined but recorded nesting in vegetation typical of fresh, brackish and saline waters. Nest is usually on or close to ground in grassy clumps and fringing bushes and is of simple, flat nest to woven dome or cup. Breeding season broadly from Aug-Jan but varies with longitude but may be earlier in west (Marchant and Higgins 1993), clutches found in South Australia from mid August to late November (SAAB 2001). Both parents tend young possibly till after fledging although time is unknown but rails typically fledge at 30-60 days. No specific information on multiple or replacement brood capacity but rails commonly only have 1 or 2 broods per season and can lay up to 3 replacement clutches (Marchant and Higgins 1993). (Marchant and Higgins 1993). Nests may be abandoned if water level drops and nests may be flooded if water level fluctuates significantly during breeding season (Marchant and Higgins 1993). *Salinity of breeding sites does not seem to affect species significantly, hydrological regime (water level stability) is of more importance as nests are abandoned or destroyed if conditions are not suitable. Increased flow regulation is expected under climate change and this may threaten the stability of breeding areas for the species unless management efforts are carefully applied. Species should be considered at moderate risk but with medium confidence as much of the information is given at the family level.*	**M**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? <u>Patchy distribution is most important factor as climate change will likely result in habitat fragmentation and further fragmentation of available gene pool (P. Wainwright pers comm. 2011).</u>	Common throughout eastern part of SA and lower south-east. No recent population estimates (Marchant and Higgins 1993). Low number of sightings in Atlas surveys of the Murray-Darling Depression and estimated represent a moderate percentage of the national population (ANRA 2010b). Post 1990 records within the SA MDB floodplain and study area above Wellington suggest low numbers (96 and 32 respectively) and patchy distribution compared to other birds assessed in this study (BDBSA 2010). Pair-bonding is probably monogamous but duration of paring is unknown. Appear to nest singly but also recorded nesting in small, loose colonies of up to 30 nests. Movements unknown but possibly dispersive, irruptive movements recorded in several locations possibly in response to rainfall or drying of wetlands. No seasonal movements known although may be more conspicuous during summer (Marchant and Higgins 1993). *All indications that species is not very abundant and patchily distributed especially within study area although may be under-represented as species is cryptic. Irruptive movements noted in response to environmental variables but uncertain if this also relates to breeding cycle. Solitary nesting in pairs or in small loose colonies raises threat to available gene pool. Restricted gene pool is likely so species should be considered at high risk but with low confidence due to lack of specific studies into population genetics and duration of pair bonding.*	**M**	**H**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change? Patchy distribution is most important factor as climate change will likely result in habitat fragmentation and further fragmentation of populations (P. Wainwright pers comm. 2011).	Pair-bonding is probably monogamous but duration of paring is unknown. Appear to nest singly but also recorded nesting in small, loose colonies of up to 30 nests (Marchant and Higgins 1993). Movements unknown but possibly dispersive, irruptive movements recorded in several locations possibly in response to rainfall or drying of wetlands. Recorded leaving drying wetlands and influx after flood or heavy rain. No seasonal movements known although may be more conspicuous during summer (Marchant and Higgins 1993). *Species is probably not very abundant especially within study area although this may be under-represented as species is cryptic. Irruptive movements noted in response to environmental variables but uncertain if this also relates to breeding cycle. Solitary nesting in pairs or in small loose colonies and monogamous pair bonds decreases gene flow opportunities. Restricted gene flow is likely so species should be considered at high risk but with low confidence due to lack of specific studies into population genetics, large-scale movements and duration of pair bonding.*	**L**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic species with no known geographic variation (Marchant and Higgins 1993). Low number of sightings in Atlas surveys of the Murray-Darling Depression and estimated represent a moderate percentage of the national population (ANRA 2010b). Post 1990 records within the SA MDB floodplain and study area above Wellington suggest low numbers (96 and 32 respectively) and patchy distribution compared to other birds assessed in this study (BDBSA 2010). *Species with high abundance, wide distribution and high mobility have a greater potential capacity for genetic flexibility even if this does not translate directly into obvious expressions of different phenotypes e.g. significant geographic variation in morphologies. Abundance and distribution appears patchy especially within study area and no geographic variation is noted in the literature. Species should be considered at high risk.*	**H**	**H**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Common throughout eastern part of SA and lower south-east (Marchant and Higgins 1993). Low number of sightings in Atlas surveys of the Murray-Darling Depression and estimated to represent a moderate percentage of the national population (ANRA 2010b). Post 1990 records within the SA MDB floodplain and study area above Wellington suggest low numbers (96 and 32 respectively) and patchy distribution compared to other birds assessed in this study (BDBSA 2010). Considered 'rare' and in probable decline in Murraylands and Murray Scroll Belt and Murray Mallee IBRA sub-regions under IUCN criteria (Gillam and Urban 2010). *All indications that species is not very abundant and appears patchily distributed especially within study area although may be under-represented as species is cryptic. Regional and sub-regional rare status. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Little data on clutch sizes but thought to be 3-6 and commonly 5. Breeding season broadly from Aug-Jan but varies with longitude but may be earlier in west (Marchant and Higgins 1993), clutches found in South Australia from mid August to late November (SAAB 2001). No specific information on multiple or replacement brood capacity but rails commonly only have 1 or 2 broods per season and can lay up to 3 replacement clutches (Marchant and Higgins 1993). *Large clutch size compared to other birds assessed in this study but breeding season restricted to 4 months in late winter/early summer. Some evidence of double-clutching and replacement brooding but information derived at family level thus reducing confidence. Species should be considered at moderate risk but with low confidence due to data deficiencies and specific knowledge gaps.*	**L**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>Need water nest for food availability, if forced to forage widely due to habitat fragmentation will likely abandon nest. Could live to 6-7 years or maybe less (P. Wainwright pers comm. 2011).</u>	Common throughout eastern part of SA and lower south-east. No recent population estimates. Post 1990 records within floodplain suggest low numbers (96) compared to other birds assessed in this study. Little data on clutch sizes but thought to be 3-6 and commonly 5. Breeding season broadly from Aug-Jan but varies with longitude (may be earlier in west). Multiple or replacement broods are unknown. Success relies on maintenance of water levels in nest sites but mortality or success rates are not given in literature. Nests may be abandoned if water level drops and nests may be flooded if water level fluctuates significantly during breeding season (Marchant and Higgins 1993). Adult plumage attained in first year, age at first breeding unknown but rails can typically breed at 1 year or earlier (Marchant and Higgins 1993). Longevity is not described but as is a small bird it is probably short. *All indications that species is not very abundant and appears patchily distributed especially within study area although may be under-represented as species is cryptic. No recent estimates of national or regional population numbers reduces confidence in assessment. Large clutch size but short breeding season and dependent on stability of water levels for breeding success. Can probably breed within 1 year but not quantified at species level thus reducing confidence. Species should be considered at high risk but with low confidence.*	**L**	**H**

Scientific Name:	*Porzana pusilla*	**Common Name:**	Baillon's Crake

FAMILY: Rallidae

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>As a cryptic species, vegetation fragmentation e.g. through salinity, may expose it to increased predation (P. Wainwright pers comm. 2011).</u>	Permanent and ephemeral terrestrial and coastal wetlands, including marshes, swamps, peat bogs, billabongs, swampy creeks and rivers, lakes and reservoirs and marshy artificial wetlands (Marchant and Higgins 1993). Prefer fresh to brackish waters and occasionally saline but much less often (Blakers et al. 1984 as cited in SAAB 2001). Wetlands usually well vegetated, with dense and/or clumped vegetation and often abundant floating vegetation. May prefer wetlands subject to fluctuating water-levels (Bryant 1942; Moore 1983 as cited in Marchant and Higgins 1993). Reclamation of wetlands has decreased available habitat (Owen and Sell 1985 as cited in Marchant and Higgins 1993). Also reliance on dense vegetation adjacent to shallow portion of wetlands makes suitable habitat prone to destruction by grazing stock. Further drainage of wetlands also likely to have severe impacts on habitat availability (SAAB 2001). Changed hydrology and salinity are identified as major threats to populations in the Murray-Darling Depression (ANRA 2010a). *Species can use range of wetlands with salinities ranging from fresh to saline though more commonly in fresh and brackish systems with good vegetative cover. Uses shallow wetlands and margins as opposed to deeper bodies and may rely on more ephemeral wetlands. A transition from permanent, freshwater wetlands to more temporary and saline wetlands is expected through increased flow regulation to mitigate effects of climate change and drought and may increase this species' range. Species that do not need deep water for foraging are less at risk. Salinity problems may however reduce available fringing vegetation in some areas. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Probably migratory, with a regular north-south winter-summer migration likely. Seasonal movements are reported to take the bird out of the southern parts of its range from April to September. Reporting rates show marked seasonal changes. In the South-East and Murray-Darling Regions reporting rates were considerably higher in summer than winter. This is complicated by birds not calling in winter and therefore less conspicuous (Blakers et al. 1984 as cited in SAAB 2001)). May also move erratically in response to vegetation dieback, receding water levels and drought or into area of flooding or high rainfall (various studies cited in Marchant and Higgins 1993). *Reasonable evidence for high mobility and dispersion. Migrations occur mainly according to season but irruptions also noted in response to environmental variables. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>As a cryptic species, vegetation fragmentation e.g. through salinity, may expose it to increased predation (P. Wainwright pers comm. 2011).</u>	Smallest rail in HANZAB area weighing to 30g, noticeably smaller than Australian or Spotless Crakes. Usually prefer to flee rather than fight unless incubating in nest then display nest defense against intruders and less likely to leave. Breeding dispersion is typically in solitary pairs (Marchant and Higgins 1993). In Australia predation by foxes, feral cats and rats presumably important (SAAB 2001), often taken by feral and domestic cats and dogs (Marchant and Higgins 1993). Omnivorous. Mostly aquatic insects, including and also seeds, molluscs, crustaceans and some small vertebrates (Barker and Vestjens 1989; Marchant and Higgins 1993 as cited in SAAB 2001). *As a very small non-aggressive species with some nest defense capacity (only when incubating) and solitary nesting habits, risk through competition is likely to be high. Predation pressure from introduced animals is also noted as a significant factor. Food competition is less likely due to broad diet and small size of prey. Species should be considered at high risk.*	**H**	**H**
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Rarely in salt water (Blakers et al. 1984 as cited in SAAB 2001). Salinity of waters used by 3 birds in south-western Australia range 0.5-4.1ppt and pH 8.1 range of 7.7 – 8.5 (Goodsell 1990). In south-western Australia between July 1981 and May 1985, preferred brackish (total dissolved solids < 10 ppt), while in September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al. 1993). Changed hydrology and salinity are identified as major threats to populations in the Murray-Darling Depression (ANRA 2010a). Omnivorous. Consumes mostly aquatic insects but also seeds, molluscs, crustaceans and some small vertebrates (Barker and Vestjens 1989; Marchant and Higgins 1993 as cited in SAAB 2001). *Species can use range of wetlands with salinities ranging from fresh to brackish but rarely saline. Vegetative cover for foraging and roosting and concealment is important for survival. Uses shallow wetlands and margins as opposed to deeper bodies and may rely on more ephemeral wetlands. River regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation so may actually increase range within study area. Species should be considered at low risk.*	**H**	**L**

	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Rarely in salt water (Blakers et al. 1984 as cited in SAAB 2001). Salinity of waters used by 3 birds in south-western Australia range 0.548 – 4.100 ppt and pH 8.1 range of 7.7 – 8.5 (Goodsell 1990). In south-western Australia between July 1981 and May 1985, preferred brackish (total dissolved solids < 10 ppt), while in September of each year preferred wetlands with low salinity compared to wetlands on which they did not occur (Halse et al. 1993). Changed hydrology and salinity are identified as major threats to populations in the Murray-Darling Depression (ANRA 2010a). Omnivorous. Consumes mostly aquatic insects but also seeds, molluscs, crustaceans and some small vertebrates (Barker and Vestjens 1989; Marchant and Higgins 1993 as cited in SAAB 2001). Chicks are precocial and nidifugous and are quick to leave nest only spending a minimum of 1 day in the nest (Aust. NRS as cited in Marchant and Higgins 1993). Time to independence is unknown but rails typically fledge at 30-60 days (Marchant and Higgins 1993). *Species can use range of wetlands with salinities ranging from fresh to brackish but rarely saline. Vegetative cover for foraging and roosting and concealment is important for survival especially for more vulnerable juveniles. Uses shallow wetlands and margins as opposed to deeper bodies and may rely on more ephemeral wetlands. River regulation aims to achieve efficiency gains through creation of temporary wetlands and removal of artificial pool-level permanent wetlands as less water is lost to evaporation so may actually increase range within study area although changes to hydrology is noted as a major threat to population in the Murray-Darling. Chicks are precocial so require less parental investment, leave nest early and grow quickly to independence reducing risk. Species should be considered at moderate risk but with medium confidence due to specific knowledge gaps of growth and development in the species.*	**M**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Breed in pairs, solitarily and generally seasonally Sep-Jan, extending to Feb in exceptionally wet summers. In SA, recorded from early Sep to early Nov (Marchant and Higgins 1993). Nest in thick vegetation above shallow water, usually within 20m of edge of swamps, flooded lake beds, irrigation channels and in samphire in southern Australia, often with two small entrances through the vegetation, and typically around 16cm above water and 48cm below top of vegetation canopy (Marchant and Higgins 1993). Recorded abandoning nest presumably when swamp dried out (Bryant and Amos 1949 as cited in Marchant and Higgins 1993). No specific information on multiple or replacement brood capacity but rails commonly only have 1 or 2 broods per season and can lay up to 3 replacement clutches. Young are precocial and nidifugous leaving nest after 1 day. Time to independence is unknown but rails typically fledge at 30-60 days (Marchant and Higgins 1993). *Short breeding season in SA compared to other birds assessed in this study but may be extended through high rainfall. Climate change is likely to reduce average annual rainfall in the study area and may threaten breeding. Thick vegetation required for nesting may also suffer degradation through salinity and changes to hydrological regimes under climate change. Will also abandon nests if wetland dries. Short time in nest and presumably fast growth rate reduces pressure on parents and means young are less vulnerable for a shorter time. Moderate time to fledging, may lay a second brood and replace eggs but this is based on family information so confidence is reduced. Species should be considered at moderate risk but with medium confidence due to specific knowledge gaps.*	**M**	**M**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Populations appear restricted to lower south-east and upper reaches of River Murray close to Vic border in SA and also in Lake Eyre drainage basin and Eyre Peninsula. The species has been described as 'probably declining' within the AMLR and the species' relative area of occupancy is classified as 'Extremely Restricted' (DEH 2008). Probably more common than records suggest (Marchant and Higgins 1993) but very few records since 1990 within SA MDB floodplain (22) and even fewer (13) within the study area above Wellington (BDBSA 2010). Probably migratory, with a regular north-south winter-summer migration likely. Seasonal movements are reported to take the bird out of the southern parts of its range from April to September. Reporting rates show marked seasonal changes. In the South-East and Murray-Darling Regions reporting rates were considerably higher in summer than winter. This is complicated by birds not calling in winter and therefore less conspicuous (Blakers et al. 1984 as cited in SAAB 2001). Pair-bonding is probably monogamous but duration is unknown. On return to breeding areas birds appear to congregate before pairing up and dispersing to breed (Marchant and Higgins 1993). Considered 'critically endangered' and in 'probable decline' in Murray Mallee and Murray Scroll Belt IBRA sub-regions within study area (Gillam and Urban 2010). *All indications that species is not very abundant and patchily distributed especially within study area although may be under-represented as species is somewhat secretive. Seasonal migrations are noted for the species and may bring together birds from different regions but this would be affected by duration of monogamous pair-bond (presumably at least one season). Solitary nesting in pairs or in small loose colonies also raises threat to available gene pool. Restricted gene pool is likely so species should be considered at high risk but with medium confidence due to lack of specific studies into population genetics and duration of pair bonding.*	**M**	**H**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Breed in pairs, solitarily and generally seasonally Sep-Jan, extending to Feb in exceptionally wet summers. Pair-bonding is probably monogamous but duration is unknown. Probably migratory, with a regular north-south winter-summer migration likely (Blakers et al. 1984 as cited in SAAB 2001). On return to breeding areas birds appear to congregate before pairing up and dispersing to breed (Marchant and Higgins 1993). Populations appear restricted to lower south-east and upper reaches of River Murray close to Vic border in SA and also in Lake Eyre drainage basin and Eyre Peninsula. The species has been described as 'probably declining' within the AMLR and the species' relative area of occupancy is classified as 'Extremely Restricted' (DEH 2008). Probably more common than records suggest (Marchant and Higgins 1993) but very few records since 1990 within SA MDB floodplain (22) and even fewer (13) within the study area above Wellington (BDBSA 2010). *Species is probably not very abundant and appears patchily distributed especially within study area. Seasonal migrations presumably to breeding areas over summer would allows birds from different regions to pair up before dispersing to breed increasing chances of gene flow. Solitary nesting in pairs and monogamous pair bonds decreases gene flow opportunities although length of bond is unknown. Restricted gene flow is likely so species should be considered at high risk but with medium confidence due to lack of specific studies into population genetics and duration of pair bonding.*	**M**	**H**

	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic species with several distinct sub-species recognized throughout the globe separated through size and colour differences (Marchant and Higgins 1993). Appears Australian populations of species comprised of only one sub-species (Marchant and Higgins 1993), but this is not clear from the literature. Populations appear restricted to lower south-east and upper reaches of River Murray close to Vic border in SA and also in Lake Eyre drainage basin and Eyre Peninsula. The species has been described as 'probably declining' within the AMLR and the species' relative area of occupancy is classified as 'Extremely Restricted' (DEH 2008). Probably more common than records suggest (Marchant and Higgins 1993) but very few records since 1990 within SA MDB floodplain (22) and even fewer (13) within the study area above Wellington (BDBSA 2010). . Probably migratory, with a regular north-south winter-summer migration likely (Blakers et al. 1984 as cited in SAAB 2001). *Species with high abundance, wide distribution and high mobility have a greater potential capacity for genetic flexibility even if this does not translate directly into obvious expressions of different phenotypes e.g. significant geographic variation in morphologies. Abundance and distribution appears very patchy and sparse especially within study area. Seasonal migrations and post-breeding dispersion may offset this to a degree. Australian populations seem to be comprised of only one subspecies with no known variation within its range but this is not clear from the literature. Species should be considered at high risk.*	**H**	**H**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Populations appear restricted to lower south-east and upper reaches of River Murray close to Vic border in SA and also in Lake Eyre drainage basin and Eyre Peninsula. Population status is unknown but probably more common than records suggest (Marchant and Higgins 1993). The species has been described as 'probably declining' within the AMLR and the species' relative area of occupancy is classified as 'Extremely Restricted' (DEH 2008). Low reporting rates in Atlas surveys and Murray-Darling Depression hosts a moderate percentage of the national population (ANRA 2010b). Very few records since 1990 within SA MDB floodplain (22) and even fewer (13) within the study area above Wellington (BDBSA 2010) compared to other birds assessed in this study. Considered 'critically endangered' and in 'probable decline' in Murray Mallee and Murray Scroll Belt IBRA sub-regions within study area (Gillam and Urban 2010). *Probably very low abundance and appears patchily distributed especially within study area. Population occupancy area declines are noted for populations in SA. Sub-regional 'critically endangered' listings within study area. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Few studies, average from eight clutches was 5.9, ranges from 5-7 (Bryant 1942; Wheeler 1948; Aust. NRS as cited in Marchant and Higgins 1993). No specific information on multiple or replacement brood capacity but rails commonly only have 1 or 2 broods per season and can lay up to 3 replacement clutches (Marchant and Higgins 1993). *Good clutch size compared to other birds assessed in this study but this is based on few studies. Species may be able to double-clutch and lay replacement eggs but this is based on family level information. Species should be considered at low risk but with low confidence due to lack of studies and specific knowledge of breeding capacity.*	**L**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>Need water nest for food availability, if forced to forage widely due to habitat fragmentation will likely abandon nest. Could live to 6-7 years or maybe less (P. Wainwright pers comm. 2011).</u>	In SA, breeding season said to be from early Sep to early Nov (Marchant and Higgins 1993). Good clutch size (mean around 6 eggs) compared to other birds assessed in this study. Success rate is given at about 50% but based on very few studies (Aust. NRS as cited in Marchant and Higgins 1993). Age at first breeding and longevity are unknown but adult plumage attained in first year and rails can typically breed at 1 year or earlier (Marchant and Higgins 1993). Recorded abandoning nest presumably when swamp dried out (Bryant and Amos 1949 as cited in Marchant and Higgins 1993). Low reporting rates in Atlas surveys and Murray-Darling Depression hosts a moderate percentage of the national population (ANRA 2010b). Considered 'critically endangered' and in 'probable decline' in Murray Mallee and Murray Scroll Belt IBRA sub-regions within study area (Gillam and Urban 2010). *Good clutch size but short breeding season compared to other birds assessed in this study. Success rate is moderate to poor but based on little data. Likely to breed in first year but based on family level information. As a small bird, it probably has a short generation time but also short longevity. Probably small population base and reduced success during drought. Species should be considered at high risk but with low confidence due to lack of studies and specific knowledge of life history relating to recruitment.*	**L**	**H**

Scientific Name:	*Porzana tabuensis*	**Common Name:**	Spotless Crake

FAMILY: Rallidae

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change?	Permanent or ephemeral, terrestrial and littoral wetlands, usually contiguous with stands of tall emergent reeds, rushes, sedges or other vegetation, including rivers, streams, tidal creeks, lagoons, lakes, inundated depression, peat bogs and saltmarshes. Often use artificial wetlands such as saltworks, sewage farms, margins of reservoirs, irrigation channels and bores (Marchant and Higgins 1993). Halse et al. (1993) places species in group restricted to fresh to brackish wetlands with dense cover. Forage on mud or shallow water at the margins of the water-bodies, either in the open or adjacent to dense concealing vegetation (Marchant and Higgins 1993). Prefer wetlands with flowing water, but avoid deeper, swifter sections (Bryant and Amos 1949 as cited in Marchant and Higgins 1993). Occur in saline, brackish or fresh water. Usually breed in large, unbroken stands of dense, tall emergent vegetation e.g. reeds, rushes, sedges, grass tussocks and stands of dense shrubs, growing near water-bodies but sometimes can be a considerable distance away from water (Marchant and Higgins 1993). Large loss of suitable habitat through drainage of wetlands (Blakers et al 1984 as cited in SAAB 2001). *Species inhabits a wide range of wetland environments with salinity ranging from fresh to saline and also uses artificial environments. Seems to prefer fresh to brackish wetlands with dense fringing and riparian vegetation. These habitats are susceptible to degradation through drainage, changes to salinity and hydrological regime and may be detrimental under climate change however may be offset by use of artificial impoundments. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Movements are poorly known. There may be some seasonal movement, with reporting rates in the South East and Murray-Darling region and South Australian range decreasing from summer to winter. However secretive nature of bird makes reporting rates unreliable (for example birds are probably much less conspicuous in winter when not calling). Reportedly able to travel long distances (Blakers et al. 1984 as cited in SAAB 2001) and large scale irruptions evidenced in influxes to Wentworth along Murray and Narrandera following good rainfall (NSW Bird Rep. 1981 as cited in Marchant and Higgins 1993). *Seasonal movements likely but uncertain of extent due to cryptic nature of bird particularly in winter. Reported to make long distance movements and large scale irruptions in response to water availability. Species probably has good capacity for mobility and dispersion and should be considered at low risk but with medium confidence as conclusive data and specific studies in SA MDB are deficient.*	**M**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Small bird to 50g, Solitary nature in pairs or in loose groups. Generally secretive, wary and shy, rarely venturing into the open to feed as do other *Porzana* crakes, often remaining in dense cover when foraging. Potential threats in SA include adverse affects of wild pigs on habitat (especially on Kangaroo Island). Also predation by feral cats and rats may be significant (Blakers et al. 1984 as cited in SAAB 2001; Marchant and Higgins 1993), and human disturbance may cause birds to destroy own eggs (Bryant and Amos 1949 as cited in SAAB 2001). Omnivorous, eats seeds, fruits, shoots of grasses and aquatic plants, adult and larval insects, molluscs, crustaceans, spiders and carrion (Barker and Vestjens 1989 as cited in SAAB 2001; Marchant and Higgins 1993). *Broad omnivorous diet of small items means limitation through food competition is unlikely. Predation by feral animals is noted as a significant factor in some areas and may be increased through climate change as introduced animals often possess competitive advantages in limiting environments. Small size, non-aggressive and solitary nature also increases risk (compared to large and colonial or flocking birds) but as is quite cryptic this risk may be offset to a large extent. Species should be considered at moderate risk.*	**H**	**M**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Is the only crake normally occurring in acidic (pH <6), fresh (<0.3 ppt), heavily vegetated swamps of south-west Western Australia (R.P. Jaensch pers. comm. as cited in Marchant and Higgins 1993). In south-western Australia between July 1981 and May 1985, preferred fresh (TDS < 3ppt), neutral (pH 6.6-7.4) wetlands with low (< 0.10 mg/L) phosphorus levels (Halse et al. 1993). Halse et al. (1993) places species in group restricted to fresh to brackish wetlands with dense cover. Often use artificial wetlands such as saltworks, sewage farms, margins of reservoirs, irrigation channels and bores (Marchant and Higgins 1993). Generally secretive, wary and shy, rarely venturing into the open to feed as do other *Porzana* crakes, often remaining in dense cover when foraging (Marchant and Higgins 1993). Forage on mud or shallow water at the margins of the water-bodies, either in the open or adjacent to dense concealing vegetation (Marchant and Higgins 1993). Omnivorous, eats seeds, fruits, shoots of grasses and aquatic plants, adult and larval insects, molluscs, crustaceans, spiders and carrion (Barker and Vestjens 1989 as cited in SAAB 2001; Marchant and Higgins 1993). *Broad omnivorous diet of small items means food limitation is unlikely unless environment becomes degraded beyond tolerances of food items (plants, insects but more importantly filter feeding molluscs and crustaceans). Preferred fresh to brackish wetlands with dense cover habitats are susceptible to degradation through drainage, changes to salinity and hydrological regime and may be detrimental under climate change however may be offset by use of artificial impoundments. As a shy, cryptic species, it relies on presence of dense cover for concealment; loss of these habitats would affect survivorship. While preference is given to fresh-brackish systems with low nutrient levels, also known to use saltworks and eutrophic sewage farms suggesting the species has wide survival tolerances. Species should be considered at moderate risk.*	**H**	**M**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Mean salinity of waters used by 5 broods in south-western Australia 1.5ppt (range 0.700 – 2.45), mean pH 7.5 (range 6.9–8.2) (Goodsell 1990). Usually breed in large, unbroken stands of dense, tall emergent vegetation e.g. reeds, rushes, sedges, grass tussocks and stands of dense shrubs, growing near water-bodies but sometimes can be a considerable distance away from water. Chicks are semi-precocial and nidifugous, spending 1-2 days in nest and then able to swim proficiently and presumably feed independently. Generally secretive, wary and shy, rarely venturing into the open to feed as do other *Porzana* crakes, often remaining in dense cover when foraging (Marchant and Higgins 1993). *Breeding territories are usually fresh to brackish wetlands with dense cover and are susceptible to degradation through drainage, changes to salinity and hydrological regime and may be detrimental under climate change. As a shy, cryptic species, it relies on presence of dense cover for concealment and this is probably more important for vulnerable juveniles; loss of these habitats would affect survivorship in the growth phase. Young are well developed at hatching and leave nest early and are probably able to feed independently quite soon compared to other birds assessed in this study. This reduces risk to species as young are less vulnerable for a shorter time. Species should be considered at moderate risk.*	**H**	**M**

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Usually breed in large, unbroken stands of dense, tall emergent vegetation e.g. reeds, rushes, sedges, grass tussocks and stands of dense shrubs, growing near water-bodies but sometimes can be a considerable distance away from water (Marchant and Higgins 1993). Recorded breeding near noisy schoolyard. Mean salinity of waters used by 5 broods in south-western Australia 1.475ppt (range 0.700-2.450), mean pH 7.5 (range 6.9-8.2) (Goodsell 1990). Monogamous and pair-bonds possibly life-long. Breed solitarily in pairs in breeding territories and display strong territoriality especially just prior to laying. Breeding is probably seasonal, occurring early Sep to early Dec, sometimes extending into Jan. In SA, eggs recorded from mid Nov to mid Jan (Morton 1953 as cited in Marchant and Higgins 1993). Nest usually over water, alongside flowing streams or near the edge of the water-body in dense vegetation, including reeds, rushes, grass tussocks, small shrubs and even in blackberries. Average height above the water of 11 nests 32cm (range 3-91 cm), and average depth below the top of the vegetation of nine nests 71 cm, (range 15-150 cm) (Australian Nest Record scheme, as cited in Marchant and Higgins 1993). Nests may be flooded if water levels fluctuate significantly during breeding season (SAAB 2001). *Short breeding season compared to other birds assessed in this study. Seem to prefer nesting over water or in close proximity to fresh water bodies but also noted as nesting further away suggesting some flexibility. Main factor is presence of suitable dense vegetation for concealment of nests, young and parents though the type of vegetation does not seem important as long as it is structurally suitable. Main threats under climate change relate to degradation of dense aquatic and riparian vegetation possibly through salinity, drought and altered hydrological regimes in an increasingly managed sytem. Flooding of nest sites may also be a threat if flood mitigation and flow regulation are not managed carefully. Species should be considered at moderate risk.*	**H**	**M**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	Probably abundant in many areas but secretive nature of bird makes assessment of population difficult and are often overlooked. Monogamous and pair-bonds possibly life-long and breed solitarily in pairs in breeding territories and display strong territoriality especially just prior to laying (Marchant and Higgins 1993). There may be some seasonal movement, with reporting rates in the South East and Murray-Darling region and South Australian range decreasing from summer to winter. However secretive nature of bird makes reporting rates unreliable (for example birds are probably much less conspicuous in winter when not calling). Reportedly able to travel long distances (Blakers et al. 1984 as cited in SAAB 2001) and large scale irruptions evidenced in influxes to Wentworth along Murray and Narrandera following good rainfall (NSW Bird Rep. 1981 as cited in Marchant and Higgins 1993). In South Australia most records in south with occasional records in the mid-North (Blakers et al. 1984 as cited in SAAB 2001), and recorded twice on eastern Eyre Peninsula (Pedler 1978 as cited in SAAB 2001). Several records from the north-east, including the Lake Eyre basin, Cooper Creek and Coongie Lakes district (Cox and Pedler 1977; Badman 1979; Blakers et al. 1984; Reid 2000 all as cited in SAAB 2001). Listed as 'rare' under NPW Act 1972, 'vulnerable' in DENR Murraylands region and Murray Scroll Belt IBRA sub-region and 'endangered' and in 'probable decline' in Murray Mallee (Gillam and Urban 2010). *Probably a small population base nationally and in SA and especially within the study area limits available gene pool. Studies indicate species has ability to move long distances and some seasonal migrations are also likely in the SA MDB region increasing chance of mixing. Long-term, monogamous pair-bonds (probably life-long) and solitary breeding (as opposed to colonial) negates advantages of dispersion and mobility. Gene pool is likely to be limited and species should be considered at high risk.*	**H**	**H**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Monogamous and pair-bonds possibly life-long. Breed solitarily in pairs in breeding territories and display strong territoriality especially just prior to laying (Marchant and Higgins 1993). Movements are poorly known. There may be some seasonal movement, with reporting rates in the South East and Murray-Darling region and South Australian range decreasing from summer to winter. However secretive nature of bird makes reporting rates unreliable (for example birds are probably much less conspicuous in winter when not calling). Reportedly able to travel long distances (Blakers et al. 1984 as cited in SAAB 2001) and large scale irruptions evidenced in influxes to Wentworth along Murray and Narrandera following good rainfall (NSW Bird Rep. 1981 as cited in Marchant and Higgins 1993). *Probably a small population base nationally and in SA and especially within the study area limit genetic diversity and flow. Studies indicate species has ability to move long distances and some seasonal migrations are also likely in the SA MDB region increasing chance of flow between different populations but long-term, monogamous pair-bonds (probably life-long) negates advantages of dispersion and mobility. Gene flow is likely to be limited and species should be considered at high risk.*	**H**	**H**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Polytypic species but geographic variation is slight. Australian and NZ birds previously considered as a separate subspecies however morphological differences vary too much to properly support delineation. Two subspecies recognized in New Guinea but status requires confirmation (Marchant and Higgins 1993). *Some geographic variation noted for birds within Aust. although delineation is clouded by variance at smaller scales. A lack of genetic profiles and specific population studies in Aust. limits confidence in assessment. Likely that species has a capacity for some plasticity considering morphological differences noted but extent is unclear. Phenotypic plasticity may also be limited through low abundance and patchy distribution of species in the SA MDB region. Species should be considered at moderate risk but with low confidence due to lack of studies and inconclusive taxonomy of subspecies.*	**M**	**M**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Probably abundant in many areas but secretive nature of bird makes assessment of population difficult and are often overlooked (Marchant and Higgins 1993). In South Australia most records in south with occasional records in the mid-North (Blakers et al. 1984 as cited in SAAB 2001), and recorded twice on eastern Eyre Peninsula (Pedler 1978 as cited in SAAB 2001). Several records from the north-east, including the Lake Eyre basin, Cooper Creek and Coongie Lakes district (Cox and Pedler 1977; Badman 1979; Blakers et al. 1984; Reid 2000 all as cited in SAAB 2001). Atlas surveys recorded a low number of sightings within the Murray-Darling Depression bioregion estimated to represent a moderate proportion of the national population (ANRA 2010b). BDBSA records within SA MDB floodplain since 1990 are sparse (95) and fewer (51) within study area above Wellington (BDBSA 2010). Listed as 'rare' under NPW Act 1972, 'vulnerable' in DENR Murraylands region and Murray Scroll Belt IBRA sub-region and 'endangered' and in 'probable decline' in Murray Mallee (Gillam and Urban 2010). *Reasonable evidence to suggest small population within Aust., SA MDB and the study area above Wellington. Species should be considered at high risk.*	**H**	**H**
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	As few as two and as many as six in poor and favourable conditions respectively. Known to lay replacement and second clutches (Marchant and Higgins 1993). *Moderate clutch size compared to other birds assessed in this study and also possess capacity for double-brooding. Overall, potential fecundity is moderateon averagecompared with the other bird species assessed. Species should be considered at moderate risk.*	**H**	**M**

	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	As few as two and as many as six eggs per clutch in poor and favourable conditions respectively. Generally 3-4 eggs per clutch and species is known to double clutch and will replace eggs upon failure or removal (Marchant and Higgins 1993). Breeding is probably seasonal, occurring early Sep to early Dec, sometimes extending into Jan. In SA, eggs recorded from mid Nov to mid Jan (Morton 1953 as cited in Marchant and Higgins 1993). Listed as 'rare' under NPW Act 1972, 'vulnerable' in DENR Murraylands region and Murray Scroll Belt IBRA sub-region and 'endangered' and in 'probable decline' in Murray Mallee (Gillam and Urban 2010). *Short breeding season compared to other birds assessed in this study. Will reduce clutch size in unfavourable conditions and climate change may increase the frequency and magnitude of these conditions (e.g. drought, flood timing/magnitude, temperatures, habitat availability). Probably a small population base especially in the study area that would limit recruitment in the regional population. Species should be considered at high risk.*	**H**	**H**

Scientific Name:	Sticonetta naevosa	**Common Name:**	Freckled Duck

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change.	'Feed by filtering and dabbling, which limits foraging to aquatic habitats especially shallow productive waters or soft mud at wetland edges (Marchant & Higgins 1990)'. 'In breeding range (L. Eyre and Murray-Darling Basins) prefer fresh densely vegetated waters particularly floodwater swamps and creeks vegetated with lignum (*Muehlenbeckia*) or canegrass (*Eragrostis*) (Hobbs 1961; Frith 1965)'. 'During dry season or drought birds move off ephemeral breeding swamps, and occupy large permanent open waters…particularly lakes and reservoirs >100ha (Marchant & Higgins 1990)'. 'Flooding of inland rivers critical to creation of breeding habitat, by filling inland swamps and wetlands with dense surrounding vegetation (SAAB 2001)'. Utilises waters with range of salinities from fresh to relatively saline, up to 37,210uS/cm documented (Kingsford & Porter 1994) but said to prefer brackish wetlands and require fresh or brackish waters for breeding (Goodsell 1990). Recorded utilizing primarily managed temporary wetlands with wetting and drying regime within study region (Harper pers. com; Waanders pers. com.). ***Reduction in flooding and productive temporary wetland habitat and large lignum swamps, and an increase in surface water salinity (particularly in breeding swamps) will significantly decrease breeding and foraging habitat availability for the species within its range. However breeding is virtually absent within the study region so the extent of impact on habitat is reduced. 'Habitat' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change.	'In wet years freckled duck are largely sedentary but in dry years disperse widely (Frith 1965)'. In most years appear to be nomadic between ephemeral inland wetlands (SAAB 2001). ***Species capable of regular long distance movements. 'Mobility & dispersal' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L

	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Specialist filter feeder (Crome 1985). 'Mosquito fish, on the other hand, are carnivores and may compete directly with waterfowl for invertebrates. They are very effective predators and can greatly reduce plankton and insect populations. Other carnivorous fish compete with waterfowl. For example perch, *Perca fluviatilis*, competes with goldeneye, *Bucephala clangula*, (Eriksson 1979, 1983; Eadie and Keast 1982) but not with mallard, or teal, *A. crecc* (Hurlbert et al. 1972 [in Crome 1986])'. ***It is expected that reduced river flows will lead to a significant decrease in high productivity ephemeral wetland filter feeding habitat and introduced fish would compete with species for food source. Decline in 'lignum breeding swamps' with reduced flood events would increase competition for available habitat though extent of impact is reduced within study region. 'Competition' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	L	M
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'During dry season or drought birds move off ephemeral breeding swamps, and occupy large permanent open waters in breeding and non-breeding ranges, particularly lakes and reservoirs >100ha in area and with salinities up to 34 ppt (Marchant & Higgins 1990). Unlike, breeding wetlands, many have little emergent or aquatic vegetation; where fringing vegetation occurs it is avoided (Marchant & Higgins 1990) '. Utilises waters with range of salinities from fresh to relatively saline, up to 37,210uS/cm documented (Kingsford & Porter 1994) but said to prefer brackish wetlands and require fresh or brackish waters for breeding, with broods in WA recorded at salinities 1.900-11.500 g/L (approx. 1140-6900 uS/cm) (Goodsell 1990). ***Though flooded lignum wetlands are required for breeding, away from breeding habitat e.g. when utilising drought refuge habitat within study region, species is not documented to have specific water regime requirements and uses range of habitat types, appearing to prefer sites with little vegetation and tolerating relatively high salinity (saline wetlands provide good filter feeding opportunities). 'Survival tolerances' are expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Feed by filtering and dabbling, which limits foraging to aquatic habitats especially shallow productive waters or soft mud at wetland edges (Marchant & Higgins 1990)'. Utilises waters with range of salinities from fresh to relatively saline, up to 37,210uS/cm documented (Kingsford & Porter 1994). ***Tolerant of salinity but due to filter feeding habit and reduced food source as result of decrease in productive ephemeral wetland habitat and the need to disperse more widely for resources potential tfor growth, health and/or development to be limited to some degree. 'Growth tolerances' are expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	L	M
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Flooding of inland rivers critical to creation of breeding habitat, by filling inland swamps and wetlands with dense surrounding vegetation (SAAB 2001)'. Wetting and drying cycles of temporary wetlands important for triggering breeding (Braithwaite & Frith 1969). Require fresh or brackish waters for breeding, with broods in WA recorded at salinities 1.900-11.500 g/L (approx. 1140-6900 uS/cm) (Goodsell 1990). ***Reduced flooding of ephemeral breeding swamps and interruption of natural wetting and drying cycles throughout species range will significantly reduce breeding rates of population. However breeding is virtually absent within the study region so reproductive tolerances are of reduced relevance, e.g. minor limitation to the ability of the regional population of the species to tolerate climate change.***	H	L

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	'Extent of occurrence believed stable, area of occupancy fluctuating, and number of breeding birds [national population] estimated at 20,000 also fluctuating (Garnett & Crowley 2000 [in SAAB 2001])'. '…widely distributed in southern Australia (Frith 1965)'. Listed as vulnerable in South Australia (NPW 1972). Small population size within study region (M. Harper & P. Waanders pers. com.). 'In wet years freckled duck are largely sedentary but in dry years disperse widely (Frith 1965)'. ***Though no information on the species gene pool was found documented, with a relatively small population size but moderate distribution and good dispersal ability 'gene pool' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	L	M
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	'…widely distributed in southern Australia (Frith 1965)'. 'Extent of occurrence believed stable, area of occupancy fluctuating, and number of breeding birds [national population] estimated at 20,000 also fluctuating (Garnett & Crowley 2000 [in SAAB 2001])'. 'In wet years freckled duck are largely sedentary but in dry years disperse widely (Frith 1965)'. In most years appear to be nomadic between ephemeral inland wetlands (SAAB 2001). 'Seasonal short term sequential monogamous bonds probably normal (Marchant & Higgins 1990)'. ***Though no information on gene flow within the species was found documented, with a fluctuating distribution and population and variable dispersal and some level of monogamous pair bonding 'gene flow' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	***Unknown: no information found on the extent that 'phenotypic plasticity' limits the ability of the regional population of the species to tolerate climate change?***	L	M
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Listed as *vulnerable* in South Australia (NPW 1972). ***Small population size: 'Population size' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	H	H
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	There are very few current or historical records of the species breeding within the study region and as a result local habitat is considered to have little importance for the breeding population of the species. ***'Reproductive capacity' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	There are very few current or historical records of the species breeding within the study region and as a result local habitat is considered to have little importance for the breeding population of the species. ***'Recruitment' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L

Scientific Name:	*Threskiornis spinicollis*	Common Name:	Straw-necked Ibis

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? Breeding colonies in temporary wetlands in River Murray e.g. Woolpolool, Watchals Lagoon (Moorook). Recently inundated wetlands such as these have triggered large breeding events. River regulation likely to make more temporary wetlands (efficiency gains through less evaporation) and remove artificial pool-level permanent wetlands (P. Wainwright 2010, pers. Comm.).	Commonly feed in saltmarsh in Australia, forage in deep or shallow water. Prefer pasture and cultivated land where land is wet. Grasslands, cultivated land, terrestrial wetlands with semi-aquatic herbs, abundant aquatic vegetation and tall emergent vegetation. Coastal and saline habitat (estuarine mudflats and saltmarsh, coastal dunes and beaches) occasionally used but mainly distributed away from coast (Ecological Associates 2010). Birds use pasture only where stands of woodland for roosting remain intact. Natural freshwater wetlands used for breeding have been destroyed or modified by drainage, clearing, grazing, burning, increased salinity, groundwater extraction and invasion of introduced plants. Widespread use of temporary waters threatened by flood mitigation and irrigation works but range may also have increased through the beneficial clearing of wooded areas, conversion to pasture and cropland, irrigation schemes and construction of impoundments that the birds take advantage of (Marchant and Higgins 1990). *Broad and flexible habitat requirements for growth and survival but generally prefer fresh wetlands and distributed mainly inland away from coasts. Less likely to occupy saline environments as is probably occupied by other large waders e.g. white ibis better adapted for coastal environments, but will use artificial environments. Increased river management likely under climate may provide added temporary wetland breeding habitat. Species should be considered at moderate risk*	**H**	**M**
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Partially migrant with some birds probably sedentary near breeding sites, other regularly travel long distances either seasonally or as local conditions vary. Two major seasonal migratory trends: N-S in spring/summer, and north in autumn-winter, regular movement between coastal refuges and inland breeding sites but may be mainly immature birds (Marchant and Higgins 1990). Bird moves to coastal areas seasonally and in times of drought (studies cited in Gosper et al. 1983). Ability of ibises to opportunistically colonize new areas and adapt their nesting behaviour so that natural or human-induced water regimes may be better exploited places these species at a much lower conservation risk than other colonially-nesting species (Leslie 2001). *Demonstrated ability to disperse and migrate in response to changing conditions reduces threat, species should be considered at low risk*	**H**	**L**
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Wide range of small animals depending on habitat but including: frogs, crustaceans (diverse range of taxa including freshwater crayfish, isopods, shrimp, crabs), fish, insects (diverse range of taxa), molluscs (including freshwater snails, mussels, bivalves, gastropods), spiders, reptiles (lizards, snakes), rats, mice (Ecological Associates 2010). Nests among stands of reeds or lignum, on the ground on islands and occasionally in trees (Marchant and Higgins 1990). *Diverse diet means competition for food is limited as species can switch where needed, nesting sites are varied also so reduces potential for space competition, species should be considered at low risk*	**H**	**L**

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	General habitat and dietary requirements (Marchant and Higgins 1990). Tolerant of slightly acidic waters on average, but only where the waters were fresh (Ecological Associates 2010). *Generalist nature of habitat and diet puts species at low risk through survival limitations*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Fed by parent until around 6 weeks after hatching (fledge at 4 weeks). Diet, growth and development is not described in literature but assumed to consist of incomplete regurgitate from the broad adult diet (Marchant and Higgins 1990). Breeding more extensive at swamps that have dried and refilled (i.e. temporary wetlands) producing high levels of organic matter, complex flora and diverse invertebrate populations (Crome 1988). *Diverse adult diet means food limitation unlikely for young but studies lacking. Adult foraging distance may be affected through climate change where increased drying and fragmentation of wetlands occurs providing a risk to the species particularly when needing to feed young at close intervals. Young are independent relatively quickly reducing risk to species as parental investment is reduced and may be able to double-brood in one season (e.g. white ibis). Species may also be able to take advantage of newly created ephemeral wetlands through increased management of system under climate change. Conservatively the species should be considered at moderate risk*	**L**	**M**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? <u>Breeding colonies in temporary wetlands in River Murray e.g. Woolpolool, Watchals Lagoon (Moorook). Recently inundated wetlands such as these have triggered large breeding events. River regulation likely to make more temporary wetlands (efficiency gains through less evaporation) and remove artificial pool-level permanent wetlands (P. Wainwright 2010, pers. Comm.).</u>	Breeding widespread in Australia. Breed communally in fresh, brackish or saline wetlands, vegetated with reeds, shrubs or trees in which nests are built. May nest on ground on islands or wetland margins. In eastern Australia breeding conditions usually created with flooding, but permanent wetlands with stable waters also used (Ecological Associates 2010). Breeding more extensive at swamps that have dried and refilled (i.e. temporary wetlands) producing high levels of organic matter, complex flora and diverse invertebrate populations (Crome 1988). *Strong evidence of hydrological influence on breeding for inland colonies. Species shows broad nesting and reproductive tolerances but distribution away from coast and opportunistic use of ephemeral wetland suggests preference for freshwater, highly productive wetland systems. The occurrence of these temporary wetlands may increase under climate change potentially benefiting species. Species should be considered at low risk*	**H**	**L**
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? <u>Large migratory breeding movements known. Birds seen coming from all over Australia to breed in Lake Eyre Basin following a flood event hence provides a very large potential gene pool (P. Wainwright 2010, pers. Comm.).</u>	Known to undertake large scale migration to inland breeding sites and are a colonial nesting species. Most abundant and widespread of Australia's ibises, Australian range has increased, through the beneficial clearing of wooded areas, conversion to pasture and cropland, irrigation schemes and construction of impoundments (Marchant and Higgins 1993). *No specific information on population genetic structure or diversity but identified in literature as widespread and abundant. Migratory and colonial nature brings together populations from various regions to breed. Species then has a very diverse potential gene pool and should be considered at low risk*	**H**	**L**

	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Banding studies reveal substantial mixing of birds from north and south of mainland driven mainly by juvenile dispersion after fledging (Marchant and Higgins 1990) and no evidence of return (philoparty) (Lowe 1984 as cited in Marchant and Higgins 1990). *Partially migrant with regular north-south migrations, dispersive after fledging means population mixing and gene flow is likely to occur. Species should be considered at low risk*	**H**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic and no evidence of geographic variation (Marchant and Higgins 1993), possible hybridization with *T. aethiopicus* but little detail given (Beckle 1982 as cited in Marchant and Higgins 1990). *No evidence of phenotypic variation or associated adaptive capacities but species has a large and diverse potential gene pool. Range of species means that geographic isolation is unlikely and subsequent speciation in response to local conditions does not occur. This aspect of the bird's biology is therefore irrelevant to the capacity of the species to tolerate climate change and should therefore be considered at low risk*	**H**	**L**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change? <u>Recently inundated wetlands such Woolpolool and Watchals Lagoon have triggered large breeding events. River regulation likely to make more temporary wetlands (efficiency gains through less evaporation) and remove artificial pool-level permanent wetlands (P. Wainwright 2010, pers. Comm.)</u>.	Most abundant and widespread of Australia's ibises, Australian range has increased, through the beneficial clearing of wooded areas, conversion to pasture and cropland, irrigation schemes and construction of impoundments (Marchant and Higgins 1993). Declining in Lake Alexandrina and Lake Albert (both now zero), variable in Coorong and stable in Murray Estuary (Ecological Associates 2010). Severe (99.9%) decline in population in South Lagoon of Coorong since 1985 (Paton et al 2009). 677 records since 1990 within floodplain, majority in Lower Lakes (522), 87 in Murray Mallee and 63 in Murray Scroll Belt (BDBSA 2010). IBRA sub-regionally listed as vulnerable and in probable decline in Murray Mallee and Murray Scroll Belt (Gillam and Urban 2010). *According to most studies, population trends in SA MDB are declining. Other literature states it is most widespread and abundant ibis species and may also be extending its range e.g. through farming practices and river regulation creating more temporary wetlands. BDBSA records indicate a moderate population size compared to white ibis but more widely distributed to north of system. Simlilar IBRA sub-regional status. Species should be considered at moderate risk.*	**H**	**M**
Resilience	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Moderate clutch size generally recorded as 2-5 eggs incubated by both parents, hatching is asynchronic. No information on laying intervals, replacement broods or number of brood per year (Marchant and Higgins 1990). *Moderate clutch size reduces risks but limited quantified data on reproduction e.g. capacity for multiple broods, means this species should be treated conservatively in relation to reproduction and be considered at moderate risk*	**L**	**M**
Resilience	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change? <u>Recently inundated wetlands such Woolpolool and Watchals Lagoon have triggered large breeding events. River regulation likely to make more temporary wetlands (efficiency gains through less evaporation) and remove artificial pool-level permanent wetlands (P. Wainwright 2010, pers. Comm.)</u>.	Breeding in Australia is widespread on mainland except dry central and western districts of country. Breed colonially often in large groups with other ibises. Breeding season varies due to heavy influence of water levels, flood and drought but in SA defined around Aug-Dec. No information exists on recruitment success rates (Marchant and Higgins 1990). *Climate change is likely to alter hydrological regimes that is linked to breeding cycles in this species increasing risk to species. Large recruitment events noted after signinficant flooding of inland breeding sites, flow regulation id carefully applied may benefit species by providing additional ephemeral wetland breeding sites. Deficiency of specific information on reproductive success or recruitment rates means forces conservative treatment. Species should be considered at moderate risk*	**L**	**M**

Scientific Name:	*Threskiornis molucca*	Common Name:	Australian White Ibis

Question		Comments/ Reference	Confid	Vul Rating
Ecology	To what extent does ***habitat*** limit the ability of the regional population of the species to tolerate climate change? <u>More coastal species than straw-necked hence association with Lower Lakes and Coorong. Potential losses of breeding habitat through degradation but may be negated if river management is carefully applied through provision of more temporary wetlands that the species can use for breeding (P. Wainwright 2010, pers. Comm.).</u>	Inhabits wetlands of almost any sort, terrestrial wetlands, sheltered marine habitats and grasslands and commonly feeds in saltmarsh. Species is significantly associated with the Murray estuary, Lower Lakes and Coorong. Nocturnal roosts in trees on seashore or over water in freshwater marshes, or rivers. Prefers feeding in shallow water over soft substrate or on muddy flats and shores and away from wetlands in moist grasslands often in open areas or where vegetation is sparse (Ecological Associates 2010). *Wide habitat preferences reduce threat level and associated with temporary wetlands for breeding. More suited to coastal and saline environments and able to utilise temporary wetlands for breeding but only if management is conducted carefully. Species should be considered at low risk.*	H	L
	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change?	Adults sedentary in SE Australia and partial migrants in SW, immature birds move widely. Movement of adults is little known but probably in response to water availability. Victorian studies indicate adults they might be sedentary but long-distance movement of birds occurs where water levels fluctuate seasonally or irregularly (Marchant and Higgins 2001). *Limited mobility and dispersal of some adult populations increases threat level however species has shown ability to relocate if conditions become unsuitable and also show long distance movement to recently flooded wetlands to breed. Post breeding dispersion is high and immature birds move widely. Species should be considered at low risk.*	H	L
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change? <u>Colonially breeding species have less competition and predation (P. Wainwright 2010, pers. Comm.).</u>	Sometimes nests in such high density (e.g. 5 per m^2) they touch and become one large platform (Marchant and Higgins 2001). *No mention of direct interactions with other species in literature. Generalist diet and habitat preferences reduce threat of competition through being able to adapt to different environments. Will nest at very high densities so space competition not as large factor as for some species and colonial nesters suffer less predation pressure. Species should be considered at low risk.*	H	L

Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Piscivores/carnivores that forage in deep or shallow water, fish, frogs, crustaceans (diverse range of taxa including freshwater crayfish, isopods, shrimp, crabs), insects (diverse range of taxa), molluscs including freshwater mussels, spiders, earthworms, and occasionally snakes, also take carrions (Ecological Associates 2010). Ability of ibises to opportunistically colonize new areas and adapt their nesting behaviour so that natural or human-induced water regimes may be better exploited places these species at a much lower conservation risk than other colonially-nesting species (Leslie 2001). Broad tolerance to range of salinities from fresh to brackish and saline habitats and artificial wetlands (Marchant and Higgins 2001). *Broad feeding biology coupled with flexible habitat requirements place species at low risk through survival limitations.*	**H**	**L**
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Nestlings take an average of 48 days to abandon nest and are fed regurgitate by both parents; following fledging young may be fed for around 21 days and some may stay for months being fed occasionally (Marchant & Higgins 1990). To initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least five and up to 10 months following flooding, this may be affected by river regulation and water extractions (Briggs and Thornton 1999). *Broad diet of adults means food is unlikely to be limited for juveniles, relatively long parental care disadvantages species as puts extra pressure on parents and young are vulnerable for longer. Reliance on long term wetland inundation for fledging success may limit species if flow regulation is badly applied. Species should be considered at high risk.*	**H**	**H**
	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change? Feared losses of breeding habitat through degradation but may be negated if river management is carefully applied through provision of more temporary wetlands that the species can use for breeding (P. Wainwright 2010, pers. Comm.).	Breed in fresh, brackish or saline wetlands vegetated with reeds, shrubs, or trees in which nests are built. Suggested that coastal breeding is stimulated by seasonal rise in water levels, but inland associated with drying and wetting cycles (Ecological Associates 2010). The interval between breeding episodes during extended drought periods was identified as most critical factor likely to affect long-term stability or persistence of breeding. Ibises are able to opportunistically colonize new areas and adapt their nesting behaviour so that natural or human-induced water regimes may be better exploited (Leslie 2001). To initiate and complete breeding, and for their young to fledge, water needs to remain under nest trees for at least five and up to 10 months following flooding (Briggs and Thornton 1999). Breeding more extensive at swamps that have dried and refilled (i.e. temporary wetlands) producing high levels of organic matter and complex flora and diverse invertebrate populations (Crome 1988). *Dependence on floodwaters to initate and complete breeding but will use wetlands with varying water quality. Flood frequency and magnitude expected to decrease under climate change. River management may provide more temporary wetlands that the species can use for breeding. This species should then be considered at moderate risk of reproductive limitations.*	**H**	**M**

Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change? Migratory and colonial breeding so not as significant a factor as in straw-necked ibis (P. Wainwright 2010, pers. Comm.).	Declining numbers in inland breeding areas (Smith and Munro 2010) and dramatic losses in Lower Lakes since 2006 (Ecological Associates 2010). Long distance migrations not regularly recorded for species, some irregular movements possibly in response to water availability but thought generally sedentary in optimal habitats. Movement to coast for breeding in dry years noted (Marchant and Higgins 1990). Relatively high number of records (516) within study area since 1990 and 3568 in SA MDB floodplain, majority of these records around Lower Lakes (BDBSA 2010). Not nationally threat listed but proposed sub-regional listing as 'vulnerable' and in probable decline in Murray Scroll Belt within study area (Gillam and Urban 2010). *Declining population numbers are a concern; it is still commonly recorded in Lower Lakes but is very sparse within study area above Wellington to state border and sub-regionally listed (IBRA) as vulnerable. A colonial breeder and forms large dense colonies. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	Long distance migrations not regularly recorded for species, some irregular movements possibly in response to water availability with birds being absent from inland breeding sites in dry years when birds move toward coast to breed (Marchant and Higgins 1990). *Gene flow is likely to be relatively good given large size of breeding colonies commonly recorded and widespread abundance. Species should be considered at low risk.*	**H**	**L**
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	Monotypic although 3 subspecies previously identified, status however is unclear. Subspecies differ in size and colour of secondary shafts (Marchant & Higgins 1990). *Unclear as to status of subspecies in taxonomy, allopatric speciation is possible mechanism as species only partial migrant and has low dispersive capacities. As information is lacking species should be considered conservatively to be at moderate risk.*	**L**	**M**
Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	Currently declining in traditional inland breeding areas owing to droughts and poor water management, this may accelerate and worsen with climate change (Smith and Munro 2010). Population trend stable in Lower Lakes before sudden decline beginning in 2006 down to 2% in Lake Alexandrina and 16% in Lake Albert (Ecological Associates 2010). Relatively high number of records (516) within study area since 1990 and 3568 in SA MDB floodplain, majority of these records around Lower Lakes (BDBSA 2010). Not nationally threat listed but sub-regionally listed as vulnerable and in probable decline in Murray Scroll Belt and Murray Mallee under IUCN criteria (Gillam and Urban 2010). *Regional populations in Lower Lakes dramatically smaller, recent BDBSA records indicate distribution still concentrated within Lower Lakes and Coorong. This is outside the study area however IBRA sub-regional ratings of vulnerable and in probable decline within study area. Further declines are expected under climate change due to increasing droughts and flow regulation. Species is still relatively common within study area should be considered at moderate risk.*	**H**	**M**

	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	Large clutch sizes vary but commonly 5-6 eggs, females can rear 2-3 broods per season depending on length of breeding period, in SA breeding season is from Sept-Dec and Jan (Marchant & Higgins 1990). Breeding more extensive at swamps that have dried and refilled (i.e. temporary wetlands) producing high levels of organic matter and complex flora and diverse invertebrate populations (Crome 1988). *Capacity for large clutch sizes and multiple broods per season reduces threat, species should be considered at low risk.*	**H**	**L**
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	Recruitment success varies annually and geographically, nesting success rates are around 49% with about 2 fledged young per nest. Longevity is not documented and members of Ciconiidae family reach breeding maturity at 3-5 years (Marchant & Higgins 1990b). Breeding more extensive at swamps that have dried and refilled (i.e. temporary wetlands) producing high levels of organic matter and complex flora and diverse invertebrate populations (Crome 1988). Relatively high number of records (516) within study area since 1990 and 3568 in SA MDB floodplain, majority of these records around Lower Lakes (BDBSA 2010). Not nationally threat listed but sub-regionally listed as vulnerable and in probable decline in Murray Scroll Belt and Murray Mallee (Gillam and Urban 2010). *High reproductive capacity (clutch size and multiple brooding) may be complemented by provision of more temporary wetlands created through increased river regulation but will only be advantageous if managed carefully. Longevity not described but probably moderate to long given large size of bird. Age at first breeding is given at 3-5 years for the stork family which is long compared to most species assessed in this study. Population base appears strong although probably under threat given regional listing. Species should be considered at moderate risk but with medium confidence due to lack of species-specific information.*	**M**	**M**

Scientific Name:	*Tadorna tadornoides*	**Common Name:**	Australian Shelduck

Question		**Comments/ Reference**	**Confid**	**Vul Rating**
Ecology	To what extent does ***habitat*** preference limit the ability of the regional population of the species to tolerate climate change.	'Found on grasslands and croplands, terrestrial waters, estuarine waters and occasionally wooded grasslands. Equally at home in terrestrial and aquatic habitats, grazing on dryland plants or aquatic plants in shallow water or on mudflats or shores (Marchant & Higgins 1990)'. '…though the species preferred muddy shorelines of brackish waters there was a dependence on freshwaters …clearly shows the importance of these freshwater lakes to the species (Norman 1971)'. 'Unlike many species of waterbirds use and prefer salt affected wetlands (Marchant & Higgins 1990). Therefore many of the threats of salinisation affecting other ducks not a threat to Australian shelduck (SAAB 2001)'. 'Population increases in some areas of WA attributed to clearing and conversion to pasture and cropland (Masters & Milhinch 1974). In study region occurs mostly and in highest abundance on managed wetlands with a wetting and drying hydrological regime (M. Harper pers. com.). ***There is conflicting information about the extent of the requirement of freshwaters to the species but it clearly tolerant of high salinity. Species has a broad diet and habitat requirements and can feed on water and on land but reduced flooding of temporary wetlands decreases breeding and foraging habitat within study region 'Habitat' is expected to be a moderate limitation to the ability of the regional population of the species to tolerate climate change.***	H	M

	To what extent does ***mobility and dispersal*** limit the ability of the regional population of the species to tolerate climate change.	Individuals recorded dispersing up to 1000km, but usually < 300km from a banded site documented (McKean & Braithwaite 1976; Norman 1971). 'Most of population migratory between dispersed breeding sites and moulting places…Migration often several hundred kilometers…(Marchant & Higgins 1990)'. ***Species capable of regular long distance movements. 'Mobility & dispersal' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
	To what extent does ***competition*** limit the ability of the regional population of the species to tolerate climate change?	Species appears to have diverse omnivorous diet, feeding in water and on land and employing many feeding techniques (Marchant & Higgins 1990). Feeding behavior throughout the day observed (Hamilton et al 2002). 'Competes with other species for nesting hollows (Marchant & Higgins 1990)'. ***No information on competition for food was found documented and although some competition from fish and other waterfowl is likely, the species' broad diet and variable foraging activity is expected to reduce any potential significant competition affects. Competition for red gum nesting hollows expected to increase as red gums decline in abundance and health. 'Competition' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
Physiology	To what extent do ***survival tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'The success of the grey teal and the Australian shelduck is partly due to behavioural and physiological mechanisms that help them prevent salt overloading. They eliminate ingested salt through their nasal glands (Goodsell 1990])'. 'Unlike many species of water birds use and prefer salt affected wetlands (Marchant & Higgins 1990). Therefore many of the threats of salinisation affecting other ducks not a threat to Australian shelduck (SAAB 2001)'. 'Even salt-tolerant species such as black swans, Australian shelducks and chestnut teal are restricted to drinking salinities of about 35 parts per thousand of total dissolved solids (ppt TDS), less than 20 ppt TDS and less than 10 ppt TDS, respectively, unless they have access to fresh water (Hughes 1976; Riggert 1977; Baudinette et al. 1982). A complicating factor, however, is that birds can fly to distant sources of fresh water and, thus, utilise lakes that are too saline to drink constantly (Halse et al 1993)'. Species appears to have diverse omnivorous diet, feeding in water and on land and employing many feeding techniques (Marchant & Higgins 1990). ***Though some conflicting reports on the extent of species salt tolerance, clearly highly saline waters are readily utilised and although reduced flooding of temporary wetlands may reduce easy foraging opportunities, survival is not restricted by water regime with species having a diverse diet and utilizing a variety of foraging techniques and habitats. 'Survival tolerance' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	H	L
	To what extent do ***growth tolerances*** limit the ability of the regional population of the species to tolerate climate change?	'Able to drink highly saline water but ducklings need freshwater for 6 days after hatching and sudden switching to saltwater causes intoxication (Riggert 1977 [in Marchant & Higgins 1990])'. Site where broods raised must contain freshwater (Marchant & Higgins 1990). Other growth tolerances not documented. ***Nestling growth documented to be inhibited by saline waters but breeding is documented in brackish-saline waters as long as freshwater is available. 'Growth tolerance' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M

	To what extent do ***reproductive tolerances*** limit the ability of the regional population of the species to tolerate climate change?	Age composition within a population was attributed to the differences in breeding success over two years due to differences in rainfall and the resulting available habitat, e.g. breeding was higher in 1964 when rainfall was 20-45% above average and low in 1969 when rainfall was 10% below average (McKean & Braithwaite 1976). In Booligal swamp in NSW increased nesting activity was observed when a temporary wetland was filled from dry and attributed to a massive production of invertebrate detritivores. Low nesting rates occurred in other seasons, even when the swamps were full and food apparently available. It is postulated that these invertebrates are easily captured by both adults and chicks and provide a superabundant food source at the water surface and in very shallow water. Important factors are the drawdown, and the production of detritus and invertebrates when the wetland basin is refilled (Crome 1986). Breed in red gum tree hollows (Crome 1986). 'For shelduck to initiate and complete breeding and for young to fledge water needs to remain under the nest tree for at least 5 months following flooding (Briggs & Thornton 1999 [in SAAB 2001])'. ***Flooding of temporary wetlands is documented to increase breeding success and below average rainfall to decrease breeding success. A decline in red gums, increase in salinity (detrimental to nestlings) and increased evaporation will also have impacts on breeding success. 'Reproductive tolerance' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	H	H
Genetics	To what extent does ***gene pool*** limit the ability of the regional population of the species to tolerate climate change?	'Widespread in south-east areas, south of Murray River and west to Spencer Gulf, less common or vagrant in east and north east areas round Lake Eyre and Cooper Creek, large numbers in the South East (Blakers et al. 1984; Parker et al. 1985). In S.A. most breeding records from the South East, Murray Mallee, Mt. Lofty Ranges and Eyre Peninsula (Blakers et al. 1984 [in SAAB 2001)'. Listed as 'secure' in all states of its range (Birds Australia 2010). ***Though no information on the gene pool of this species found,*** **species is widespread and relatively common and population size within study region is considered moderate.** ***'Gene Pool' is expected to be a minor limitation on the ability of the regional population of the species to tolerate climate change.***	M	L
	To what extent does ***gene flow*** limit the ability of the regional population of the species to tolerate climate change?	'Most of population migratory between dispersed breeding sites and moulting places (Marchant & Higgins 1990)'. 'This species is monogamous and some birds are known to create permanent pair-bonds (Birds Australia 2010)'. ***Though no information on gene flow within species found,*** **species has good dispersal ability though movements are often to regular seasonal sites. Population size within study region is considered moderate though species is often in pairs or small groups and gene flow would be reduced by monogamous nature of species.** ***'Gene Flow' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	M	M
	To what extent does ***phenotypic plasticity*** limit the ability of the regional population of the species to tolerate climate change?	***Unknown: no information found on the extent that 'phenotypic plasticity' limits the ability of the regional population of the species to tolerate climate change.***	L	M

Resilience	To what extent does ***population size*** limit the ability of the regional population of the species to tolerate climate change?	'Widespread in south-east areas, south of Murray River and west to Spencer Gulf, less common or vagrant in east and north east areas round Lake Eyre and Cooper Creek, large numbers in the South East (Blakers et al. 1984; Parker et al. 1985). In S.A. most breeding records from the South East, Murray Mallee, Mt. Lofty Ranges and Eyre Peninsula (Blakers et al. 1984 [in SAAB 2001)'. Listed as 'secure' in all states of its range (Birds Australia 2010). ***Species is common within study region but population size is considered 'moderate', e.g. several other waterfowl species are more abundant and large aggregations are not common. 'Population Size' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change.***	H	M
	To what extent does ***reproductive capacity*** limit the ability of the regional population of the species to tolerate climate change	'Clutch size: Ten to fourteen. Incubation: 33 days (Birds Australia 2010)'. ***Though average clutch size is high, little information found of large breeding events so it is expected that even under ideal breeding conditions population increase would be moderate. 'Reproductive capacity' is expected to be a moderate limitation on the ability of the regional population of the species to tolerate climate change***	M	M
	To what extent does ***recruitment*** limit the ability of the regional population of the species to tolerate climate change?	'Clutch size: Ten to fourteen (Birds Australia 2010)'. 'Many ducklings died [e.g. predation, starvation, exposure] between hatching and arrival at brood territories, but having arrived 60% survived to flapper stage. On Rottnest Island [e.g.less predation than mainalnd] each pair reared 4-5 young per season (Storr 1965 [in Marchant & Higgins 1990]). In study region very low recruitment success recorded with clutches often observed reduced to 3-4 young and very few surviving to flapper stage - attributed to lack of cover in preferred temporary breeding wetlands (M. Harper pers. com.). ***Moderate recruitment success recorded and some evidence of increased survival rate of species. 'Recruitment' is expected to be a major limitation on the ability of the regional population of the species to tolerate climate change.***	H	H

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