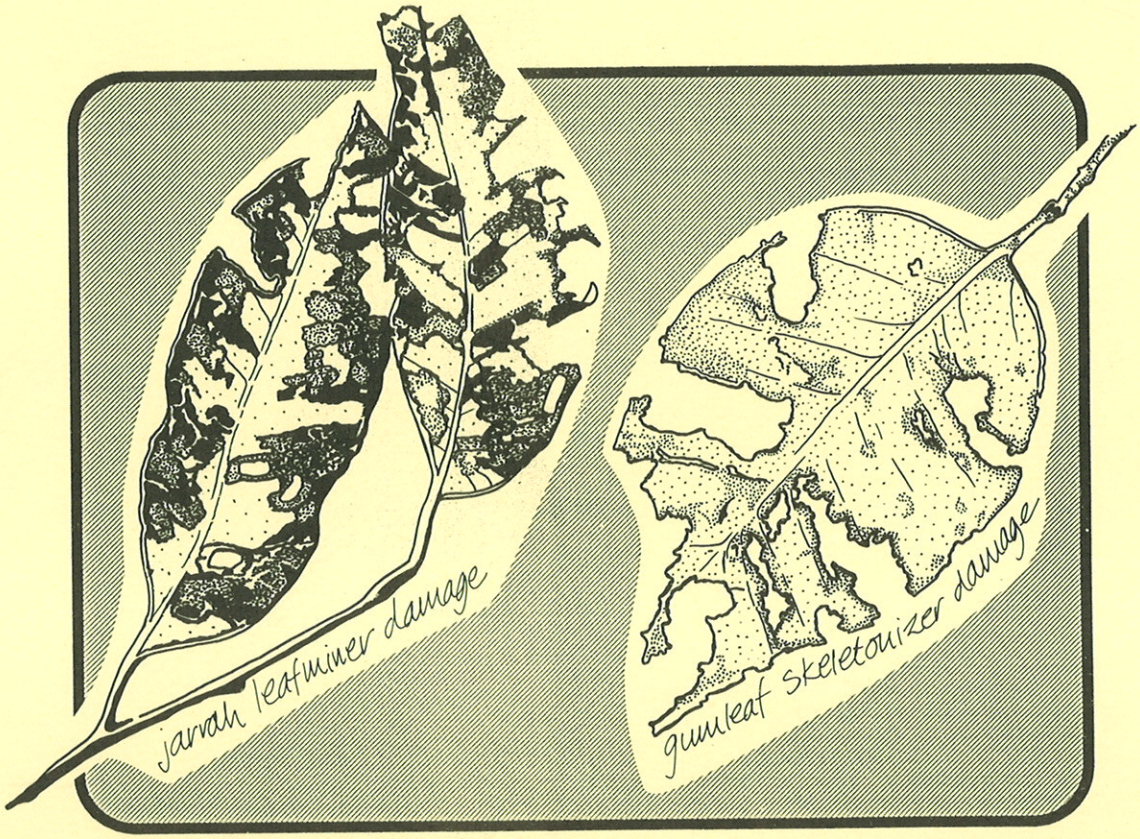
Records of outbreaks of defoliating insects in jarrah forest, south-west Western Australia, from 1960 to 1990

Ian Abbott



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Abstract

A considerable amount of unpublished information on past and current infestations by the two major defoliators of jarrah forest - jarrah leafminer and gumleaf skeletonizer - has been collated and synthesized into 24 maps. Precise locations of 60 leafminer monitoring plots and 45 skeletonizer monitoring trees are also provided. Limitations of these maps and monitoring points are briefly discussed.

INTRODUCTION

Insect outbreaks in hardwood forests of south-west Western Australia were unknown before 1960, as evidenced by the lack of documentation in Departmental (i.e. Department of Conservation and Land Management - CALM - previously Forests Department) files and in publications by Lane-Poole (1921), Clark (1921) and also Newman and Clark (1925). Foresters in general are acute observers of the forests under their superintendence. Therefore the absence of evidence of outbreaks may safely be taken as evidence of their absence.[1]

The objective of this report is to collate the large amount of unpublished material contained in Departmental and CSIRO files, and make this synthesis more accessible to others. This material exists either as copious notes or in the form of maps showing the extent of outbreaks of jarrah leafminer *(Perthida glyphopa* Common - Lepidoptera: Incurvariidae) and gumleaf skeletonizer *(Uraba lugens* Walker - Lepidoptera: Nolidae) in jarrah (*Eucalyptus marginata* Donn ex Sm.) forest.

Between 1984 and 1987 permanent monitoring points were selected throughout the jarrah forest to monitor populations of these insects. The precise location of these points is tabulated for the benefit of future researchers.

[1] Strictly speaking, it is fallacious reasoning (*Argumentum ad Ignorantiam*) to imply that absence of evidence is evidence of absence. Other supporting evidence of the truth of this statement in this instance is:

(a) the bark beetle *Ips grandicollis* was first detected by foresters in pine plantations in 1952, 18 years before it became a pest;

(b) a permanent forest entomologist in Western Australia was not appointed until 1964, presumably because there was no need for such a position;

(c) the CSIRO in Western Australia had no scientist studying forest insect outbreaks until 1961 - this agency has had involvement in entomological research in agriculture in Western Australia since 1937.

METHODS

Jarrah Leafminer outbreaks

Material was found for the years 1964, 1966 to 1976 inclusive, 1980 and 1983. Only that for 1971 has previously been published (map in Mazanec 1974). The 1964, 1966, 1967 and 1983 information was mapped by staff of the Forests Department of Western Australia. All other material was collected by CSIRO staff (principally Z. Mazanec).

All of the material found on the extent of outbreaks is based on road traverses, carried out in late spring or early summer. A.D. Mather (Forests Department) assessed all major roads running east of Manjimup and noted that the western edge ('front') outbreak was 'fairly easily found'. Moderate infestation was recognized if an observer travelling at *c*.60 km per hour had *little* difficulty in seeing attacked leaves. A *brownish* colour was sometimes present in the upper canopy, and the young regrowth was heavily attacked. Severe infestation was recognized if an observer travelling at *c*. 60 km per hour had *no* difficulty in seeing infestation. The upper canopy was *quite brown* and looked as if it had been burnt. Mather noted that the colour was not as red as with fire damage.

CSIRO adopted the following criteria for their traverses. For moderate damage, there was enough leafminer to discolour foliage red or reddish-brown, but some green leaves still remained. The colour was visible from a distance. Mazanec noted that this category is 'fairly wide'. For heavy damage, the whole of the tree's crown was red-brown. No green leaves remained.

Visual studies by Van Heurck and myself near Manjimup and Collie since 1984 indicate that moderate damage refers to an average damage per leaf area of at least 40 per cent, and severe damage refers to leaf damage of at least 60 per cent.

I have carefully perused the information held on file by CSIRO and transferred annual records of moderate and

severe damage on to maps, which were then prepared to professional standard by staff of the Land Information Branch of CALM. It proved not possible to map separately stands showing moderate or severe damage, as they interdigitate in a labyrinthine fashion over short distances.

These maps can of course only be taken as accurate for the area of jarrah forest that was assessed. Broken lines have therefore been used to indicate where mapping was incomplete.

Specific annotations follow:

1968 Much of the south-west was traversed in November-December but the outbreak was relatively limited in area. Areas traversed, but lacking outbreaks, include forest south of Coalfields Road, Collie, and east to Kojonup; Albany north to the Porongurup Range and to Kojonup along Albany Highway; and forest between Bunbury, Busselton, Margaret River, Nannup, Bridgetown and Alexander Bridge.

1969 Essentially the same area as in 1968 was traversed, excepting the Busselton - Margaret River - Nannup forest.

1970 Similar area to 1968 was traversed

1971 Similar area to 1968 was traversed

1972 Similar area to 1969 was traversed

1973 Similar area to 1968 was traversed

1974 Similar area to 1968 was traversed

1975 Similar area to 1968 was traversed

1976 Similar area to 1968 was traversed excepting forest between Rocky Gully, Walpole, Albany and Cranbrook.

1980 Similar area to 1968 was traversed, excepting forest south of Kojonup to Denmark, and eastwards, and forest between Busselton, Margaret River and Nannup.

1983 This map is a composite of information provided by each forest District. It is therefore largely confined to State forest and forest occurring along major roads outside State forests. It does not separate moderate-severe damage from light damage.

1986 to 1990
Jarrah leafminer outbreak maps were based on a combination of road traverses and aerial survey. Only forest in Collie District was assessed.

Distribution of Jarrah Leafminer north of the Collie outbreak

This was determined annually between October and December for 1985 to 1990 inclusive. In 1985 only presence/absence of jarrah leafminer was noted, for the whole of the northern jarrah forest. In subsequent years resources did not permit coverage of the whole northern jarrah forest, but the information collected was more sophisticated. Several categories were distinguished: leaf mines absent; mines dead or aborted; mining completed (cutouts present); old cutouts (1986 and 1987 only). In addition, the cutout boundary and the extent of moderate-severe jarrah leafminer damage were mapped.

The sampling strategy was to obtain two sample points in each forest block. Points were selected to facilitate their location. In 1985 and 1990 most of these surveys were conducted by operational staff who had been trained by staff of the Entomology Research Program in CALM. Surveyors were asked to complete a proforma (Table 1) on site and attach samples of jarrah leaves as a check.

Plots for measuring damage to foliage caused by Jarrah Leafminer

Sixty permanent plots have been established in order to monitor damage to new foliage of jarrah by jarrah leafminer and other insects. Twenty plots each have been established near Manjimup (November 1984), between Mundaring and Dwellingup (November 1985) and near Collie (October 1987).

At each plot 30 new leaves of jarrah are marked in October/November. Damage by insects is measured 12 months later, and the number of jarrah leafminer cutouts is counted (Abbott *et al.* unpublished).

Gumleaf Skeletonizer outbreaks

This species was first recorded reaching outbreak levels in January 1983. Detailed aerial and ground surveys were used to produce a map of moderate-severe damage to forest (mostly jarrah, some karri, *Eucalyptus diversicolor* F. Muell). In 1984 I inspected the file containing this information but it has since been lost. Outbreak maps were also prepared in January in 1984, 1985 and 1986. The 1985 and 1986 maps are not reliable in that the outbreak was declining and it proved difficult to map accurately moderate-severely damaged forest (Strelein[2], personal communication).

There is one possible error in the 1983 and 1984 maps. The cell of moderate-severely damaged forest near Greenbushes was checked by me in late 1984 and I could see no evidence of skeletonizer damage but ample evidence of leafminer damage. This cell may therefore represent jarrah leafminer damage. However, it is puzzling that such damage should still be evident in January.

[2] G. Strelein, Department of Conservation and Land Management, Bunbury.

Gumleaf Skeletonizer monitoring points

In 1986, 45 jarrah trees were selected within a 50 km radius of Manjimup. Their crowns were sampled from a cherry picker for invertebrates on nine occasions between January 1986 and January 1988 (Abbott *et al.* in press). Subsequent sampling has been restricted to caterpillars of gumleaf skeletonizer and has served to document the collapse of the outbreak. These data will be published elsewhere by J.D. Farr.

RESULTS AND DISCUSSION

Jarrah Leafminer outbreaks

Maps of jarrah forest infested to a moderate-severe degree by jarrah leafminer are presented as Figures 1 to 13. They show clearly that the outbreak commenced to the east of Manjimup and gradually spread west and north. The infestation near Margaret River was a distinct outbreak, possibly deriving from outbreaks on the Swan Coastal Plain dating to at least 1914 (Newman and Clark 1925). It is also possible that the outbreak in the southern jarrah forest ultimately began near Albany, where outbreaks were also recorded prior to the 1920s (Newman and Clark 1925). In addition, D. Perry in December 1960 recorded heavy infestation on jarrah along the south coast between Albany and Frankland River, and M. Wallace at the same time observed heavily infested jarrah near Mt. Barker. However, Abbott (1990) calculated that the uniform rate of spread of outbreaks in State forest indicates that the outbreak began in 1960. As it takes time for an outbreak to build up, it is likely that it was developing in the late 1950s. The appointment in 1961 of a research scientist by CSIRO to study jarrah leafminer and of a forest entomologist by the Forests Department in 1964 is consistent with this calculated date.

The extent of the outbreak of jarrah leafminer in the vicinity of Collie is shown for the years 1986 to 1990 in Figures 16 to 20. The outbreak is slowly moving northwards.

The cutout boundary (i.e. the line to the north of which jarrah leafminer failed to complete its life cycle) has been mapped since 1986 (Figs 16 to 20). Extensive annual changes in its position are evident. To the north of this boundary, sporadic cases of successful completion of mining became more frequent in 1989, particularly in the Avon Valley and the western edge of the Darling Plateau. In 1989 the Swan Coastal Plain between Rockingham/Jarrahdale and Yanchep was surveyed; nearly every inspection point had cutouts present (Fig. 19).

Jarrah Leafminer monitoring plots

The precise location of the 60 plots is given in Table 2. Temporal and spatial patterns in damage by leafminer to jarrah leaves have been discussed in detail by Abbott *et al.* (unpublished).

Gumleaf Skeletonizer outbreaks

The four maps produced of gumleaf skeletonizer outbreaks in the southern jarrah forest are presented in Figures 21 to 24. They show an increase in area to 1984. In 1983 nine cells were mapped; 12 months later several of these had coalesced, resulting in 7 cells, further diminishing to 4 cells and decreasing in intensity in 1985 and 1986. See Abbott (1990) for a summary of the changes in hectares of forest infested.

Gumleaf Skeletonizer monitoring points

The precise location of the 45 trees monitored is given in Table 3. Each tree was blazed, numbered, and a sign affixed. Spatial and temporal patterns in the abundance and diversity of arthropods collected have been considered in detail by Abbott *et al.* (in press).

GENERAL DISCUSSION

The jarrah leafminer outbreak maps provided significantly augment published material. The first map published (Wallace 1970) appears to be a congeries of records up to 1969 and does not distinguish occurrences on jarrah from other eucalypts. The records plotted also do not necessarily refer to outbreaks. The only other map published (Mazanec 1974) overcomes these problems.

The maps published here still have several limitations. Firstly, they are subjective, even though the 1964 to 1967 and 1968 to 1980 maps are based on information collected by the same observers (A. Mather and Z. Mazanec, respectively). Secondly, there is considerable interpolation from road traverses to nearby forest which was not surveyed. Intensity of damage is known to vary considerably over short distances. Finally, a rather broad categorization of moderate-severe jarrah leafminer damage has been mapped i.e. > 40 per cent damage to foliage.

However, I do not wish to leave the impression that the maps are so unreliable as to be worthless. As stated earlier, Figures 4 to 13 have been compiled from detailed field notes made by Mazanec and assistants. These maps are as accurate as possible, and considerably amplify knowledge about the distribution of leafminer outbreaks.

In 1988/89, the feasibility of using remote sensing techniques to map jarrah leafminer outbreaks was investigated by the CSIRO Western Australia Remote Sensing Group, Division of Exploration Geoscience, Floreat Park. This pilot project showed that spectral separation of jarrah leafminer damaged and undamaged leaves was

possible at specific wave lengths. This objective means of mapping damage clearly displays the intricate spatial variability of infestations (Behn *et al.* 1990). The first LANDSAT satellite imagery dates from 1972, so it is unlikely that any better spatial representation of jarrah leafminer outbreaks before then (Figs 1 to 7) will become available. One problem with the southern jarrah forest is in obtaining cloud-free images in October/November (Hick[3], personal communication).

The 60 jarrah leafminer monitoring plots (based on 30 leaves per plot) are obviously an infinitesimal proportion of jarrah foliage present in the forest each spring, but with available resources it is doubtful that they could be increased in number very substantially. Nevertheless, they do provide reasonable geographic coverage of the jarrah forest (Fig. 25).

Similar considerations apply to the 45 jarrah trees within a 50-km radius of Manjimup (Fig. 26). These 105 sampling points are sufficiently detailed to pick up trends in jarrah leafminer damage or gumleaf skeletonizer caterpillar abundance.

NOTE ADDED IN PROOF

Since preparing the text, I have found further information in a file containing forest insect questionnaires compiled by Forests Department staff in Spring 1960. E. Crawford (based at Heartlea) first recorded jarrah leafminer in 1954 in the Chowerup area, which is outside State forest. However P. Barrett had noted leafminer damage in 1954 along Boyup Brook - Cranbrook Road and Westbourne Road.

In 1957 severe damage was recorded at only two localities in State forest: on the Boyup Brook - Cranbrook Road (Yendicup and Yackelup blocks, approximate CALM map reference GT95) and on Westbourne Road (Yendicup and Keninup blocks, ref. GN98). Outside State forest a large area bounded by Tone River, Boyup Brook - Cranbrook Road, Terrace Road and Ongup Pool was severely infested.

In 1958 severely infested forest was noted in an area of State forest (Keninup block) bounded by Distributor Road and Westbourne Road, and extending into private property north and east of Wournbelup. Severely infested forest was also recorded in a small area just east of Tonebridge.

By 1959 moderate damage was widespread, mainly north of Boyup Brook - Cranbrook Road in Dwalgan, Keninup, Balban, Yendicup and Moopinup blocks, and penetrating just south of this road into Yackelup block. Light damage was also recorded by Barrett to sapling and coppice growth near Nyamup and Tone River mills, and to the south of Boyup Brook - Cranbrook Road in Chariup block.

In 1960 C. Murphy (based at Tone River settlement) first noted leafminer damage in compartments 4 and 5 of Meribup block (i.e. west of Cup Road) and in Stoate block (south of and close to Muir Highway). Damage was confined to areas of 100-200 acres (c 40-80 ha). A. Hart recorded damage in 1960 in Camelar block (ref. GW91) near private property.

Taken together, this new information conclusively proves that the jarrah leafminer outbreak invaded State forest east of Manjimup from the low quality jarrah forest along the upper reaches of the Perup and Tone Rivers.

ACKNOWLEDGEMENTS

I thank Zan Mazanec for allowing me to extract information from his field notes, CALM Operational staff for completing proformas for leafminer surveys, Paul Van Heurck and Tom Burbidge for collating this survey information into map form, CALM's Land Information Branch staff for preparing the maps to acceptable cartographic standard, and J. Nicholson for word-processing.

REFERENCES

Abbott, I. (1990). Insect outbreaks in forests of Western Australia. In: *Population Dynamics of Forest Insects*, (eds A.D. Watt, S.R. Leather, M.D. Hunter and N.A.C. Kidd), Intercept, Andover. pp. 95-103.

Abbott, I., Burbidge, T., Williams, M. and Van Heurck, P. (in press). Arthropod fauna of jarrah (*Eucalyptus marginata*) foliage in mediterranean forest of Western Australia. *Australian Journal of Ecology*.

Behn, G.A., Wallace, J.F. and Hick, P.T. (1990). Airborne multispectral scanner data for mapping insect damage in jarrah forest of Western Australia. Paper presented to Remote Sensing Conference, October, Perth.

Clark, J. (1921). Forest entomology in Western Australia. *Australian Forestry Journal* **4**, 142-144.

Lane-Poole, C.E. (1921). Forest entomology in Western Australia. In: *Notes on the forests and Forest Products and Industries of Western Australia*. 2nd edn., Government Printer, Perth. pp. 231-234.

Mazanec, Z. (1974). Influence of jarrah leafminer on the growth of jarrah. *Australian Forestry* **37**, 32-42.

Newman, L.J. and Clark, J. (1925). The jarrah leafminer. *Journal of Agriculture*, Western Australia 2 (series 2), 372-378.

Wallace, M.M.H. (1970). The biology of the jarrah leafminer, *Perthida glyphopa* Common (Lepidoptera: Incurvariidae). *Australian Journal of Zoology* **18**, 91-104.

[3] P. Hick, CSIRO Division of Exploration Geoscience, Underwood Avenue, Floreat Park W.A.

Table 1

Proforma used by operations staff for
Survey of presence/absence of Jarrah Leafminer in forest blocks

STAPLE LEAF TO
EACH SHEET

Date: .....

Observer: .....

Block: .....

Specific location of observation (Reference tree, road intersection etc.)
N.B. If jarrah lacking, then move to nearest jarrah stand.

Evidence for presence of Jarrah Leafminer:

(Tick boxes)

* Mines seen but no exit holes ☐
* Mines and exit holes seen ☐
* Neither of the above, therefore conclude that Jarrah Leafminer is absent ☐
* If mines are present, is there any evidence of parasitism? ☐

Any other comments (e.g. other insect damage of significance found en route to observation point, Gumleaf Skeletonizer, brown crowns)

_____

_____

_____

_____

_____

Table 2

Jarrah Leafminer Permanent Monitoring Plots
(see also Fig. 25)

RT = reference tree - for locations see CALM's 1:50 000 forest maps
MWS = Metropolitan Water Supply
SECWA = State Energy Commission of Western Australia

Plot No.	Block	Location
1	Illawarra	S side of Brookton Highway, 0.6 km E of Boulder Rock.
2	Canning	S side of Brookton Highway, just E of RT BE 69/1 (1.5 km further E of previous plot).
3	Lesley	N side of Brookton Highway and E of intersection with Ashendon Road (1.0 km E of previous plot).
4	Lesley	N side of Brookton Highway, 3.9 km E of previous plot. Walk 100 m along a track to virgin forest.
5	Lesley	N side of Brookton Highway, 0.6 km E of RT BJ 74/1 (2.0 km E of previous plot).
6	Lesley	N side of Brookton Highway, at intersection with Omeo Road (0.8 km E of previous plot).
7	Dale	N side of Brookton Highway, at intersection with track 0.2 km W of Dale pine plantation (11.4 km E of previous plot).
8	Brady	W side of Watershed Road, 8.7 km from previous plot.
9	Flint	E side of Metro Road, 0.8 km S of RT BR 85/1 (8.7 km from previous plot).
10	Gibbs	E side of Metro Road, 2.0 km S of crossing with McCallum Road (6.1 km from previous plot).
11	Bannister	W side of Wearn Road (5.0 km E of Albany Highway or 27.6 km from previous plot).
12	Loc. 4829 (MWS)	Cowcher Road, just in from Albany Highway at the gate. The plants are E of the gate.
13	O'Neill	N side of North East Road (5.4 km SW of Snake Road or 0.5 km NE of Ranger Road).
14	Clinton	N side of Vern Road, 9.3 km E of its intersection with North Road.
15	Clinton	N side of Berkeley Road, 0.2 km E of its intersection with North Road.
16	Mundlimup	S side of Jarrahdale Road, 1.6 km E of Bunning's Jarrahdale mill. At gate.
17	Chandler	N side of Jarrahdale Road 1.4 km from previous plot, take the track to the left, and 0.4 km further take the second track to the left. The plot is 0.1 km along this track and to the right.
18	Randall	E side of Albany Highway, at the gate on Randall Road. The plants are to the S.
19	Randall	E side of Albany Highway, 1.3 km N of intersection with Millars Log Road (Sullivan Rock).
20	335	(Sullivan Rock) E side of Albany Highway, 0.4 km N of Millars Log Road.
21	Hamilton	Labour Road, 100 m N from Mornington Road (west side).
22	Arklow	DJ Road, 800 m from junction with Arklow Road (east side).
23	Darrell	600 m S along road to Loc. 1168, from Norm Road (west side).
24	Palmer	Yourdamung Road 300 m NE of intersection with the Williams-Collie Road.

Table 2 *(cont.)*

Plot No.	Block	Location
25	Palmer	100 m S of intersection of Yourdamung Road and the Williams-Collie Road.
26	Palmer	Yourdamung Road, 200 m S of track to 'Teddy Bear Mill' (west side): EE 76/5/4.
27	Trees	Williams-Collie Road 500 m NE of Pumping Station, (N side of road).
28	Godfrey	Sun Road, 600 m S of intersection with the Williams-Collie Road (west side).
29	Nundedine	Batalling Road, 2.3 km N of intersection with Summer Road (east side).
30	'Cordering Farm'	900 m in from intersection with the Bowelling-Duranillin Road (east side).
31	Bennelaking	Pine Road, 100 m W of Trigwell Bridge Road.
32	Muja	On the Bowelling-McAlinden Road, 1.6 km N of intersection with Boyup Brook Road North (west side).
33	Centaur	Hebb Road, 2.4 km S of intersection with Coalfields Road (east side).
34	Fleays	Don's Road, 500 m from intersection with Coalfields Road (and 200 m W of SECWA powerline) (west side of Don's Road).
35	Loc. 1120	EL 80/1/0 (100 m W of block boundary).
36	Western	First track W of Lime Road and N of Muja Powerhouse Road (100 m in).
37	Mungalup	100 m E of Mungalup Road, 900 m SW from intersection with Palmer Road.
38	Westralia	Flora Road, 200 m in from Coalfields Road (east side).
39	Gervasse	Lullaby Road, 300 m from intersection with Coalfields Road.
40	Gervasse	Halo Road, 100 m E of intersection with Beela Road.
41	Netic	S side of Stallard Road, 0.8 km NW from its intersection with Sears Road.
42	Yornup	E side of the Brookes-McAlinden Road, 1.6 km NW of junction with Donnelly Mill Road.
43	Mersea	N. side of Aerial Road, 0.3 km E of junction with SECWA powerline.
44	Dwalgan	N side of Distributor Road, 0.7 km E of intersection with the Boyup Brook-Cranbrook Road.
45	Easter	N side of Dickson Road, 0.6 km W of intersection with Sand Road (0.6 km E of Newchum Road).
46	Yanmah	S side of Len Road, 0.5 km W of intersection with Paganini Road.
47	Alco	N side of Palgarrup West Road, 0.9 km W of boundary of State forest and Loc. 13116.
48	Yardup	N side of John Road, 0.1 km W of junction with Edwards Road.
49	Beavis	Both sides of Beaver Road, 0.2 km N of its junction with Seven Day Road.
50	Channybearup	S side of Palings Road, 1.0 km SE of intersection with Channybearup Road.
51	Dingup	S side of Smeathers Road, 0.9 km S of intersection with Hamilton Road.
52	Cardac	S side of Ford Road, 0.5 km W of Wilgarup River bridge.
53	Yeticup	N side of Ned Road, 0.5 km SE of Kepal Road crossing.
54	Meribup (CSIRO)	E side of Cup Road, 0.1 km S of intersection with Mordalup Road.

Table 2 *(cont.)*

Plot No.	Block	Location
55	Boyicup	N side of Mordalup Road, 0.4 km E of intersection of Roo Road.
56	Brockman	W side of Fox Road, 0.1 km N of its intersection with Vasse Highway.
57	Quininup	E side of South Western Highway, 0.3 km S of intersection with Gray Road.
58	Meribup (Deeside)	E side of Arboretum Road, 0.1 km NE of intersection of Arboretum Road and Perup Road.
59	Talling	N side of Muir Highway, 2.8 km E of Bunnings Log Road crossing (and 1.8 km W of Thomson Road).
60	Poole	W side of Wallace Road, 0.1 km S of its junction with Kessell Road.

Table 3

Gumleaf Skeletonizer Permanent Monitoring Points (individual trees)
(see also Fig. 26)

Note - for locations see CALM's 1:50 000 forest maps

Tree No.	Block	Location
1	Carter	N side of Donnelly Mill Road, 0.5 km W of intersection with Mokerdillup Road.
2	Yanmah	W side of Sears Road, 2.2 km S of intersection with Donnelly Mill Road.
3	Yanmah	S side of Len Road, 1.2 km W of intersection with Sears Road.
4	Yanmah	W side of Gregory Road, 2.9 km N of intersection with Paganini Road.
5	Netic	S side of Penny Road, 0.2 km W of intersection with Sears Road.
6	Wheatley	E side of Penny Road, 0.9 km S from the Donnelly River bridge.
7	Wheatley	N side of Gregory Road, 0.3 km E of intersection with Tom Road.
8	Gordon	E side of Austin Road, 0.4 km S of intersection with Mobil Road.
9	Lewin	E side of Coronation Road, 0.3 km S of intersection with Dickson Road.
10	Graphite	N side of Palings Road, 2.9 km E of intersection with Austin Road.
11	Graphite	N side of Palings Road, 0.2 km further E of Tree No. 10.
12	Solai	S side of Waistcoat Road 0.2 km S of intersection with Palings Road.
13	Solai	E side of Record Road, 0.1 km S of intersection with Waistcoat Road.
14	Solai	N side of Seven Day Road, 4.1 km E of intersection with Record Road (0.1 km W of intersection with Etherington Road).
15	Solai	W side of Appadene Road, 1.9 km N of intersection with Seven Day Road.
16	Alco	S side of track heading N off Palgarrup West Road, 2.0 km W of intersection with South Western Highway (this tree is next to a research plot).
17	Mersea	N side of Mersea Road, 0.7 km E of intersection with South Western Highway.
18	Mersea	S side of Seaton Ross Road, 0.6 km W of intersection with Mersea Road.
19	Mersea	S side of Seaton Ross Road, 5.5 km further W of Tree No. 18 (and 2.6 km E of intersection with South Western Highway).
20	Yeticup	N side of Kepal Road, 0.1 km W of intersection with Perup Road.
21	Yeticup	S side of Kepal Road, 0.3 km W of intersection with Jackson Road.
22	Mooralup	E side of Kepal Road, 5.4 km past Tree No. 21 (and 1.1 km N of intersection with Cardac Road).
23	Cardac	S side of Cardac Road, 0.3 km W of intersection with Kepal Road.
24	Cardac	N side of Ford Road, 0.3 km W of Wilgarup River bridge.
25	Dingup	W side of Smeathers Road, 0.8 km S of intersection with Muir Highway (N.B. this is the intersection nearest Ford Road).
26	Dingup	N side of Sherman Loop Road, 1.7 km E of intersection with Smeathers Road (and 0.1 km W of intersection with Muir Highway).

Table 3 *(cont.)*

Tree No.	Block	Location
27	Quillben	E side of Wheatley Coast Road, 0.1 km S of intersection with Muir Highway.
28	Kinkin	E side of Wheatley Coast Road, 1.8 km S of Warren River bridge (0.4 km S of SECWA powerline).
29	Dordagup	E side of Wheatley Coast Road, 3.0 km S of Tree No. 28 (0.5 km N of Access Road).
30	Quininup	E side of South Western Highway, 0.5 km S of intersection with Gray Road (this tree is in a research plot).
31	Coonan	W side of Corbalup Road, 2.1 km N of intersection with Perup Road.
32	Warrup	W side of Corbalup Road, 0.1 km N of intersection with Telephone Track.
33	Corbal	W side of Corbalup Road, 0.8 km N of intersection with Lea Road (and 0.3 km S of Reference Tree GR 88/1).
34	Dwalgan	E side of Corbalup Road, 0.2 km S of intersection with Kingston Road.
35	Dwalgan	N side of the Boyup Brook-Cranbrook Road, 0.9 km SE of intersection with Distributor Road.
36	Dwalgan	2.8 km SE of Tree No. 35 on N side of the Boyup Brook-Cranbrook Road 0.9 km SE of Tamar Gully.
37	Yendicup	3.9 km SE of Tree No. 36 on N side of the Boyup Brook-Cranbrook Road 1.6 km SE of Perup River.
38	Yackelup	6.1 km SE of Tree No. 37 on E side of Northern Road, 0.1 km S of intersection with the Boyup Brook-Cranbrook Road.
39	Yackelup	E side of Northern Road, 3.5 km further S from Tree No.38.
40	Camelar	E side of Northern Road, 0.8 km S of intersection with Seaton Ross Road.
41	Camelar	E side of Northern Road, 1.0 km S of intersection with Fordson Road.
42	Boyicup	E side of Northern Road, 0.2 km S of intersection with de Landgrafft Road.
43	Boyicup	E side of Northern Road, 5.4 km further S of Tree No. 42 (0.6 km N of intersection with Mordalup Road).
44	Meribup	W side of Cup Road, 1.2 km S of intersection with Mordalup Road.
45	Meribup	E side of Cup Road, 0.6 km S of Spud Road.

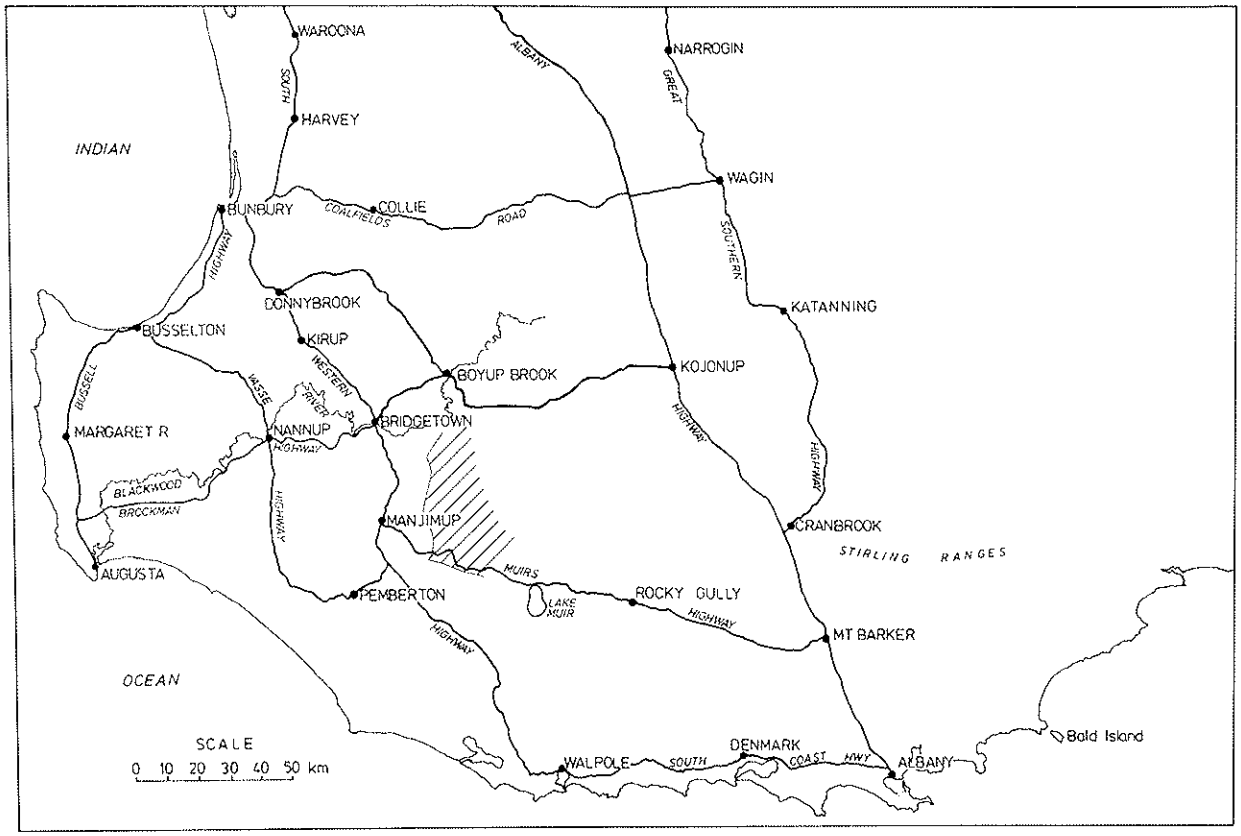

Figure 1

Moderate-severe infestation by jarrah leafminer of jarrah forest in 1964 (based on map by A. Mather).

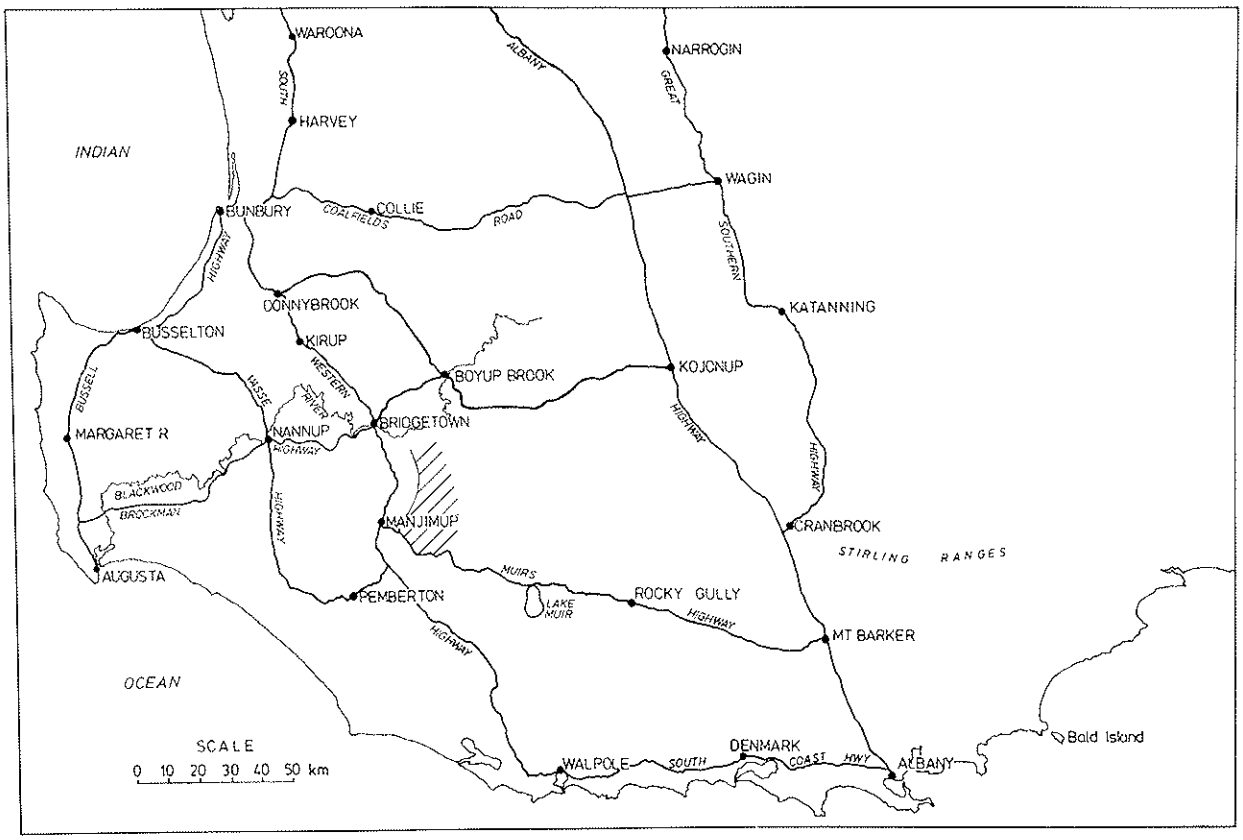

Figure 2

Moderate-severe infestation by jarrah leafminer of jarrah forest in 1966 (based on map by A. Mather).

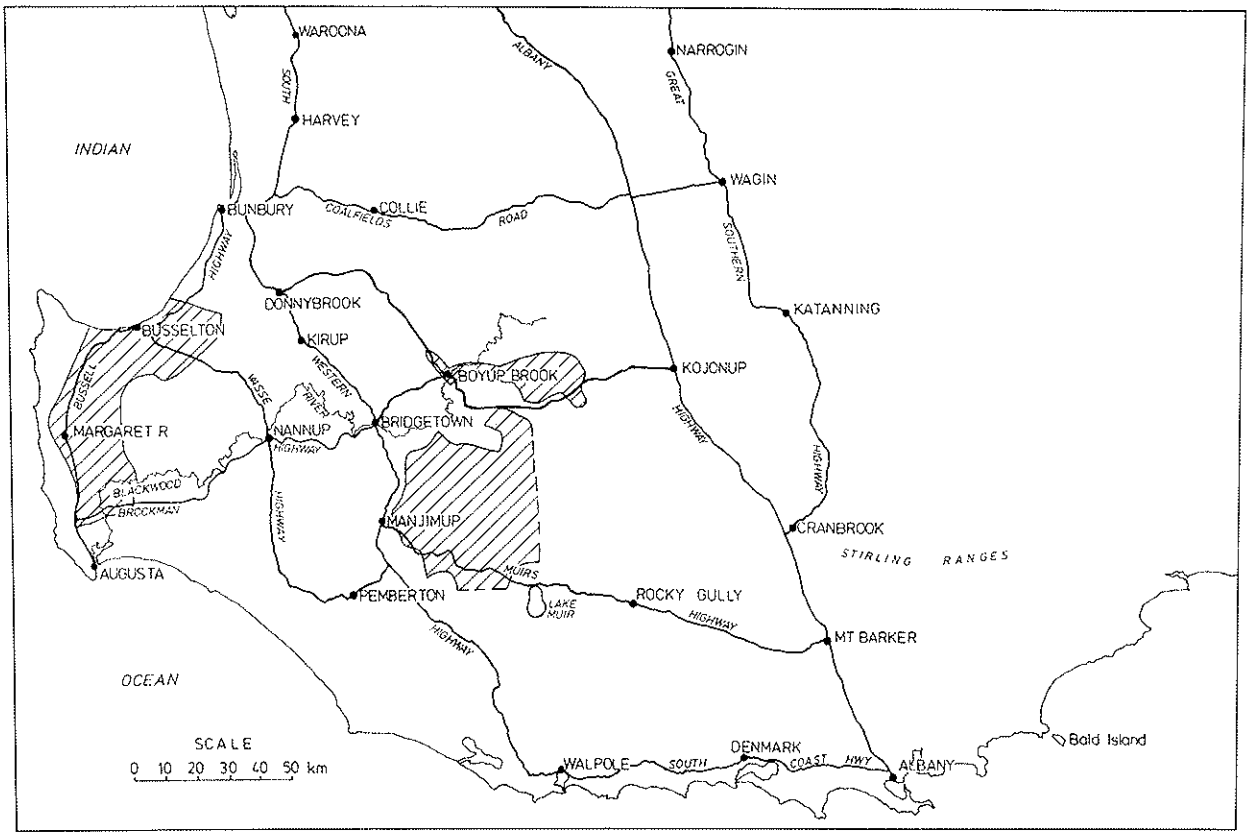

Figure 3
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1967 (based on map by A. Mather).

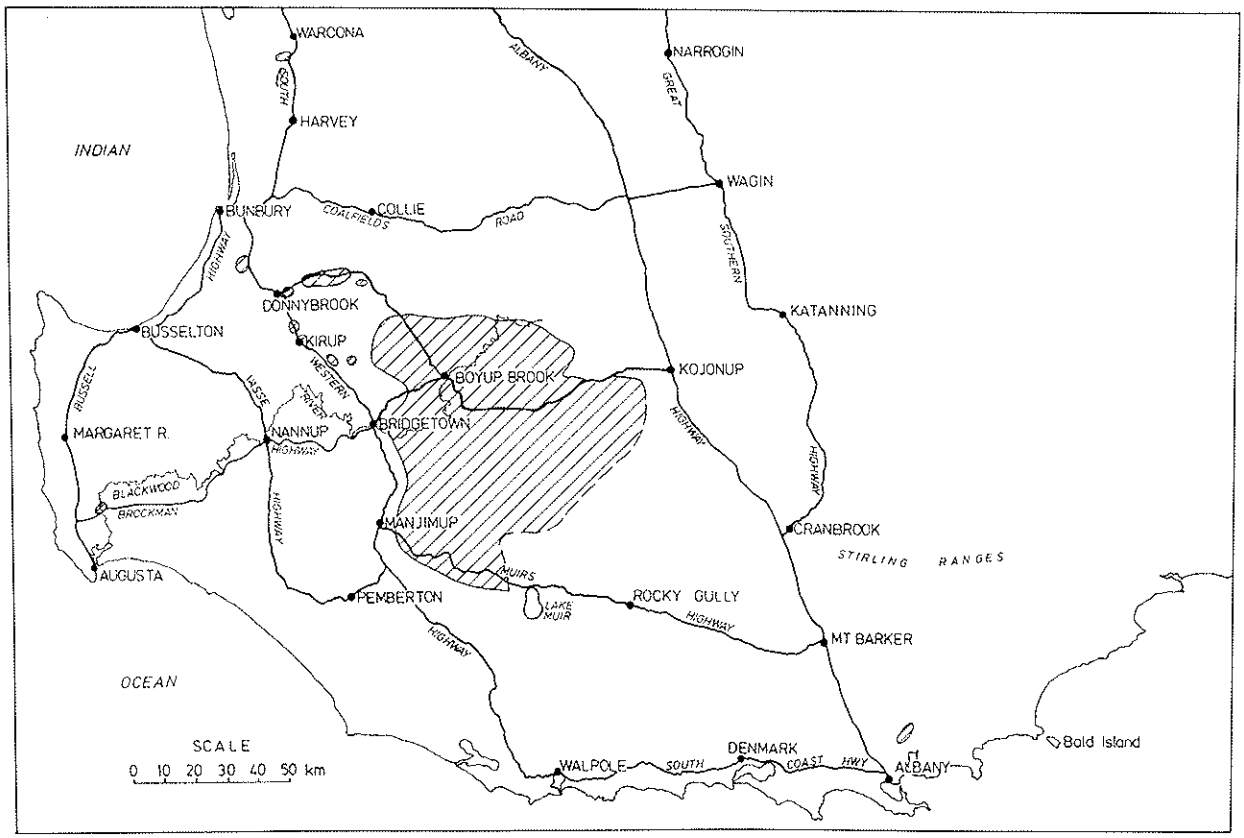

Figure 4
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1968
(based on information provided by Z. Mazanec).

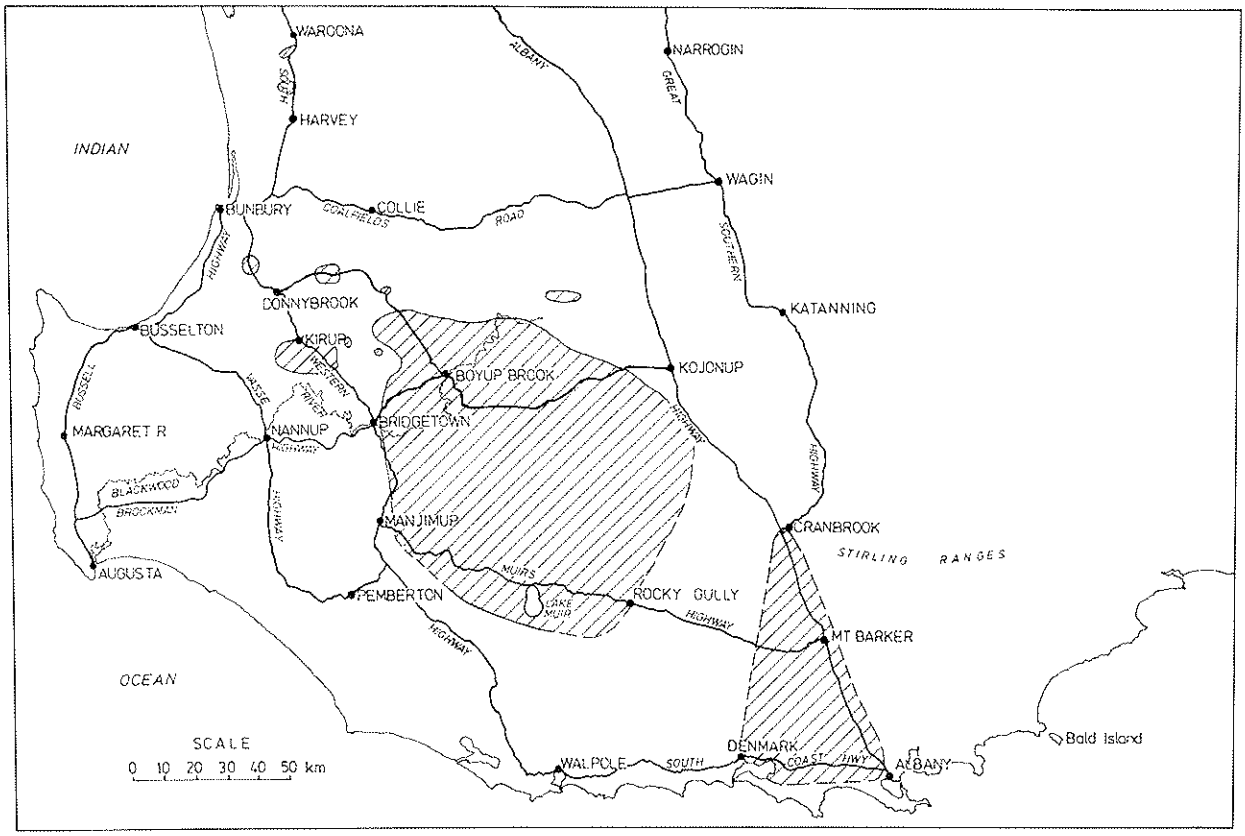

Figure 5
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1969
(based on information provided by Z. Mazanec).

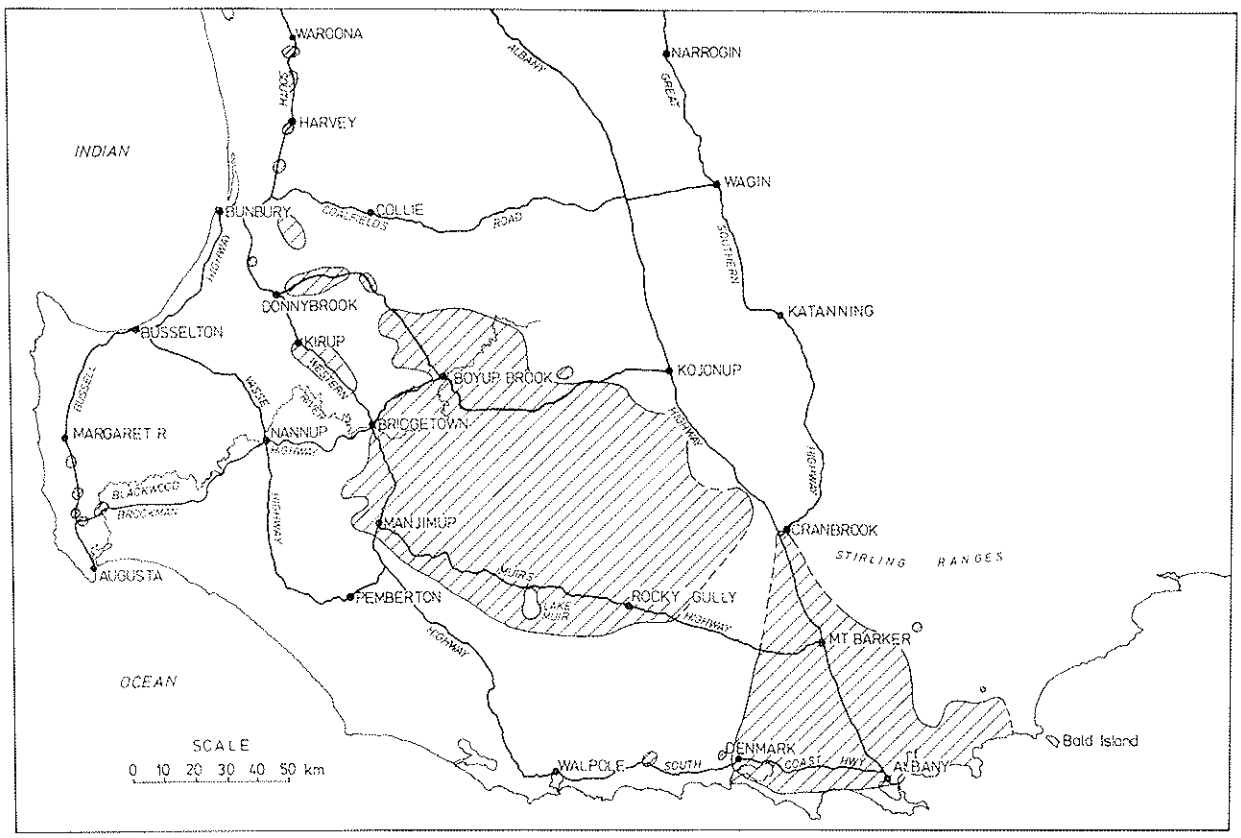

Figure 6
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1970 (based on information provided by Z. Mazanec).

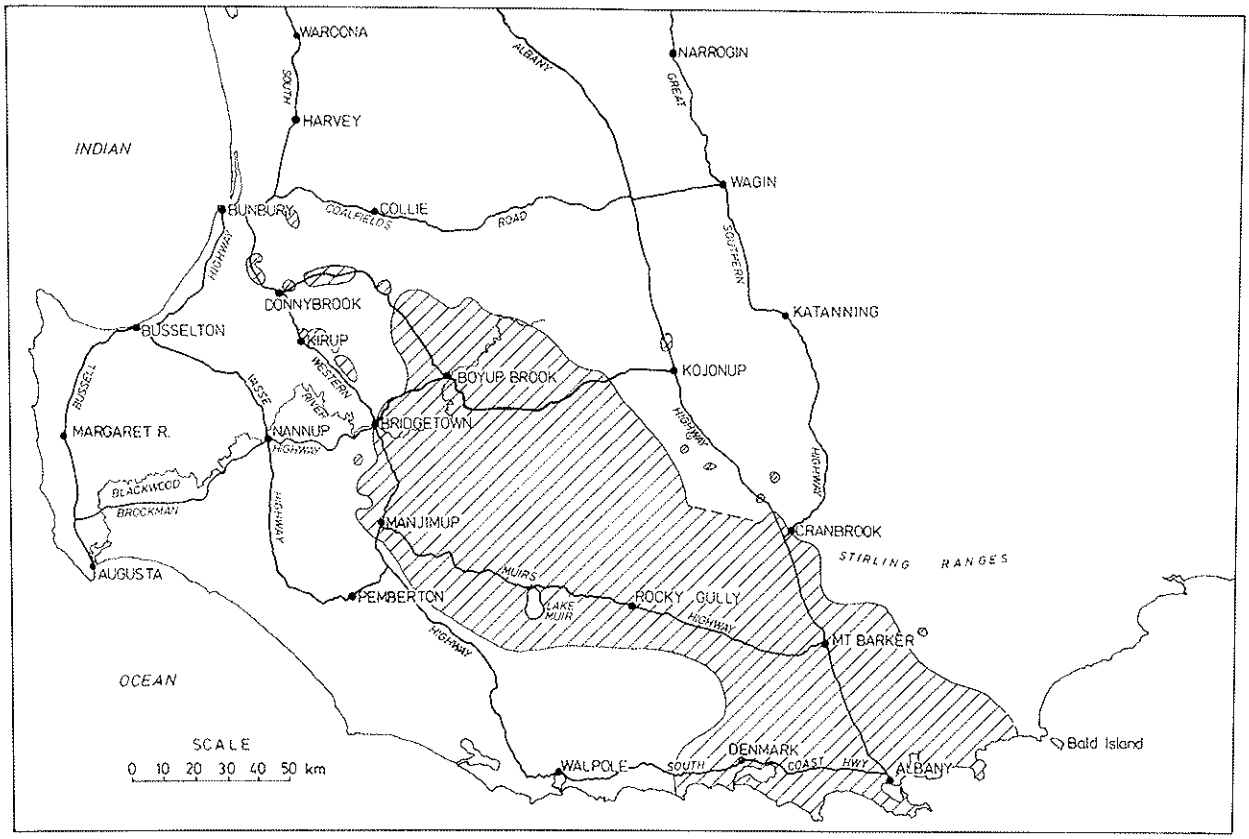

Figure 7
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1971
(based on information provided by Z. Mazanec).

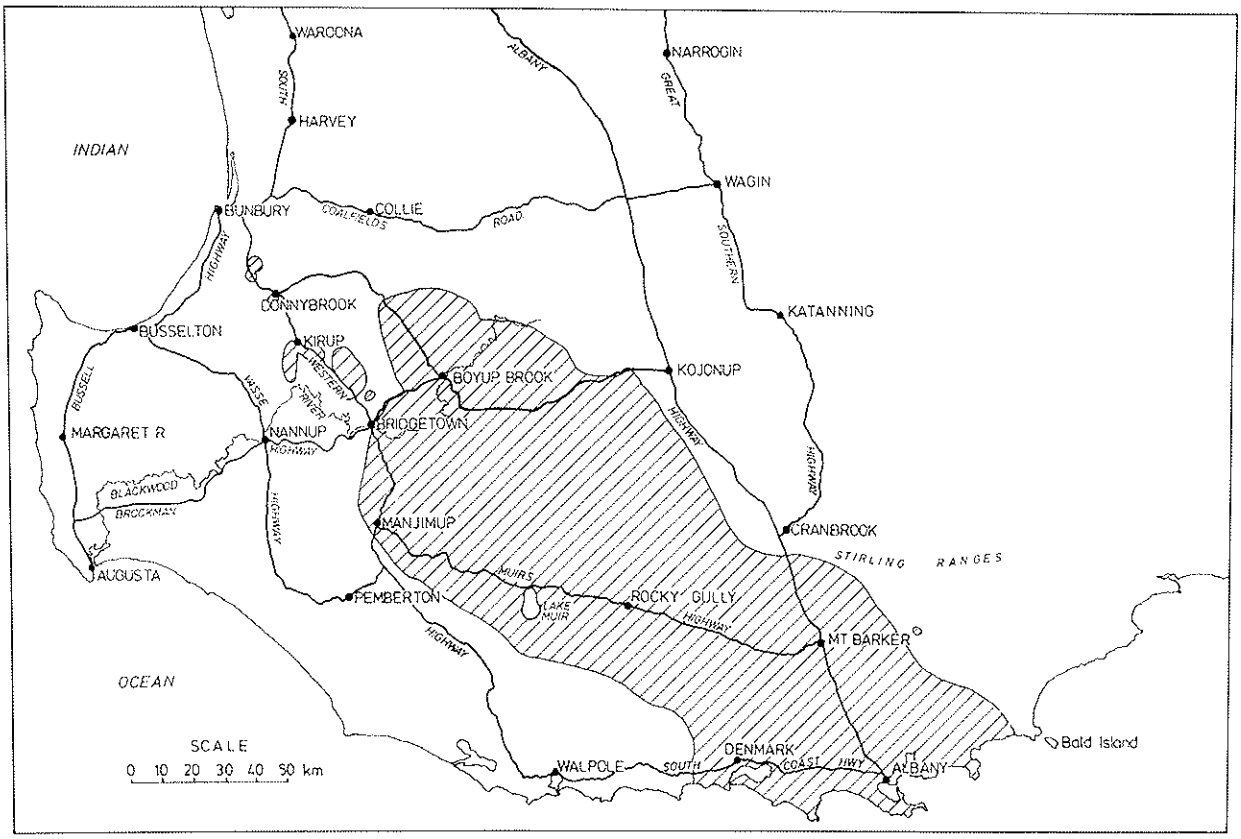

Figure 8
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1972
(based on information provided by Z. Mazanec).

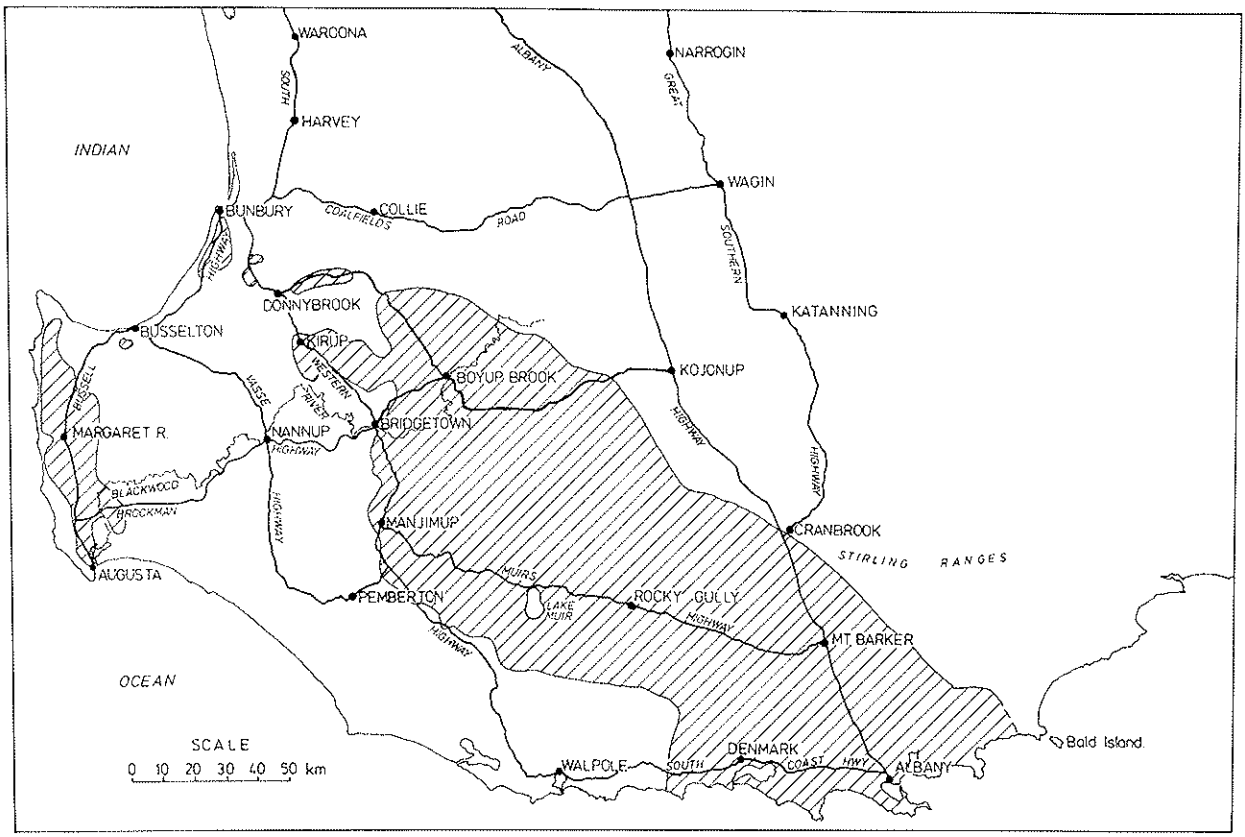

Figure 9
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1973
(based on information provided by Z. Mazanec).

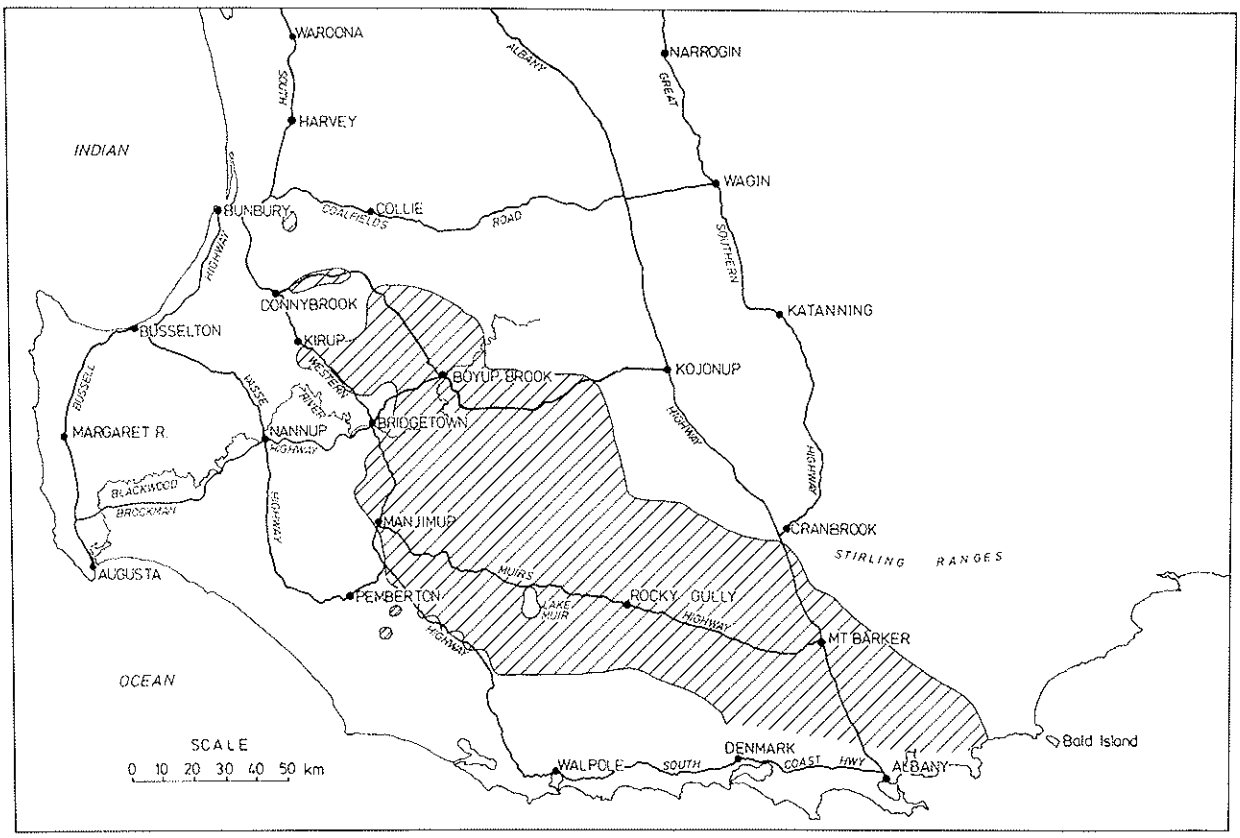

Figure 10
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1974
(based on information provided by Z. Mazanec).

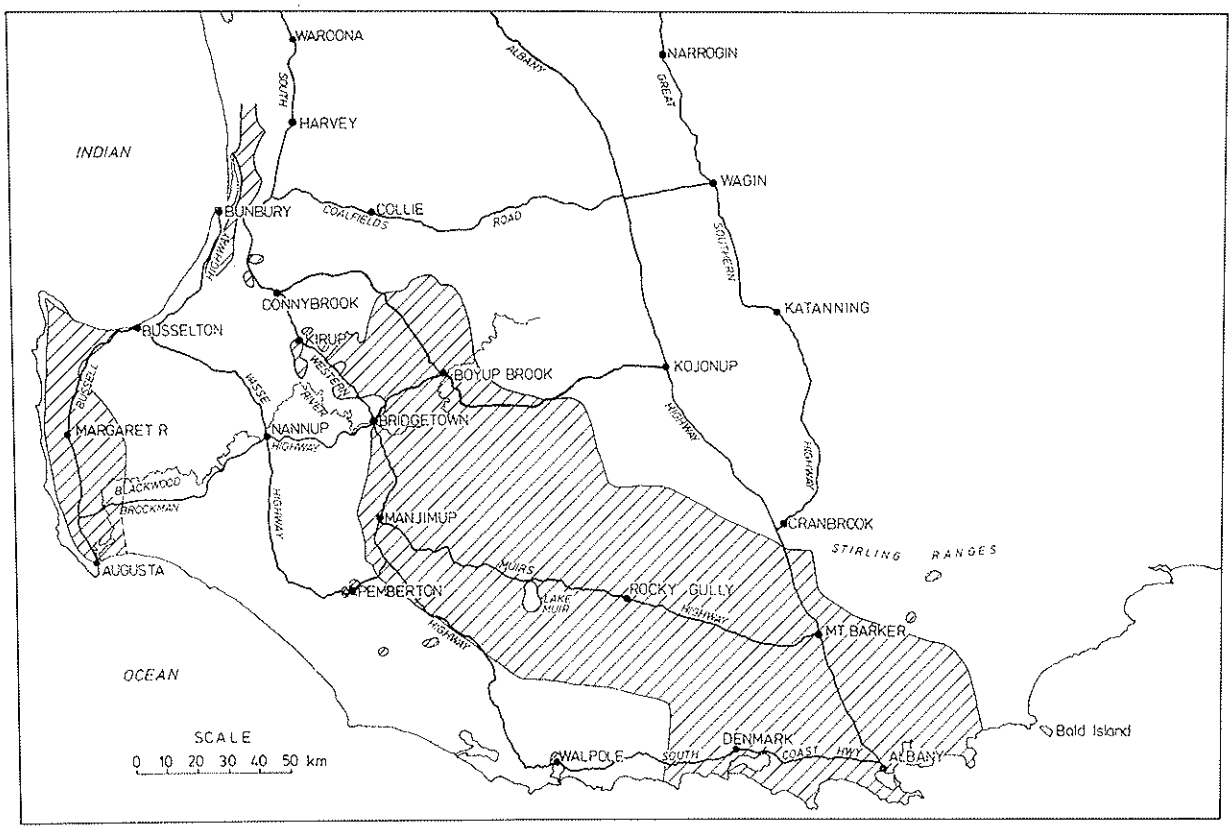

Figure 11
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1975
(based on information provided by Z. Mazanec).

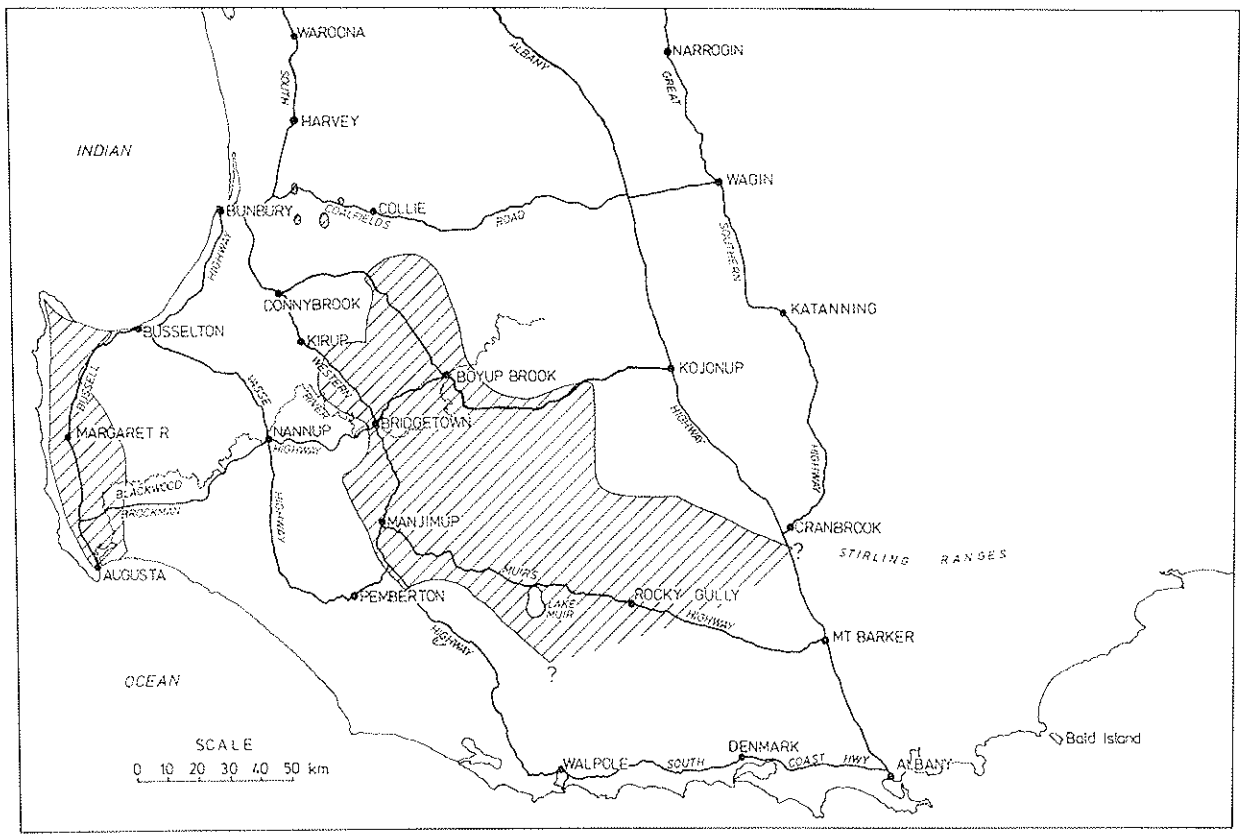

Figure 12
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1976 (based on information provided by Z. Mazanec).

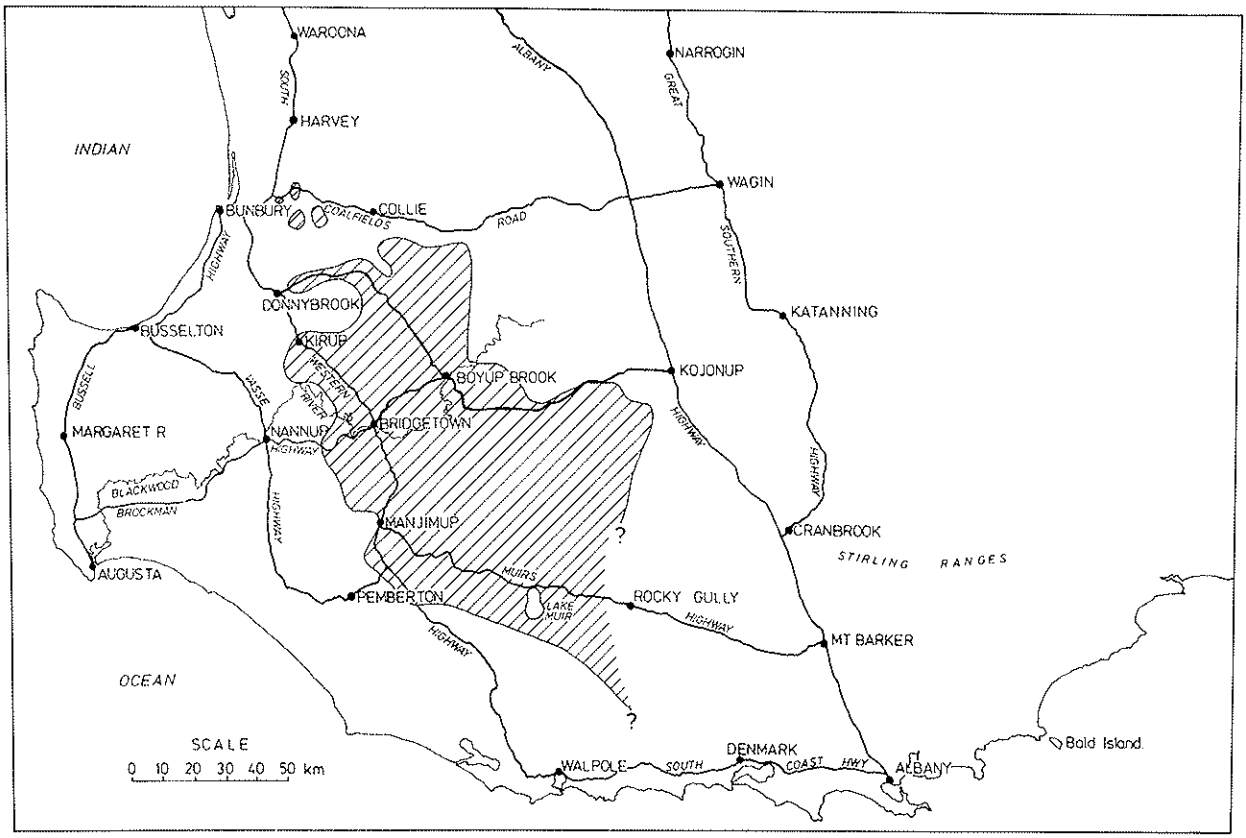

Figure 13
Moderate-severe infestation by jarrah leafminer of jarrah forest in 1980
(based on information provided by Z. Mazanec).

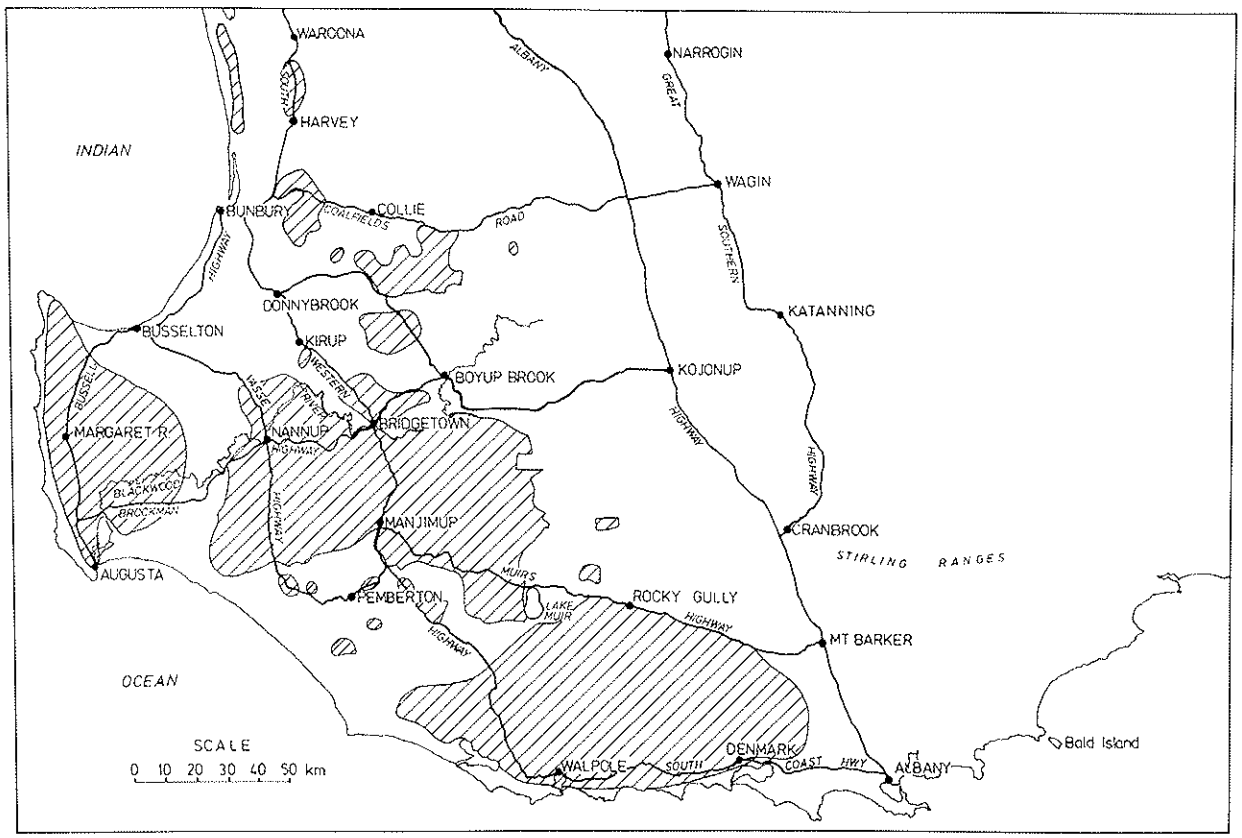

Figure 14
Infestation of jarrah forest by jarrah leafminer in 1983 (Forests Department compilation).

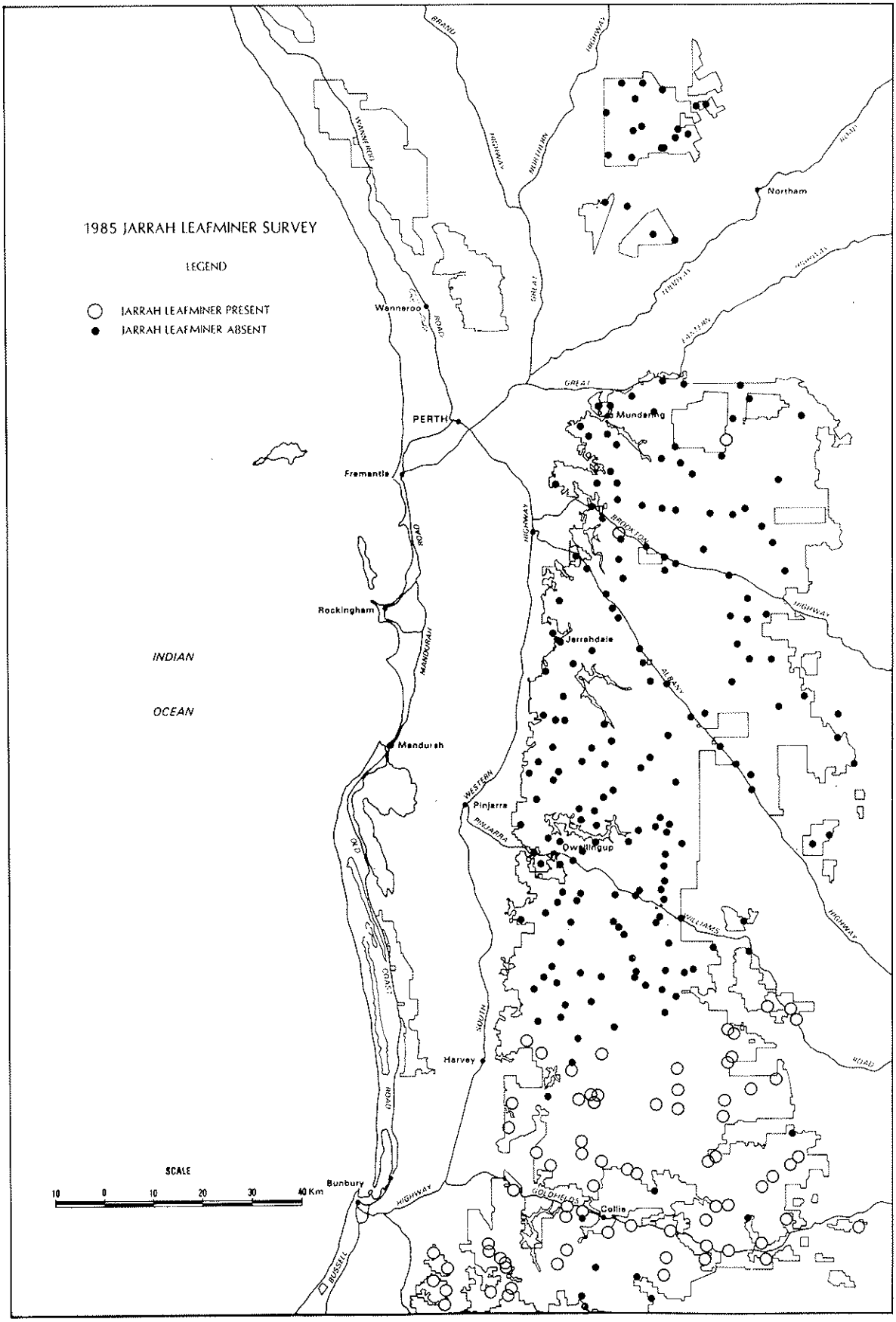

Figure15
Jarrah leafminer occurrence and distribution in the northern jarrah forest in 1985.

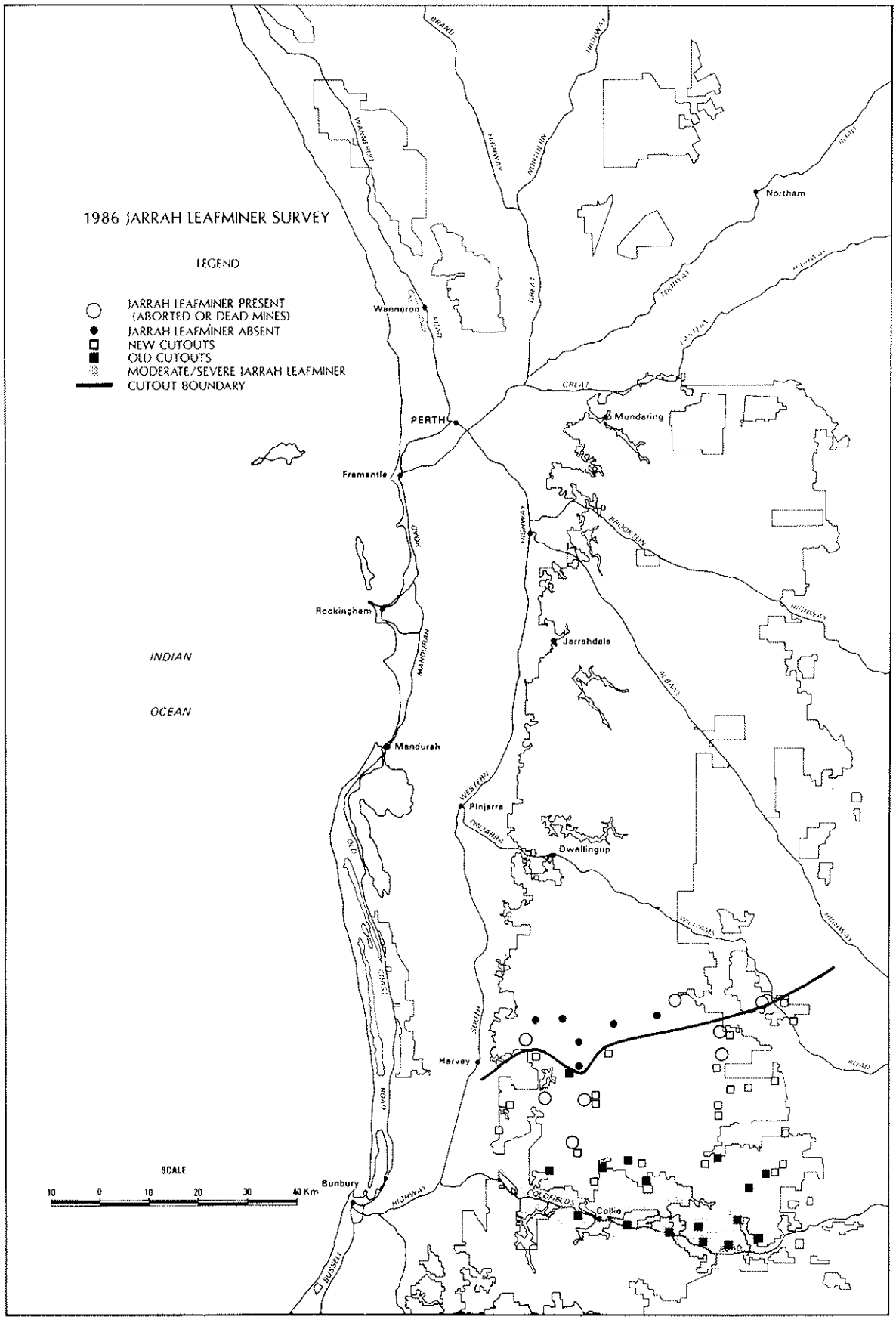

Figure 16
Jarrah leafminer occurrence and distribution in the northern jarrah forest in 1986.

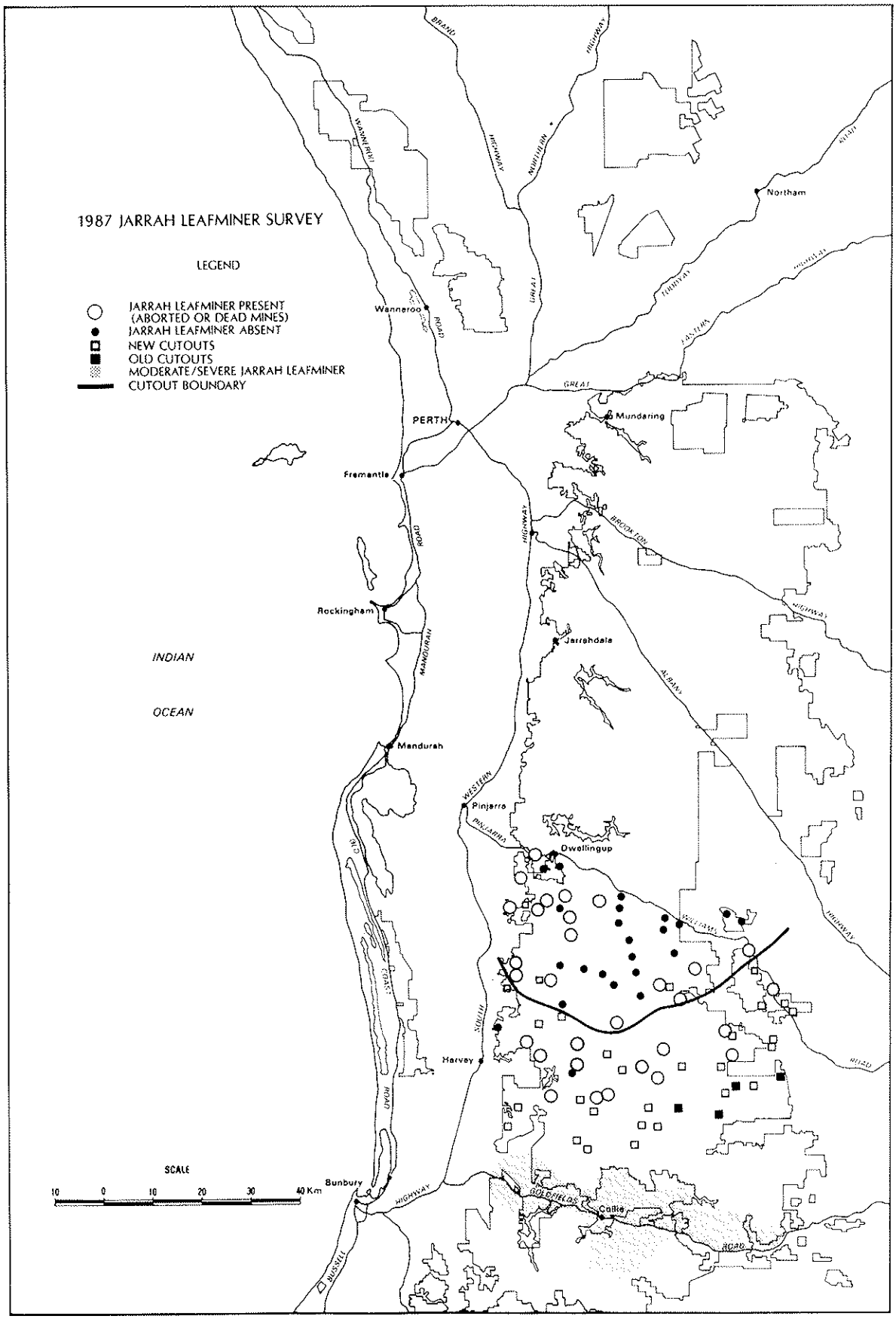

Figure 17
Jarrah leafminer occurrence and distribution in the northern jarrah forest in 1987.

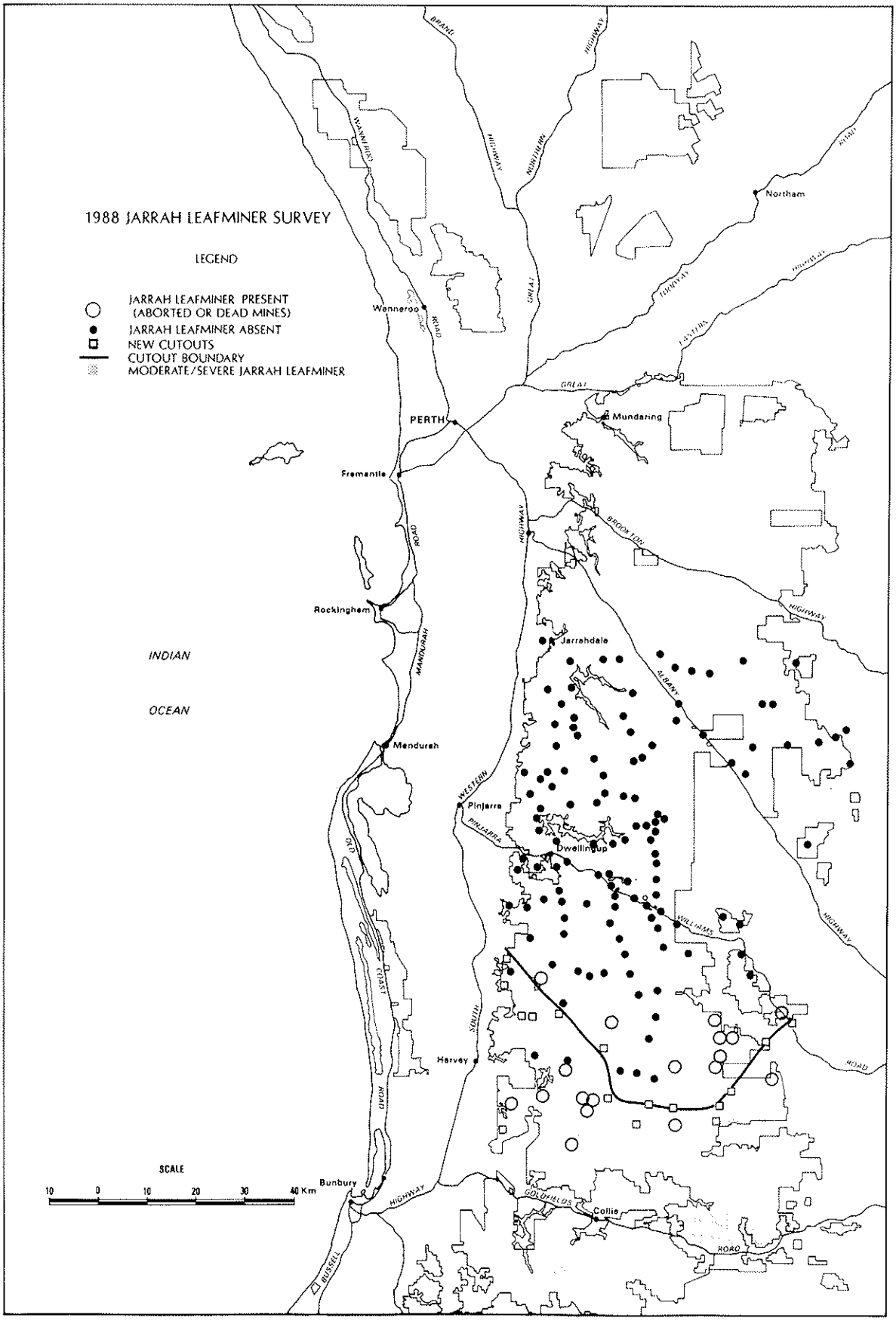

Figure 18
Jarrah leafminer occurrence and distribution in the northern jarrah forest in 1988.

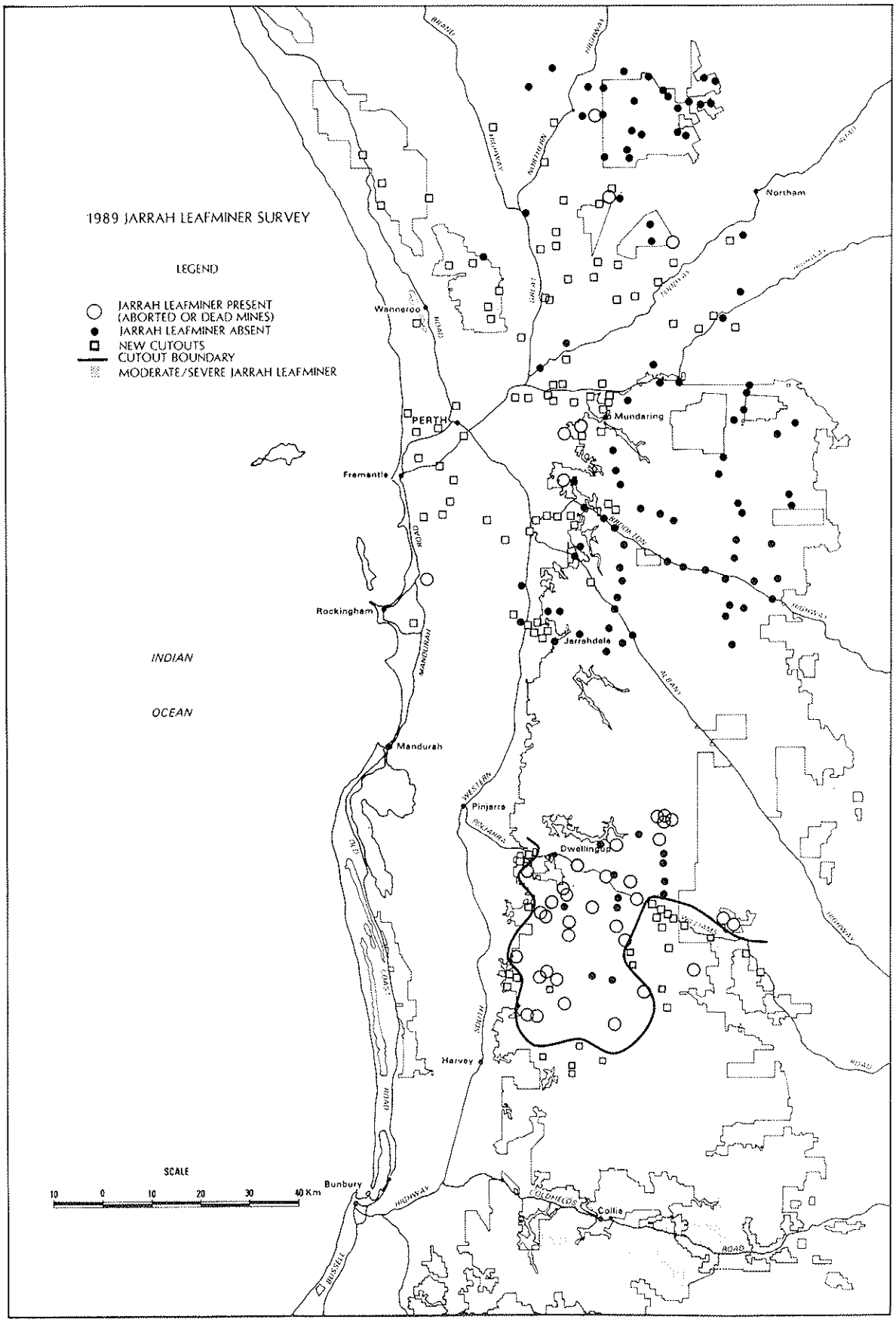

Figure 19
Jarrah leafminer occurrence and distribution in the northern jarrah forest in 1989.

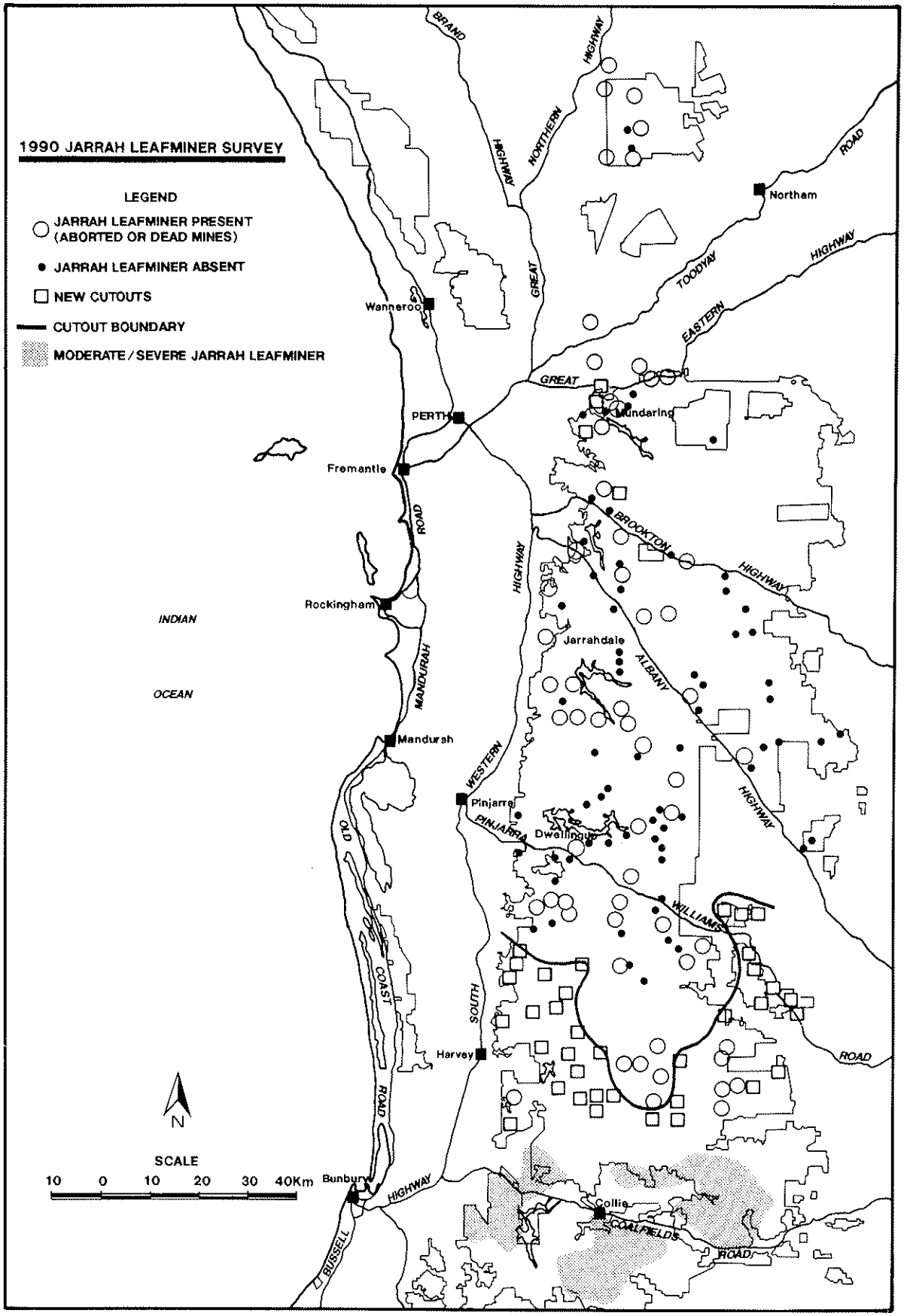

Figure 20
Jarrah leafminer occurrence and distribution in the northern jarrah forest in 1990.

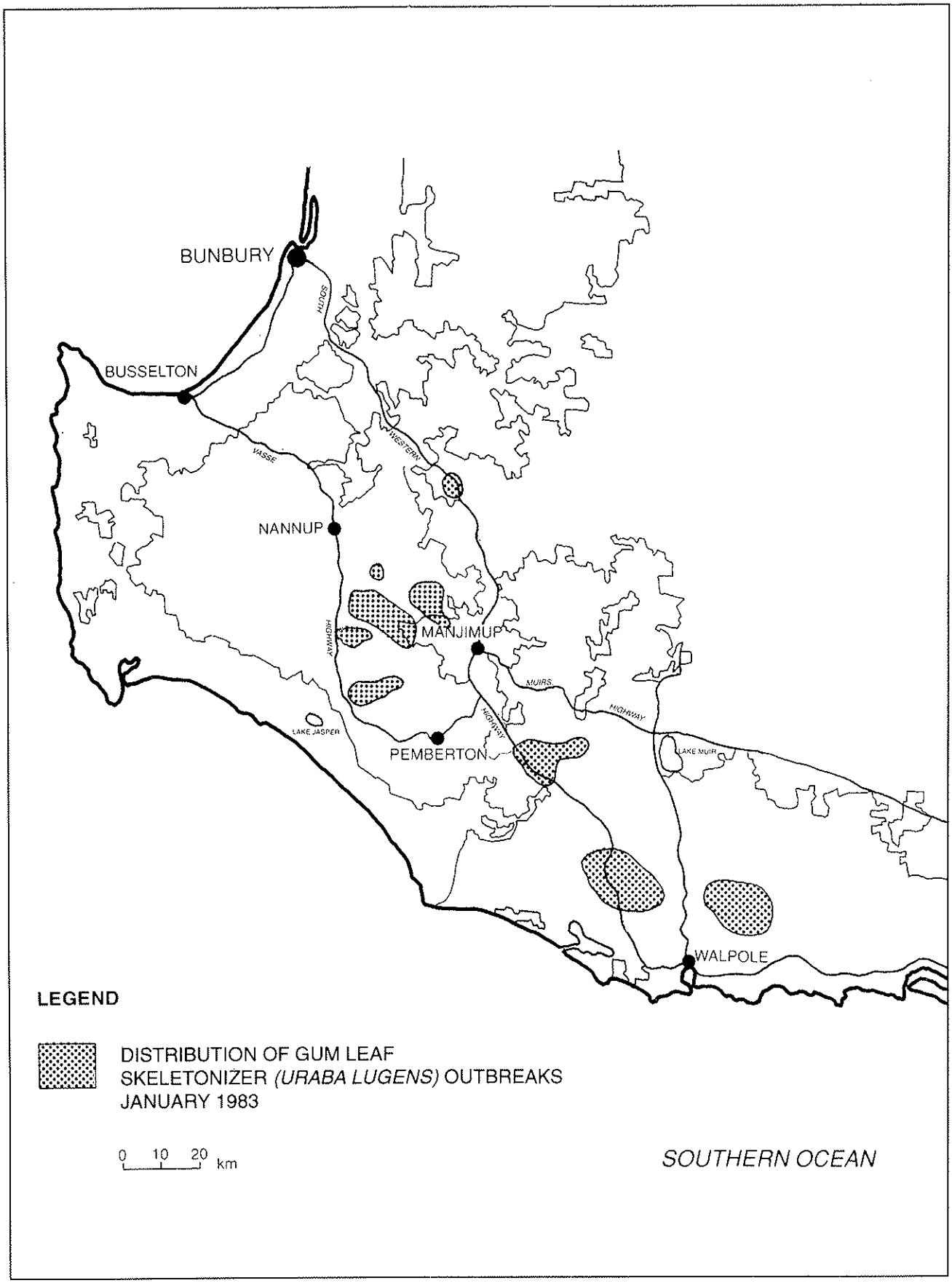

Figure 21
Gumleaf skeletonizer infestation in the southern jarrah forest in 1983.

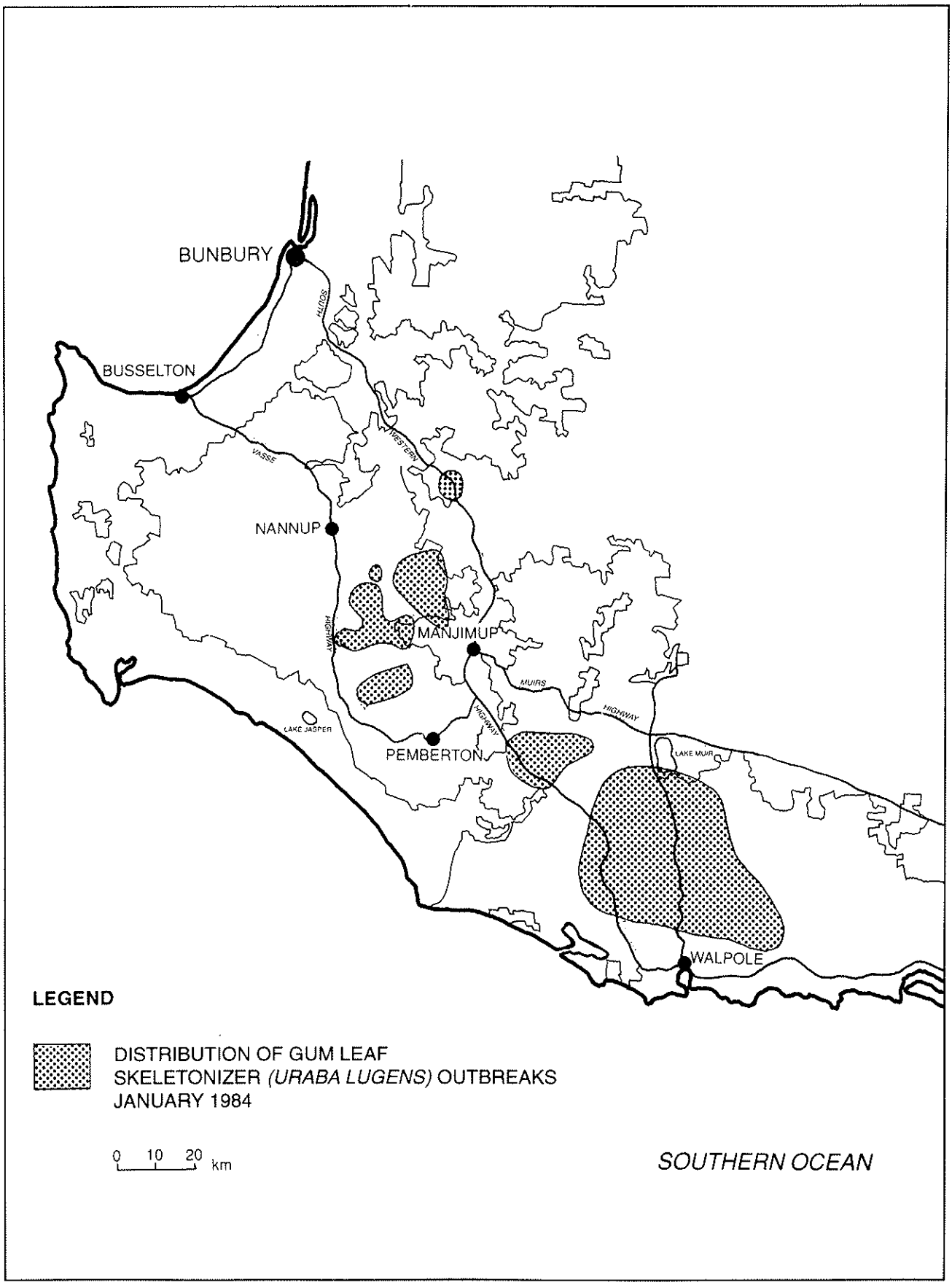

Figure 22
Gumleaf skeletonizer infestation in the southern jarrah forest in 1984.

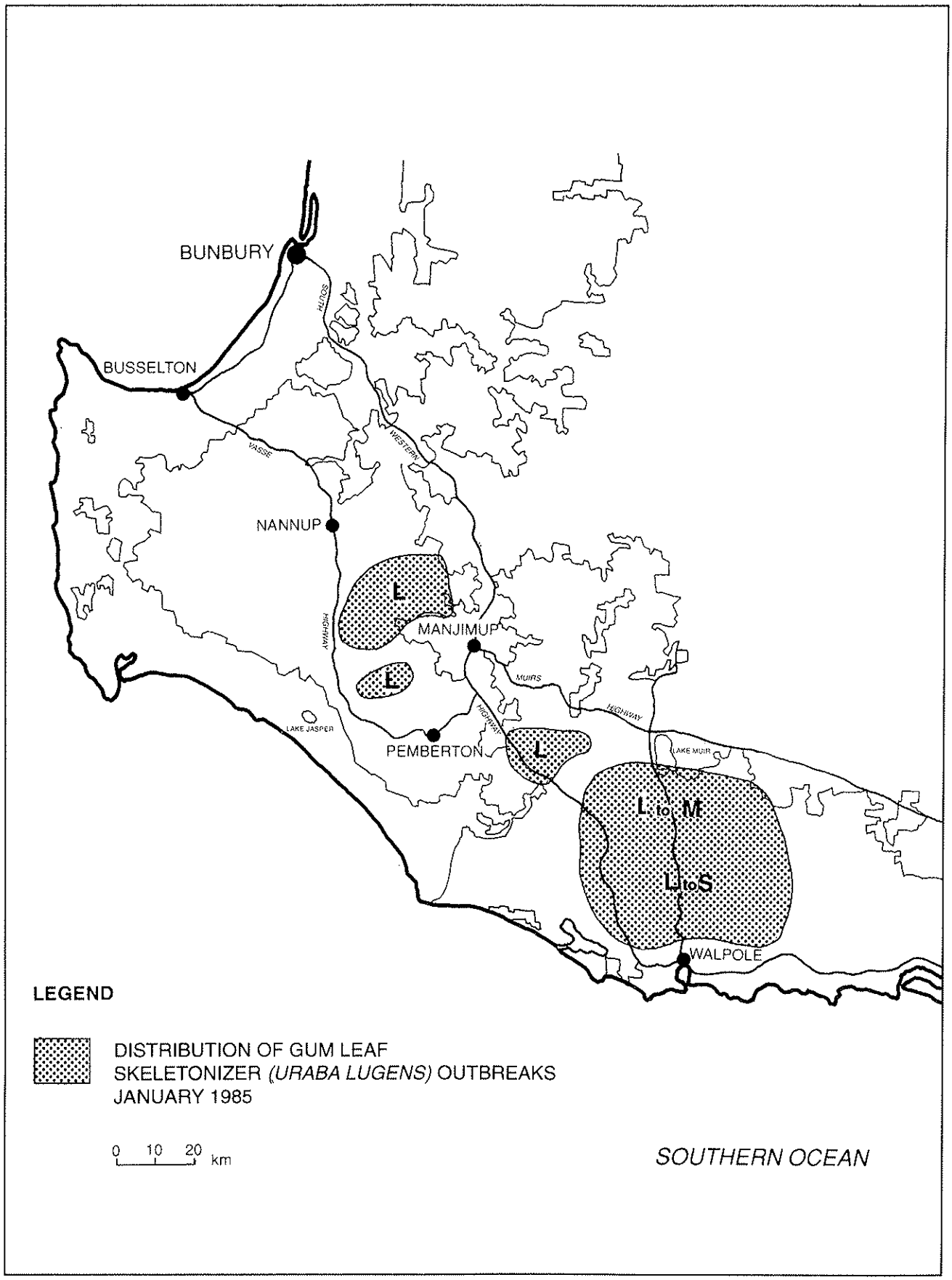

Figure 23
Gumleaf skeletonizer infestation in the southern jarrah forest in 1985.
L = light, M = moderate S = severe infestation

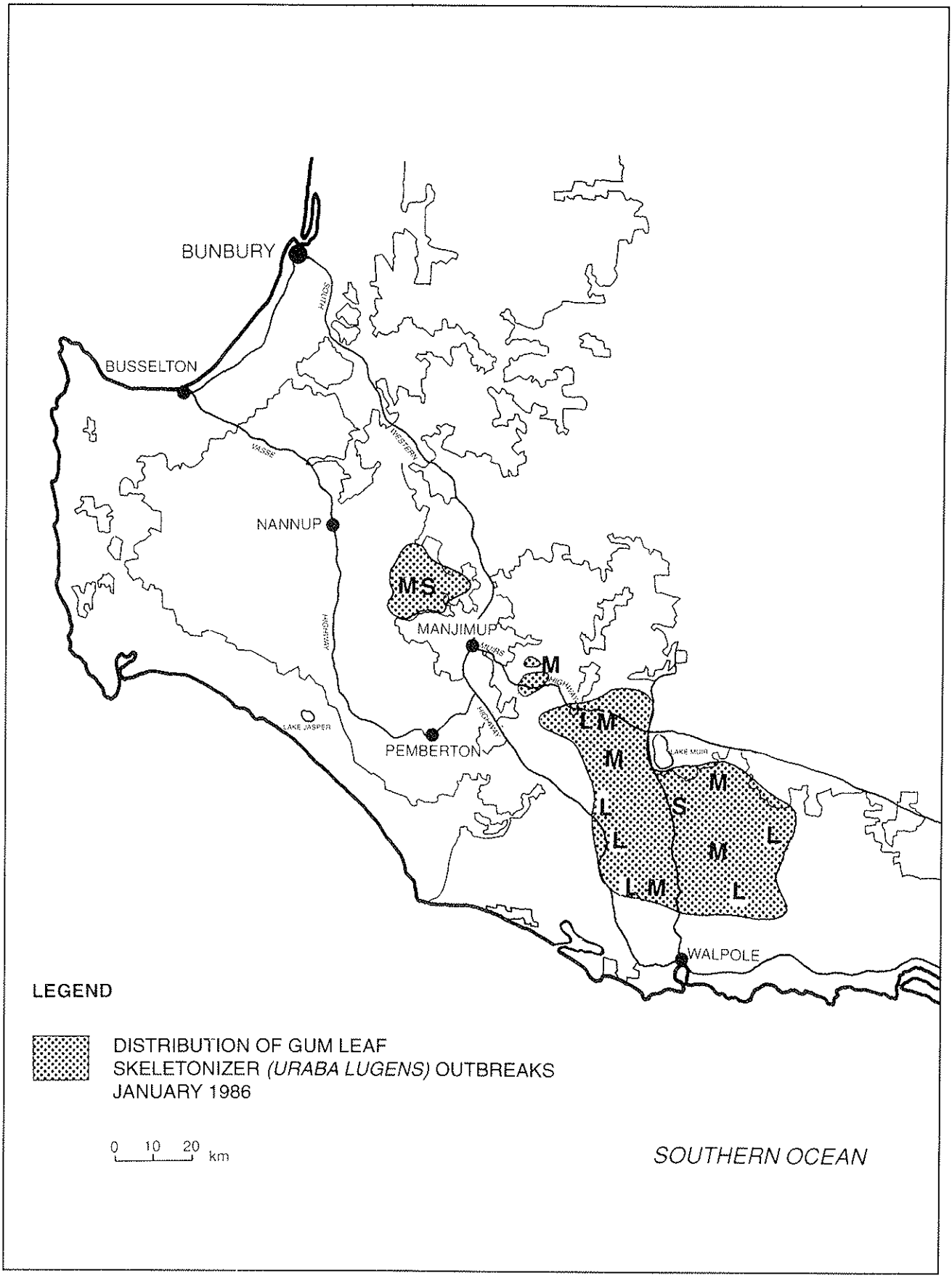

Figure 24
Gumleaf skeletonizer infestation in the southern jarrah forest in 1986.
L = light, M = moderate, and S severe infestation.

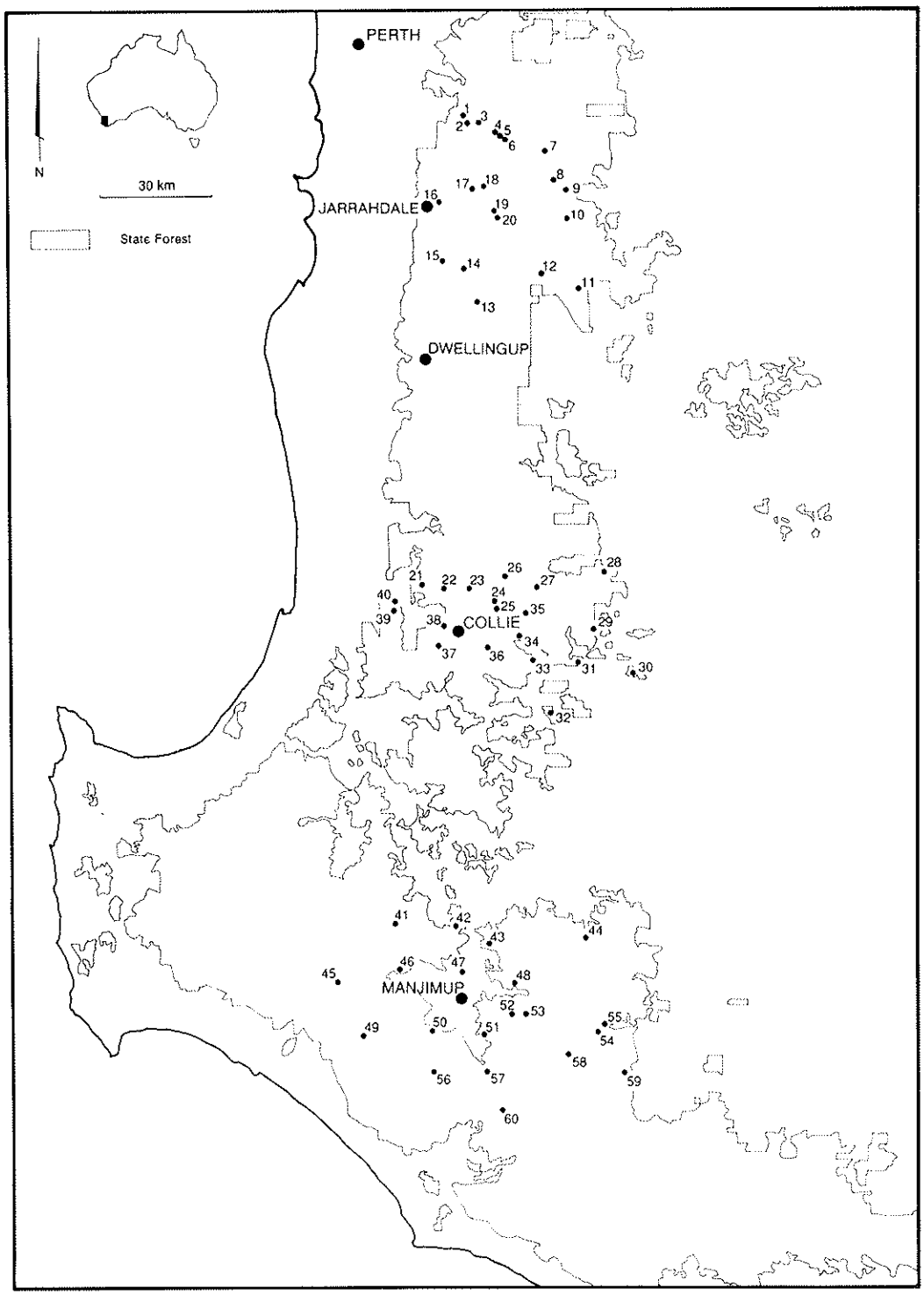

Figure 25
Location (e.g. • 58) of 60 jarrah leafminer monitoring plots.

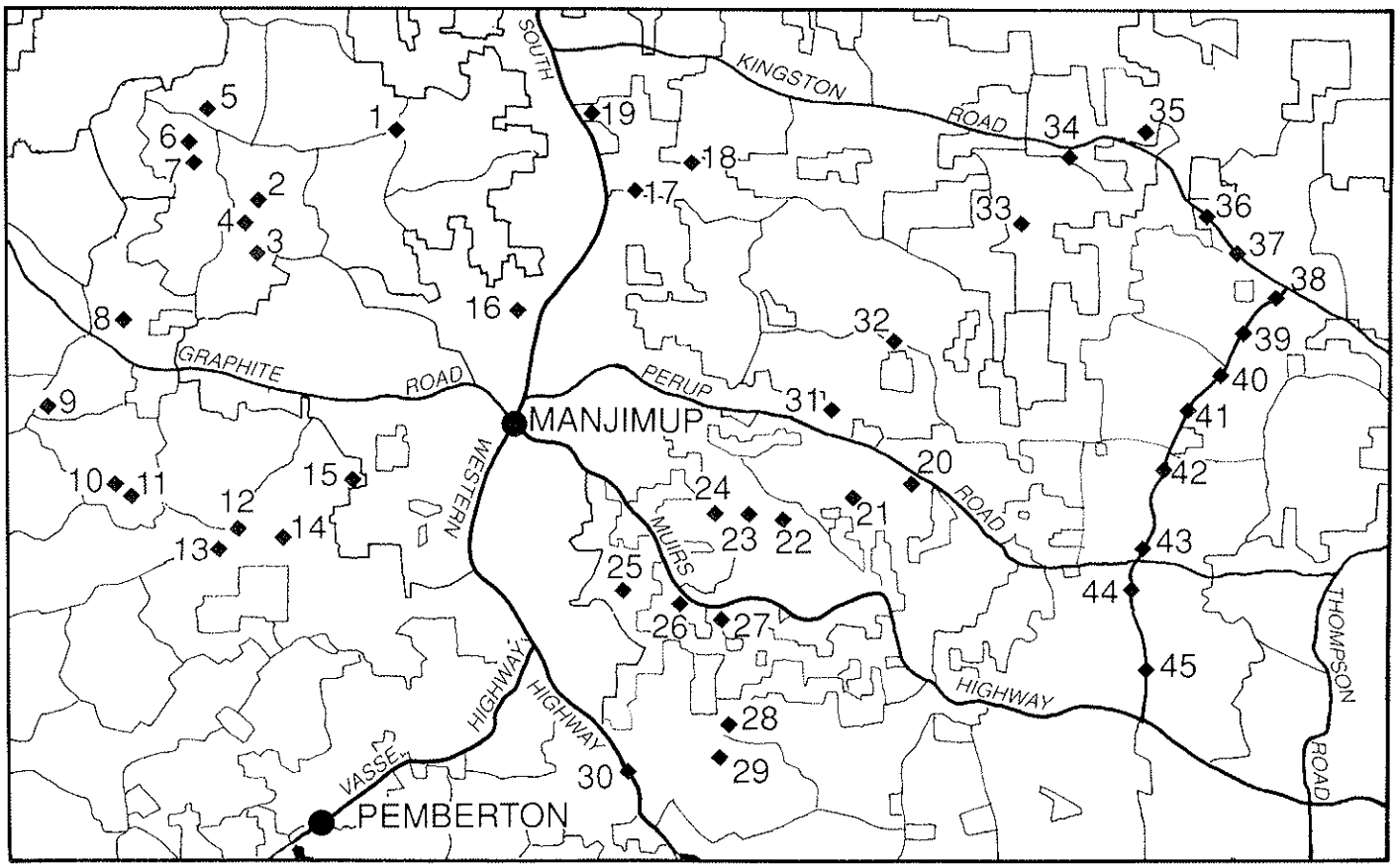

Figure 26
Location (◆) of 45 gumleaf skeletonizer monitoring points.

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