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USE OF VEGETATIVE STRUCTURE BY POWERFUL OWLS IN OUTER URBAN MELBOURNE, VICTORIA, AUSTRALIA—IMPLICATIONS FOR MANAGEMENT

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ABSTRACT.—The Powerful Owl (*Ninox strenua*) is Australia's largest owl and is considered of least concern nationally. Although a number of studies have reported on the ecology of Powerful Owls inhabiting forests, few have focused on these owls living in urban areas. We report on the characteristics of different roost trees used by Powerful Owls in a continuum of habitats from urban Melbourne to the more forested outskirts. Records of weather conditions and daily temperatures were also analyzed to determine whether the owls were selecting particular roost trees for specific climatic conditions. We found that roost-tree height and perch height was highly correlated, with the owls always roosting in the top one-third of the tree, regardless of the tree height. As ambient temperature increased perch height decreased, and vice-versa, but owls always roosted in the top one-third of the roost tree. Powerful Owls did not simply move up and down the one tree, but moved to more suitable trees according to the weather conditions. Hence, the species requires a structurally heterogeneous habitat to provide roost trees for different temperatures. Furthermore, successful management of this species in the future will require the protection of structurally diverse vegetation.

KEY WORDS: *Powerful Owl;* Ninox strenua*; disturbance; management; temperature; urbanization; vegetation structure.*

USO DE LA ESTRUCTURA VEGETATIVA POR *NIÑOX STRENUA* EN EXTERIORES URBANOS DE MELBOURNE, VICTORIA, AUSTRALIA—IMPLICACIONES PARA EL MANEJO

RESUMEN.—*Ninox strenua* es el búho más grande de Australia y es considerado nacionalmente de menor interés. Aunque un numero de estudios se han concentrado en su ecología en bosques, pocos se han enfocado sobre los que habitan en áreas urbanas. Reportamos las características del uso de diferentes árboles percha utilizados por *Ninox strenua* en un continuum de hábitats desde el Melbourne urbano hasta los alrededores más boscosos. Adicionalmente se analizaron los registros de condiciones climáticas y temperaturas diarias para determinar si los búhos estaban seleccionando árboles percha particulares debido a condiciones climáticas específicas. Encontramos que la altura de los árboles percha y la altura de la percha utilizada estaba altamente correlacionados con el uso del tercio mas alto del árbol, sin tener en cuenta la altura del árbol. Cuando la temperatura ambiente incrementaba la altura de la percha decrecía, y viceversa, pero los búhos siempre percharon en el tercio mas alto del árbol percha. Los búhos no se movieron simplemente hacia arriba y abajo del árbol, sino que se movieron a árboles más adecuados de acuerdo a las condiciones climáticas. Por lo tanto, la especie requiere un hábitat estructuralmente heterogéneo que provea árboles perchas para diferentes temperaturas. Además de esto, el manejo exitoso de esta especie en el futuro requiere de la protección de vegetación estructuralmente diversa.

[Traducción de César Márquez]

The Powerful Owl (*Ninox strenua*) is the largest Australian owl. The male is slightly larger than the female, growing to a length of 65 cm with a mass of up to 1700 g (Higgins 1999). The Powerful Owl is a nocturnal predator, with a diet consisting almost exclusively of medium-sized, arboreal, marsupial prey (Webster et al. 1999, Cooke et al. 2002).

The Powerful Owl is classified nationally as of

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"least concern" (rated nationally of conservation significance, but at the lowest level, Garnett and Crowley 2000), occurring at low densities in southeastern continental Australia. Within the state of Victoria the species is listed as endangered (Department of Natural Resources and Environment, Victoria 1999) and threatened within the Greater Melbourne Area (Mansergh et al. 1989). Estimates of population numbers in the state of Victoria are less than 500 pairs across the state (Garnett and Crowley 2000).

The Powerful Owl was once considered to be a specialist in ecological terms because of its apparently restricted habitat and dietary requirements (Fleay 1968, Seebeck 1976, Roberts 1977), indicating that it is vulnerable to habitat modification and that it has specific conservation needs. Recent studies, however, have contested these earlier findings and consequently have questioned the degree to which the Powerful Owl is vulnerable to habitat modification and disturbance (Debus and Chafer 1994, Kavanagh and Bamkin 1994, Pavey et al. 1994, Cooke et al. 1997, Cooke et al. 2002).

Urban and suburban areas surrounding Melbourne have been mostly cleared throughout the past 100 years, with only small patches of remnant vegetation remaining. Surprisingly, Powerful Owls still remain in some urban areas, with one known breeding pair located only 18 km from central Melbourne. Powerful Owls have also been recorded living in close proximity to other Australian cities, including Brisbane (Pavey et al. 1994, Pavey 1995) and Sydney (Rose 1993). Little research has been undertaken to determine the resources these owls require for long-term survival in urban environments. Here, we describe roost tree characteristics and features of roosts used in urban and suburban areas by Powerful Owls. Results from this study are then used to identify management options for Powerful Owls in urban areas. The results of this study may also provide valuable information for the future management of other top-order raptors with similar ecological attributes in urban areas.

STUDY AREAS

During this study, we examined how Powerful Owls used the structure of vegetation in a continuum of environments ranging from urban Melbourne (two sites), through the urban fringe (three sites), and into more forested areas (one site). Each site was selected on the basis that it had a confirmed breeding pair of owls present for several years.

The two sites located closest to Melbourne were the Yarra Valley Metropolitan Park (100 ha) and Warrandyte State Park (586 ha), which were urban parklands managed for public recreation and 18 km and 24 km northeast of central Melbourne, respectively. Both parks have been extensively modified in the past and now consist of riparian areas and the occasional patch of remnant trees surrounded by a matrix of revegetated woodlands.

The next three sites along the continuum were One Tree Hill Reserve (143 ha), Smiths Gully (2.4 ha), and Steels Creek (21 600 ha). One Tree Hill Reserve and Smiths Gully are both located 35 km from central Melbourne while Steels Creek is located 65 km from Melbourne. These three sites are all dry, open forests and consist primarily of different *Eucalyptus* spp. as upper canopy trees with *Acacia* spp. dominating the middle story. These three sites are also regularly visited by people and also show signs of disturbance.

The sixth site along our continuum was Toolangi State Forest (35 000 ha), which is located 80 km northeast of Melbourne. This forest is a relatively undisturbed wet sclerophyll forest dominated by mountain ash (*Eucalyptus regnans*). Middle story species are less common in this area; however, the understory is dominated by various ferns and bracken.

METHODS

A total of 1300 day visits were made to the six study sites between 1996–99. During these visits the roost tree in which the Powerful Owl was located was recorded Roost trees were those in which Powerful Owls spent time during the daylight hours.

Here, we examined the different roost trees used by the Powerful Owl at each of the study sites and the characteristics of each tree used. These included the species of tree, tree height, and the diameter at breast height (DBH). Records of weather conditions and daily temperatures were also analyzed to determine whether the owls are selecting particular roost trees for specific climatic conditions.

Each study site was visited at least once weekly over a 4-yr period and each roost tree was examined for the presence of the Powerful Owl or evidence that an owl had used the tree recently. Evidence of usage included fresh whitewash (excreta) or regurgitated food pellets Temperature and weather conditions were noted, regurgitated food pellets were collected and, in situations where the Powerful Owl was using the roost tree, the perch height was measured using a clinometer.

RESULTS

The Powerful Owls used 179 individual roost trees at the six study sites. Twenty different tree species were used as roost trees. The main trees used for roosting were *Eucalyptus* spp. (54%), *Acacia* spp. (18%), and *Leptospermum* spp. (15%). Other roost trees were hazel pomaderris (*Pomaderris aspera*), the introduced Monterey pine (*Pinus radiata*), cherry ballart (*Exocarpos cupressiformis*), Christmas bush (*Prostanthera lasianthos*), the non-

Table 1. Roost-tree characteristics at each of the six study sites. Values represent mean ± 1.96 SE.

Site	N	Tree Height (m)	DBH (cm)	Perch Height (m)
Yarra Valley Metropolitan Park	22	15.7 ± 2.2	55.0 ± 12.2	10.2 ± 1.9
Warrandyte	29	13.3 ± 2.3	40.3 ± 11.3	9.6 ± 2.0
One Tree Hill	22	16.2 ± 1.9	48.8 ± 10.0	12.2 ± 1.9
Smiths Gully	24	12.7 ± 1.8	37.1 ± 9.7	8.1 ± 1.1
Steels Creek	23	16.1 ± 2.2	38.5 ± 5.0	10.3 ± 1.9
Toolangi	59	13.0 ± 2.1	49.7 ± 9.6	11.2 ± 1.8
Pooled data	179	14.4 ± 0.9	45.6 ± 4.4	10.4 ± 0.8

indigenous sweet pittosporum (*Pittosporum undulatum*), and swamp paperbark (*Melaleuca ericifolia*).

To determine whether the dimensions of roost trees varied between sites we compared the tree height, roost height, and DBH of roost trees at each site (Table 1). Roost tree heights were not different among the six study sites ($F_{5,173}$ = 1.856, P = 0.104), with the mean height of roost trees being 14.4 m ± 0.9 m (±1.96 SE). Perch heights between the six study sites also did not differ significantly ($F_{5,173}$ = 1.643, P = 0.15), with the mean perch height being 10.4 m ± 0.8 m (±1.96 SE). There was also no significant difference in the DBH of the roost trees between the six study sites ($F_{5,173}$ = 1.52, P = 0.186). Overall, the mean DBH was 45.6 cm ± 4.4 cm (mean ± 1.96 SE). These results suggest that the trees used for roosting have similar physical dimensions at each site even though the tree species may differ between sites.

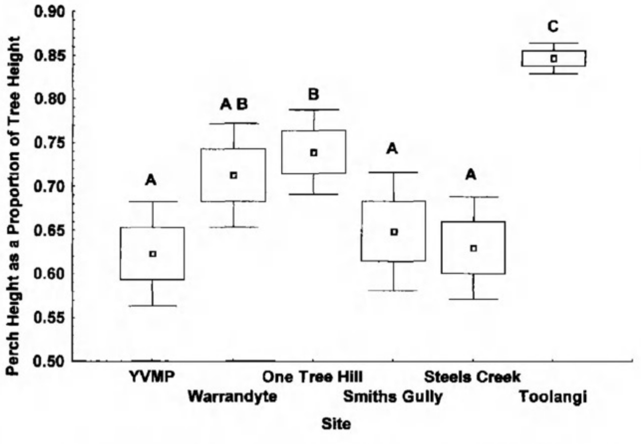

Figure 1. Perch heights as a proportion of tree heights (mean ± 1 and 1.96 SE) at each of the six study sites. Plots with the same letters indicate homogeneous groups as revealed by the Student Newman-Keuls (P < 0.05). YVMP = Yarra Valley Metropolitan Park.

Given the variety of tree species used by the owls for roosting, we decided to determine whether the roost trees were being used in a similar fashion among sites. Specifically, the relationship between perch height and tree height was examined. Overall, perch height was positively correlated with tree height (r = 0.91, P < 0.001, N = 179). Hence, although the species of roost tree varied, the owls tended to perch toward the top of the selected roost tree. The perch height as a proportion of tree height varied significantly between sites ($F_{5,173}$ = 17.76, P < 0.001). Perch heights at the Yarra Valley Metropolitan Park, Warrandyte State Park, Smiths Gully, and Steels Creek were lower within the roost trees than those in Toolangi State Forest (Student Newman-Keuls test, P < 0.05; Fig. 1).

Although the mean perch height as a proportion of the tree height varied among sites, roost tree height was a predictor of perch height within each site (Fig. 2). High R^2 values at all sites (except Smiths Gully) suggest that there was a strong and consistent relationship between perch height and tree height (Table 2).

To further understand this relationship, a comparison was made between perch height and different temperature and weather conditions. When there was no precipitation a strong negative association between temperature and perch height was found (Table 3), with the owls at all sites choosing lower perch heights as the temperature increased. On days where rainfall occurred this trend was less evident, with the owls at most sites showing no consistent association between perch height and temperature (Table 3).

Discussion

The Powerful Owls inhabiting the six study sites used 179 roost trees. Of these, 87% were from only

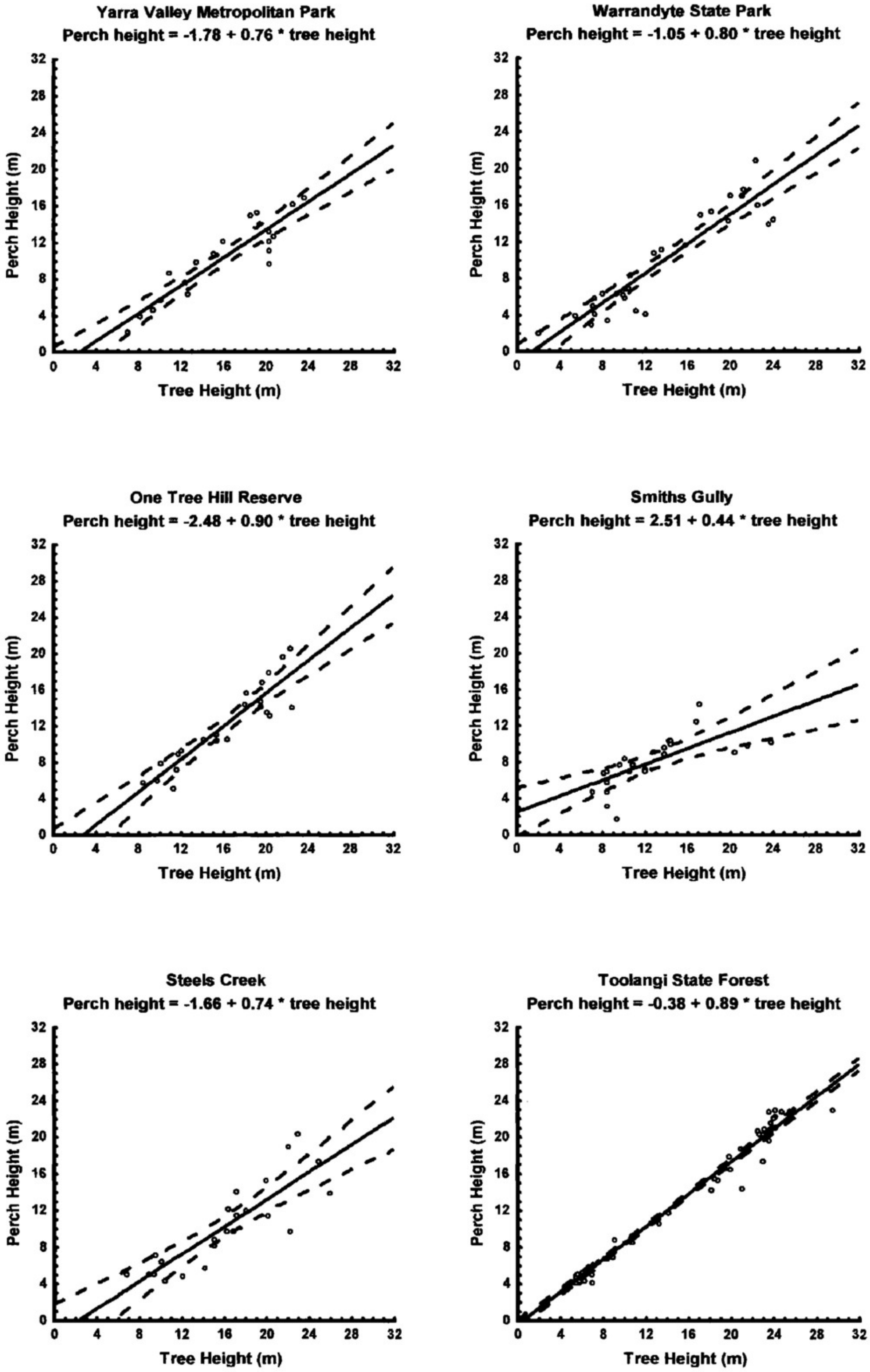

Figure 2. The relationship between perch height and tree height at each of the six study sites. Lines indicate the regression lines with 95% confidence limits.

Table 2. Regression results of the relationship between perch height and tree height at all sites.

SITE	R^2	df	F	P
Yarra Valley Metropolitan Park	0.844	1, 20	114.71	<0.001*
Warrandyte	0.859	1, 27	171.34	<0.001*
One Tree Hill	0.825	1, 20	100.33	<0.001*
Smiths Gully	0.463	1, 22	20.84	<0.001*
Steels Creek	0.718	1, 21	56.89	<0.001*
Toolangi	0.980	1, 57	2792.09	<0.001*

* Represents a significant relationship between perch height and tree height.

three different genera, *Eucalyptus* (54%), *Acacia* (18%), and *Leptospermum* (15%). The other 13% of roost trees consisted of a variety of genera that were infrequently used by Powerful Owls. Overall, Powerful Owls roosted in 20 different tree species at the six study sites and in most cases the roost trees used were the most common species at the specific study site. This indicates that the Powerful Owls in the Yarra Valley corridor are probably using abundant and available tree species rather than selecting less common species.

Roost tree characteristics such as height, perch height, and DBH did not differ between the six sites. Roost tree height and perch height, however, were highly correlated, indicating a direct relationship between the height of the roost tree and the perch height. Powerful Owls observed at all six sites generally roosted in the top one-third of the roost tree, regardless of the tree height.

Overall, these results suggested that Powerful Owls roosted in a number of tree species and they were most likely found in the most common tree species. It is probable that Powerful Owls are generalists in terms of the tree species in which they will roost. The fact that the roost tree characteristics (e.g., perch height, DBH) were similar at all sites suggested that there was some degree of selection of individual trees that offer optimal roost characteristics. This was particularly highlighted by the relatively small number of roost trees used at each site compared with the number of trees available.

When temperature and weather conditions were considered in relation to roost tree usage, the results suggested that as temperature increased perch height decreased, and vice-versa. On hot days, Powerful Owls were roosting lower in shadier sites and on cooler days they roost at higher levels, possibly to absorb sunlight. However, independent of the height of the roost tree the Powerful Owls still roosted in the top one-third of the roost tree. This result suggests that they require habitats with a large degree of structural variation to provide roost trees for different temperatures.

The choice of roost trees used by the Powerful Owls in clear and rainy conditions was also examined. The results showed that there was no significant difference in the perch height used by the Powerful Owls at five of the six sites on wet days. Steels Creek was the only exception to this pattern. At most sites, Powerful Owls roosted in slightly lower trees on rainy days. However, at Steels Creek the Powerful Owls actually roosted in taller, canopy trees on precipitation days. Thus, it would appear that the height at which Powerful Owls roost in different weather conditions was not as important as the amount of canopy cover provided by the specific roost tree.

Results from this study also suggest that the structural diversity within a site is important, given

Table 3. Correlation results from comparisons of perch height and temperature on days with and without precipitation.

SITE	NO PRECIPITATION		PRECIPITATION	
	r-VALUE	P-VALUE	r-VALUE	P-VALUE
Yarra Valley Metropolitan Park	−0.80	<0.001*	−0.03	0.875
Warrandyte	−0.27	0.021*	0.06	0.714
One Tree Hill	−0.87	<0.001*	−0.06	0.065
Smiths Gully	−0.68	<0.001*	−0.39	0.006*
Steels Creek	−0.45	<0.001*	0.62	<0.001*
Toolangi	−0.59	<0.001*	−0.18	0.112

* Represents a significant relationship between perch height and temperature.

that the Powerful Owls may use trees of different heights to regulate their temperature in relation to climatic conditions. Unfortunately environmental change accompanying urbanization often results in less structural diversity in vegetation, which can mean that Powerful Owls have less choice in suitable thermal environments. What effect loss of structure will have on survival and reproduction is largely unknown, but it may in part explain why the Powerful Owl is rarely found in highly-urbanized areas.

This information is important for future management of the Powerful Owl because it suggests that this species does not simply move to higher or lower branches in the one tree; rather, it moves to an alternative roost tree with more suitable structural characteristics when it changes heights. Therefore, management of the vegetation in the urban areas must ensure that there is structural diversity in the vegetation. Currently, the focus of vegetation management for the Powerful Owl has been on maintaining old eucalypts (canopy layer). However, this may not provide for the structural resource requirements of this species. Vegetation management for the Powerful Owls should, therefore, be expanded to include the obviously important mid-story species such as *Acacia* and *Leptospermum.*

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LITERATURE CITED

COOKE, R., R. WALLIS, A. WEBSTER, AND J. WILSON. 1997. Diet of a family of Powerful Owls *Ninox strenua* from Warrandyte, Victoria. *Proc. R. Soc. Vic.* 107:1–6.

———, R. WALLIS, AND A. WEBSTER. 2002. Urbanization and the ecology of Powerful Owls *Ninox strenua* in outer Melbourne, Victoria. Pages 100–106 *in* I. Newton, R. Kavanagh, J. Olsen, and I. Taylor [EDS.], Ecology and conservation of owls. CSIRO Publishing, Melbourne, Australia.

DEBUS, S.J.S. AND C.J. CHAFER. 1994. The Powerful Owl *Ninox strenua* in New South Wales. *Aust. Birds* (Supplement) 28:20–38.

DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT, VICTORIA. 1999. Powerful Owl *Ninox strenua.* Flora and fauna guarantee act. Department of Natural Resources and Environment, Melbourne, Australia.

FLEAY, D. 1968. Nightwatchmen of bush and plain. Jacaranda Press, Brisbane, Australia.

GARNETT, S.T. AND G.M. CROWLEY. 2000. The action plan for Australian birds. Canberra: Environment Australia, Australian Government. Canberra, Australia.

HIGGINS, P.J. 1999. Handbook of Australian, New Zealand and Antarctic birds. Vol. 4. Oxford Univ. Press, Melbourne, Australia.

KAVANAGH, R.P. AND K.L. BAMKIN. 1994. Distribution of nocturnal forest birds and mammals in relation to the logging mosaic in south-eastern New South Wales *Biol. Conserv.* 71:41–53.

MANSERGH, I.C., C. BEARDSELL, S. BENNETT, R. BRERETON, K. O'CONNER, K. SANDIFORD, AND M. SCHULZ. 1989. Report on the sites of zoological significance in the Upper Yarra Valley (western section) and Dandenong Ranges. Arthur Rylah Institute for Environmental Research, Tech. Rep. Ser. No. 90, Melbourne, Australia

PAVEY, C.R. 1995. Food of the Powerful Owl *Ninox strenua* in suburban Brisbane, Queensland. *Emu* 95:231–232.

———, A.K. SMYTH, AND J. MATHIESON. 1994. The breeding season diet of the Powerful Owl *Ninox strenua* at Brisbane, Queensland. *Emu* 94:278–284.

ROBERTS, G.J. 1977. Birds and conservation in Queensland. *Sunbird* 8:73–82.

ROSE, A.B. 1993. Notes on the Powerful Owl *Ninox strenua* in New South Wales. *Aust. Birds* 26:134–136.

SEEBECK, J.H. 1976. The diet of the Powerful Owl *Ninox strenua* in western Victoria. *Emu* 76:167–170.

WEBSTER, A., R. COOKE, G. JAMESON, AND R. WALLIS. 1999 Diet, roosts, and breeding of Powerful Owls *Ninox strenua* in a disturbed, urban environment: a case for cannibalism? Or a case for infanticide? *Emu* 99:80–83.

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