TERMITE SURVEY AND HAZARD MAPPING

L.J. Cookson[1] and A.C. Trajstman[2]

[1]CSIRO Forest Biosciences, Private Bag 10, Clayton South, Victoria 3169
[2]CSIRO Mathematical and Information Sciences, Private Bag 10, Clayton South, Victoria 3169

June 2002

This research was a joint investment between CSIRO and the Forest and Wood Products Research and Development Corporation (FWPRDC). The information contained in this report is copyright, and cannot be copied without the written permission of CSIRO or the FWPRDC.

We would like to thank Dr John French for the concept and initiation of the Termite Tally Survey, Rebecca Scott for coordinating the survey through CSIRO's Double Helix Science Club, Berhan Ahmed for helping with the verification survey and data entry, Arn Tolsma for further data entry, Dr Gerry Trinidad for helping us explore various approaches in termite mapping, Jim Creffield for identifying termites returned to CSIRO, and Dr Trevor Booth for pointing us in the direction of the agro-ecological map. The Forest and Wood Products RDC provided essential funding and support for this project. Mr Colin Mackenzie of TRADAC provided helpful comments on the manuscript.

Interviews were conducted Australia wide during 1996-8 to determine the influence of location and house construction type on termite activity. Information on 5122 dwellings was obtained, with the majority coming from a 'Termite Tally' survey conducted by the Double Helix science club.

List of Tables and Figures

Production of the Interim Termite Hazard Map

Note that not all totals will add to 5122 in this and following tables, as data for some of the questions asked for each house were not supplied.

Table 1. House Age

Survey question: What is the approximate age of your house?

State	Sample Number	Mean House Age (Years)	Standard Error	Median House Age (Years)
NT	91	15	1.5	12
QLD	918	27	0.8	20
SA	246	36	1.7	30
TAS	98	38	2.6	31
VIC	1037	33	0.8	25
WA	447	27	1.0	20
NSW	1961	30	0.6	20
ACT	209	25	0.9	25
Australia	5007	30	0.4	20

Conclusion: The mean house age in the study was 30 years. Youngest mean house age occurred in NT (Darwin mainly), due to the influence of rebuilding after Cyclone Tracy in 1974.

Table 2. Occupancy Time in House

Survey question: How long have you lived in the house?

Note that this question was not asked in the Termite Tally survey. It was an additional question posed for the telephone and CSIRO email surveys.

State	Sample Number	Mean Time in House (Years)	SE Mean Time in House	Median Time in House (Years)
NT	23	8	1.5	5
QLD	172	9	0.7	5
SA	66	11	1.2	8
TAS	32	9	1.3	8
VIC	263	11	0.7	8
WA	67	9	1.2	6
NSW	162	13	0.9	10
ACT	114	11	0.9	8
Australia	899	10.6	0.3	8

Conclusion: The mean occupancy time in the study was 11 years. Therefore, when homeowners were asked if their building ever had termites, they were giving results from a knowledge for the house that spanned a mean of 11 years.

Table 3. Frame Type

Survey question: Does your house have steel frame, solid masonry walls or timber frame?

	Percentage Frame Type (and number)						
State	**Timber**	**Timber + Masonry**	**Timber + Steel**	**Timber + Masonry + Steel**	**Masonry**	**Masonry + Steel**	**Steel**
NT	21.6 (19)	2.3 (2)	2.3 (2)	0.0 (0)	38.6 (34)	2.3 (2)	32.9 (29)
QLD	73.8 (683)	4.0 (37)	1.1 (10)	0.2 (2)	14.7 (136)	0.1 (1)	6.2 (57)
SA	36.8 (91)	8.5 (21)	0.0 (0)	0.4 (1)	53.0 (131)	0.0 (0)	1.2 (3)
TAS	78.4 (76)	4.1 (4)	1.0 (1)	0.0 (0)	10.3 (10)	0.0 (0)	6.2 (6)
VIC	85.4 (894)	2.6 (27)	0.2 (2)	0.1 (1)	10.6 (111)	0.0 (0)	1.2 (12)
WA	30.5 (135)	3.2 (14)	0.5 (2)	0.2 (1)	60.7 (269)	0.0 (0)	5.0 (22)
NSW	72.8 (1437)	2.9 (58)	0.4 (7)	0.0 (0)	17.8 (351)	0.2 (4)	5.5 (109)
ACT	69.7 (147)	7.1 (15)	0.9 (2)	0.0 (0)	16.1 (34)	0.0 (0)	6.2 (13)
Australia	69.3 (3482)	3.5 (178)	0.5 (26)	0.1 (5)	21.4 (1076)	0.1 (7)	5.0 (251)

Conclusions: Timber was the most common framing material in Victoria, Tasmania, Queensland, NSW and the ACT. Masonry predominates in WA, SA and NT. Only 5% of framing were steel alone, with the highest proportion found in the NT. Buildings with mixed framing types were relatively scarce, with timber and solid masonry (mainly double brick walls) the most common combination. During the surveys it was noted that mixed frames appeared to be more common in renovated or extended buildings, and they occurred more often in older houses.

Table 4. Floor Type

Survey question: What is your floor type: timber on stumps/piers or concrete slab?

	Percentage Floor Type (and number)		
State	**Timber**	**Timber + Concrete**	**Concrete**
NT	18.5 (17)	2.2 (2)	79.3 (73)
QLD	45.8 (424)	6.4 (59)	47.8 (443)
SA	44.5 (110)	22.3 (55)	33.2 (82)
TAS	74.2 (72)	8.3 (8)	17.5 (17)
VIC	67.2 (704)	5.3 (56)	27.5 (288)
WA	30.3 (137)	10.2 (46)	59.5 (269)
NSW	55.5 (1094)	7.9 (156)	36.6 (721)
ACT	61.0 (128)	10.0 (21)	29.0 (61)
Australia	53.3 (2686)	8.0 (403)	38.7 (1954)

Conclusion: Timber was the most common flooring material in Tasmania, Victoria, NSW and the ACT. Concrete floors were most common in the NT and WA. Queensland had similar proportions of timber and concrete floors. Mixtures of floor type (timber and concrete) were more common than mixtures of framing types.

Table 5. Incidence of Termites Inside and Outside Buildings

Survey questions: Using a house plan (provided in questionnaire), indicate where you found termite activity inside your house. Using a property plan (provided in questionnaire), locate where you found termite activity outside your house.

State	**Number of Dwellings**	**% Inside** (and number)	**% Outside** (and number)	**% Both Inside and Outside** (and number)	**% Termites Somewhere** (and number)
NT	93	16.1 (15)	64.5 (60)	14.0 (13)	66.7 (62)
QLD	933	20.9 (195)	36.8 (343)	12.5 (117)	45.1 (421)
SA	247	21.1 (52)	36.0 (89)	13.4 (33)	43.7 (108)
TAS	98	0.0 (0)	1.0 (1)	0.0 (0)	1.0 (1)
VIC	1074	12.2 (131)	15.8 (170)	5.9 (63)	22.1 (238)
WA	479	14.4 (69)	47.0 (225)	8.4 (40)	53.0 (254)
NSW	1984	18.3 (358)	28.4 (564)	11.4 (226)	35.0 (696)
ACT	214	7.5 (16)	18.7 (40)	5.6 (12)	20.6 (44)
Australia	5122	16.3 (836)	29.1 (1492)	9.8 (504)	35.6 (1824)

Conclusion: Highest termite incidence outside was in the NT and WA, and lowest incidence outside was in Tasmania. The termite incidence inside is more difficult to interpret, because these numbers do not take house age into account. That issue is tackled in more detail in Table 11.

Table 6. Termite Removal Methods for Houses with Termites Inside

Survey questions: Have the termites gone (Yes or No)? How did you get rid of them: disturbed them, ignored them, treated the soil, treated the wood, replaced damaged wood, other?

There were 836 houses with termites inside. Of these, 708 (85%) claimed to have successfully eradicated the termite problem. Of the 836 houses with termites inside, 769 specified eradication attempts from a choice of six methods. As combination methods were possible, information on 37 eradication regimes was obtained. By ignoring regimes comprising less than 5% of the sample, the following list was obtained:

Eradication Method	% Usage of Total Sample	% Removal Success
Chemically treat soil	15	96
Treat soil and wood	9	96
Replace and treat wood	6	96
Chemically treat wood	18	95
Replace wood, treat soil	6	93
Replace wood	8	92
Other	7	90
Disturb and treat soil	7	84
Disturb	5	83
Ignore	5	59

Conclusion: A high level of success in termite eradication was obtained by treating the soil or wood. Least success was obtained by ignoring the problem, followed by simply disturbing the affected area.

Table 7. Location of Termites Inside House

Survey question: Using a property plan (provided in questionnaire), indicate where you found termite activity inside your house.

Location	Occurrence (number)	% With Termites at This Location (for houses with termites)
Wall (combined 'wall frame', 'timber frame' and 'wall stud' categories)	173	21
Flooring or floor covering	158	19
Wall Frame (cavity)	158	19
House Stump	140	17
Architrave	130	16
Skirting Board	129	15
Floor Joist	125	15
Floor Bearer	117	14
Wall Stud	102	12
Timber Frame	102	12
Window Frame	90	11
Others	90	11
Rafter	78	9
Cupboard / Fitting	67	9
End of Roof Timbers	51	6
Timber Plinth	48	6
Shelving / Fitting	34	4
Ridge Timber	26	3
Stairs	19	3

The above percentages will not sum to 100 as many houses had multiple termite locations. Because the difference between wall frame, timber frame and wall stud may not have been clear in the survey, houses with at least one of these categories were grouped into the 'wall' category. The original questionnaire included timber decking and timber sleepers abutting the house as 'inside'. Both of these categories were transferred to the 'outside' category.

Conclusion: Termites were often found in walls, flooring, house stumps, architrave and skirting boards, joists, bearers and window frames. Termites were less common in, but not excluded from, roofing timbers.

Table 8. Location of Termites Outside House

Survey question: Using a property plan (provided in questionnaire), locate where you found termite activity outside your house.

Location	Occurrence (number)	% Termites At This Location (for houses with termites outside)
Wood piles/branches	463	31
Live tree	296	20
Fencing	270	18
Dead tree	264	18
Sleepers	214	14
Dead tree stump	210	14
Shed	199	13
Posts	121	8
Garage	113	8
Other	102	7
Timber garden borders	81	5
Decking	68	5
Poles	57	4
Live tree stump	45	3
Compost area	42	4
Pergola	36	2
Patio	26	2
Compost bin	19	1
Trellis	10	1
Steps	9	1
Anywhere	1492	

The above percentages will not sum to 100 as many houses have multiple termite locations.

Conclusion: Termites outside were most often found in wood piles/branches, live and dead trees, fencing, sleepers, dead tree stumps, and the garden shed (often in cardboard boxes on the damp floor of garden sheds).

Termite species found outside would include some that are unable to attack sound wood in buildings. Other results (Howick, pers. comm.) indicate that the nests of economically important termite species are most often found in trees, tree stumps and sleeper retaining walls.

Table 9. How Termites were Noticed

Survey question: What evidence did you find of termite activity: damaged wood, mud tubes or wings?

Location	Number of Properties	Damaged Wood	Mud Tube	Wings
NT	62	45	36	15
QLD	421	367	164	28
SA	108	99	33	4
TAS	1	1	0	0
VIC	238	221	46	19
WA	254	229	77	16
NSW	696	575	260	54
ACT	44	33	10	1
Australia	1824	1570	626	137
% of total		86%	34%	8%

Conclusion: Most termites were noticed by the damage they caused to timber, followed by mud tube construction.

Table 10. House Protection Methods

Survey question: Is your house protected from termites by ant caps (Caps), soil poisoning (Soil), annual inspection (Inspect), other (which may include Granitgard, Termimesh, treated framing, and none) or don't know (a choice that cannot be made in combination with another)?

The questionnaire did not ask whether the protection methods were installed before or after termite attack, so we cannot determine directly which protection methods failed.

Protection method	Number Installed	Installation Percentage
Don't know	1314	27.7
Inspect	753	15.8
Soil	742	15.6
Caps	720	15.2
Other	482	10.1
Caps + inspect	196	4.1
Caps + soil	192	4.0
Soil + inspect	160	3.4
Caps + soil + inspect	127	2.7
Caps + other	22	0.5
Soil + other	15	0.3
Inspect + other	12	0.3
Caps + inspect + other	8	0.2
Caps + soil + inspect + other	4	0.1
Caps + soil + other	3	0.0
Soil + inspect + other	2	0.0
Any above (total)	4752	100

Conclusions: About 25% of people surveyed did not know if or how their home was protected against entry by termites. Of the remainder, inspection, soil treatment and 'ant' caps were similarly used.

Table 11. Proportion of Houses with Termites Inside Relative to Frame Type and House Age

Age (years)	**Proportion** (standard error, number of houses)				
	Masonry	**Masonry & Timber**	**Steel**	**Timber**	**Timber & Steel**
0-10	0.09 **(0.02,212)**	0.04 (0.04,26)	0.10 (0.03,136)	0.07 (0.01,803)	0.00 (0,5)
11-20	0.11 (0.02,267)	0.17 (0.05,52)	0.11 (0.04,76)	0.13 (0.01,827)	0.33 (0.21,6)
21-30	0.14 (0.03,135)	0.21 (0.08,28)	0.00 (0,15)	0.15 (0.02,563)	0.17 (0.17,6)
31-40	0.18 (0.04,90)	0.27 (0.12,15)	0.00 (0,5)	0.20 (0.02,334)	0.00 (*,1)
41-50	0.25 (0.04,96)	0.19 (0.10,16)	0.50 (0.5,2)	0.24 (0.03,297)	0.67 (0.33,3)
51-60	0.19 (0.05,58)	0.00 (0.00,3)	NA	0.33 (0.04,123)	1.00 (*,1)
61-70	0.33 (0.07,52)	0.42 (0.15,12)	0.00 (*,1)	0.30 (0.04,113)	NA
71-80	0.31 (0.07,49)	0.25 (0.16,8)	NA	0.28 (0.04,102)	1.00 (*,1)
81-90	0.53 (0.12,19)	0.40 (0.25,5)	NA	0.35 (0.07,52)	NA
91-100	0.35 (0.08,35)	1.00 (0.00,2)	1.00 (*,1)	0.43 (0.06,70)	0.50 (0.50,2)
100+	0.33 (0.09,27)	0.50 (0.29,4)	NA	0.53 (0.09,32)	NA

**Not enough data to produce a standard error*

Conclusions: The best data sets in each age group, where sample sizes are greater than 50, are masonry and timber framed houses. Steel is not well represented in houses that are over 20 years of age. Houses with combination frame types are not well represented in any age group. For those frames that are well represented, the probability of termites inside the house increases with age. Reading across most age group rows where sample sizes are significant reveals that the proportions of houses with termites inside are about the same, irrespective of frame type.

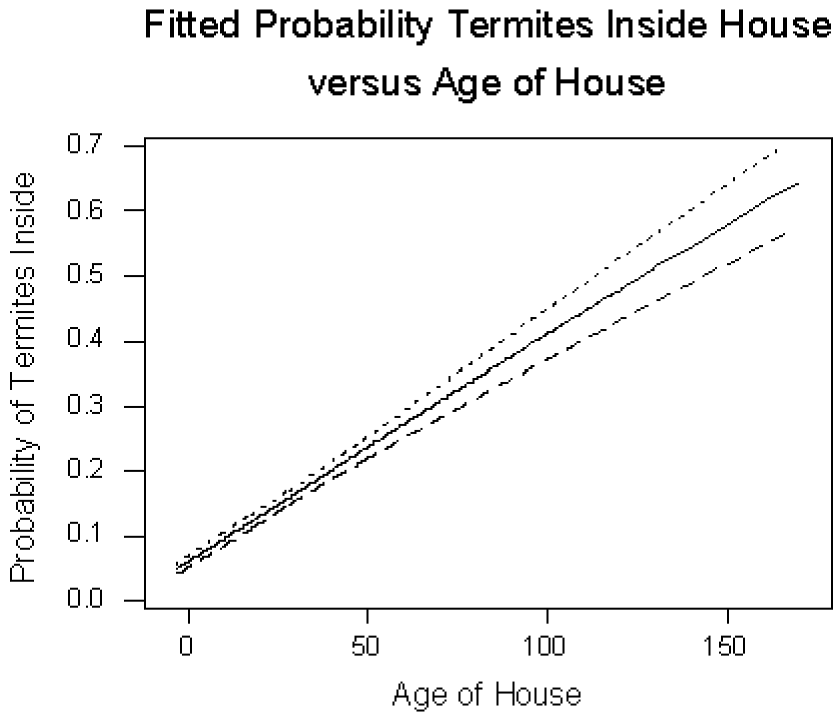
Table 12. Proportion of Houses with Termites Inside Relative to Floor Type and House Age

Age (Years)	**Proportion** (standard error, number of houses)		
	Concrete	**Timber & Concrete**	**Timber**
0-10	0.07 (0.01,803)	0.11 (0.05,45)	0.10 (0.02,334)
11-20	0.13 (0.01,697)	0.16 (0.05,68)	0.13 (0.02,463)
21-30	0.15 (0.02,214)	0.15 (0.05,60)	0.15 (0.02,473)
31-40	0.28 (0.06,51)	0.29 (0.06,55)	0.17 (0.02,339)
41-50	0.37 (0.10,27)	0.30 (0.06,66)	0.22 (0.02,321)
51-60	0.09 (0.09,11)	0.23 (0.11,17)	0.30 (0.04,157)
61-70	0.11 (0.11,9)	0.58 (0.12,19)	0.29 (0.04,150)
71-80	0.50 (0.20,8)	0.23 (0.09,22)	0.29 (0.04,130)
81-90	0.50 (0.29,4)	0.50 (0.17,10)	0.37 (0.06,62)
91-100	0.33 (0.17,9)	0.35 (0.12,17)	0.45 (0.06,83)
100+	0.00 (0.00,3)	0.40 (0.17,10)	0.48 (0.07,50)

Conclusions: The data set contains relatively few houses older than 40 years with concrete floors alone. Concrete floors in older houses are slightly more prevalent in association with timber floors, probably resulting from house renovations. Timber floors are well represented in the sample for all age groups. For those floor types that are well represented, the probability of termites inside the house increases with age. Reading across most age group rows where sample sizes are significant reveals that the proportions of houses with termites inside are about the same, irrespective of floor type.

Figure 1. Risk of Termites to House According to Age

A logistic regression using house age, frame and floor type to explain the proportion of houses with termites inside was plotted. The factors of frame and floor type were excluded from the model as they were found not to be statistically significant. A reasonable fit was obtained if the proportion of houses with termites inside was modelled as a logistic regression in the square root of house age, excluding frame and floor type. The graph of the model shown here gives the probability of termites being found inside as a function of house age (and associated 95% confidence interval).



Conclusions: The graph illustrates how the proportion of houses with termites inside increases as house age increases. Reference to Figure 1 indicates that the incidence of termites inside increases by about 0.4%/year, irrespective of house construction type. There are several possible reasons why older houses carry higher termite risk. For example, termite barriers (chemical and physical) installed in a new house during construction may gradually break down, or become breached upon further landscaping and renovation. Older houses also tend to have low floor clearance leading to poor ventilation and restricted access for proper inspection. They may use older style masonry ventilators that are less effective than modern pressed steel ventilators. With age, plumbing or spouting may develop leaks and cause localised moisture build up. Moist damp conditions attract termites. Sleeper retaining walls will deteriorate with age, and trees will mature, allowing both to become possible nesting sites for termites.

These findings help to explain why termite attack to houses is so high in the Port Melbourne and South Melbourne regions of Greater Melbourne (Howick, 1966). The effect can be explained by house age (e.g. old terrace houses with minimal ground clearance) rather than the presence of an unusually active population of termites. The same influence of house age may account for some of the ‘hot spots’ found in other termite surveys (Postle and Abbott, 1991).

Even though house construction type does not influence termite incidence inside, bad building practices will have an impact. However, the effect of bad building practice does not show through in the statistics, because such practices are not confined to one house construction type over another. Therefore, placing fill or wood piles high against a house wall is likely to increase the risk of termite attack, no matter whether the house is steel, masonry or timber framed. Similarly, the added risk of leaving timber debris under a house will be a common problem for any wall frame type.

Table 13. Risk of Termites to House According to Age

Age (Years)	**Fitted Proportion of Houses with Termites Inside Based on Model** (standard error)
0-10	0.08 (0.005)
11-20	0.12 (0.005)
21-30	0.16 (0.005)
31-40	0.19 (0.006)
41-50	0.23 (0.008)
51-60	0.27 (0.010)
61-70	0.30 (0.012)
71-80	0.34 (0.014)
81-90	0.37 (0.017)
91-100	0.41 (0.020)
100+	0.47 (0.024)

Table 14. Risk of Termites to House According to Frame Type

Frame Type	Sample Size	% Sample	Average Age of House (years)	% Termite Inside	Estimated% Termites Inside (adjusted to 30 year house)
Timber	3445	69.2	29.4	17	17
Masonry	1071	21.5	34.6	18	16
Steel	249	5.0	12.1	10	17
Steel + masonry	7	0.1	27.7	0	Not detn
Timber + masonry	177	3.6	33.6	22	21
Timber + steel	26	0.5	31.4	32	Not detn
Timber + steel + masonry	5	0.1	70.0	40	Not detn

Not detn = not determined due to low sample number.

Conclusion: The average age of purely steel framed houses (12.1 years) is much less than for purely timber (29.4 years) or masonry framed houses (34.6 years). House age rather than construction type is the dominant influence on termite presence inside. The mean incidence of finding termites inside increases by 0.4%/year. This figure was used to estimate termite incidence inside the various house construction types when they were adjusted to the mean house age of 30 years. The calculated termite incidence for thirty-year houses constructed from just timber, masonry or steel is 16-17%.

Table 15. Risk of Termites to House According to Floor Type

Floor Type	Sample Size	% Sample	Average Age (years)	% Termite Inside	Estimated % Termites Inside (adjusted to 30 year house)
Timber	2649	53.1	38.7	19	16
Concrete	1935	38.8	15.4	11	17
Timber + concrete	402	8.1	41.0	24	20

Conclusion: The average age of houses with concrete flooring only is much less (15.4 years) than purely timber or timber plus concrete combinations (38.7 and 41.0 years, respectively). An age adjustment of floor types was made in the same way as for frame types. The calculated termite incidence for thirty-year old houses with timber or concrete floors is 16-17%. Houses with a timber and concrete floor combination had a slightly higher termite incidence (20%) than either floor type alone, but the differences were still not significant. From the phone survey and CSIRO email survey it was noted that termite attack in houses with timber and concrete flooring combinations often occurred at the junction where the two flooring types met.

Table 16. Termite Identifications

Identifications (by Jim Creffield) of samples returned to CSIRO for verification. W = Worker, S = Soldier.

Student #	State	Identification	Termite Caste	Place Collected
13	NSW	Nasutitermes	W/S	
13	NSW	Microcerotermes	W/S	
13	NSW	Schedorhinotermes	W/S	
13	NSW	Coptotermes	W/S	
13	NSW	Schedorhinotermes	W/S	
21	NSW	Nasutitermes	W	Shed
21	NSW	Coptotermes	S	Fencing
23	NSW	Termite	W	
24	NSW	Termite	W	Power pole
35	NSW	Nasutitermes	W/S	Tree
35	NSW	Coptotermes	S	Tree

40	NSW	Nasutitermes	S	
42	NSW	Termite	W	In or outside
42	NSW	Termite	W	Tree stump
43	NSW	Coptotermes	S	
45	NSW	Termite	W	
50	NSW	Nasutitermes	S	Outside
50	NSW	Coptotermes	S	Tree stump
50	NSW	Schedorhinotermes	S	Hospital
91	NSW	Termite	W	Timber sleeper
111	NSW	Termite	W	
119	NSW	Coptotermes	W/S	
121	NSW	Nasutitermes	S	
122	NSW	Schedorhinotermes	W/S	Wood pile
124	NSW	Nasutitermes	W/S	Rotten wood
127	NSW	Termite	W	Wood
140	NSW	Coptotermes	S	Inside
140	NSW	Termite	photo of damage	Door frames
142	NSW	Nasutitermes	W/S	Outside
145	NSW	Glyptotermes	W	
148	NSW	Coptotermes	W/S	Stump/garage
151	NSW	Schedorhinotermes	W	Outside
151	NSW	Schedorhinotermes	S	
154	NSW	Coptotermes	W/S	
157	NSW	Termite	W	

Table 16. Termite Identifications (cont.)

Identifications (by Jim Creffield) of samples returned to CSIRO for verification. W = Worker, S = Soldier.

Student #	State	Identification	Termite Caste	Place Collected
8	Qld	Coptotermes	W/S	
8	Qld	Termite	W	
10	Qld	Schedorhinotermes	S	Pile of wood
15	Qld	Termite	W	Dead tree
15	Qld	Termite	W	Termite nest
16	Qld	Tumulitermes	S	Outside
16	Qld	Nasutitermes	S	Tree and deck
19	Qld	Termite	W	Wooden chair
19	Qld	Termite	W	Pile of wood
20	Qld	Termite	W	Garden shed
20	Qld	Schedorhinotermes	S	Bathroom walls
22	Qld	Microcerotermes	S	Mound outside
22	Qld	Microcerotermes	S	Post outside
22	Qld	Microcerotermes	S	Mound outside
22	Qld	Schedorhinotermes	S	Pile of wood
22	Qld	Microcerotermes	W/S	Mound outside
22	Qld	Termite	W	Pile of wood
22	Qld	Microcerotermes	S	Mound outside
22	Qld	Microcerotermes	W/S	Mound outside
41	Qld	Schedorhinotermes	W/S	Moist log
41	Qld	Termite	W	Moist log
92	Qld	Nasutitermes	W/S	Under wood
101	Qld	Schedorhinotermes	W/S	Pile of wood
101	Qld	Schedorhinotermes	S	Sleeper
117	Qld	Heterotermes	S	Pile of wood
118	Qld	Termite	W	

118	Qld	Nasutitermes	W/S	
123	Qld	Coptotermes	W/S	
141	Qld	Termite	W	Back yard
141	Qld	Termite	W	
141	Qld	Slater		
146	Qld	Termite	alate & W	Pile of wood
224	Qld	Termite	W	
224	Qld	Schedorhinotermes	S	
224	Qld	Schedorhinotermes	S	
224	Qld	Termite	W	
224	Qld	Termite	W	
224	Qld	Schedorhinotermes	W/S	
230	Qld	Termite	W	
?	Qld	Termite	W	

Table 16b. Termite Identifications (cont.)

Identifications (by Jim Creffield) of samples returned to CSIRO for verification. W = Worker, S = Soldier.

Student #	State	Identification	Termite Caste	Place Collected
220	VIC	Termite	W	
17?	VIC	Schedorhinotermes	S	
29	VIC	Coptotermes	W/S	log
47	VIC	Nasutitermes	S	
85	VIC	Nasutitermes	S	Wood pile
86	VIC	Termite	W	Bridge
86	VIC	Termite	W	Outside
86	VIC	Coptotermes	S	
206	VIC	Coptotermes	S	Tree stump
206	VIC	Nasutitermes	S	Tree stump

4	SA	Nasutitermes	S	Stump + nest
18	SA	Coptotermes	S	In or outside
105	SA	Coptotermes	W/S	
105	SA	Heterotermes	W/S	
105	SA	Termite	W	
105	SA	Termite	W	
105	SA	Nasutitermes	S	
105	SA	Termite	W	
105	SA	Heterotermes	S	
180	SA	Termite	W	
126	WA	Spiderlings	-	
81	WA	Coptotermes	S	Outside
81	WA	Coptotermes	S	Outside
81	WA	Nasutitermes	S	Outside
81	WA	Amitermes	W/S	In or outside
114	WA	Coptotermes	W/S	In or outside
115	WA	Heterotermes	S	Shed
115	WA	Coptotermes	S	
115	WA	Heterotermes	S	
115	WA	Ants	-	
120	WA	Termite	W	Tree stump
173	WA	Termite	W	Pile of wood
116	NT	Mastotermes	W/S	Tree
116	NT	Heterotermes validus	W/S	Wood pile
116	NT	Termite	W	Outside

Conclusions: Many students sent several samples. Some samples were identified only to ‘Termite’, because they were dry and shrivelled or lacked soldiers. Of 109 samples returned, only 3 samples were not termites. A few of the samples included non-wood feeders such as Tumulitermes, but most were from genera that contain species of economic importance.

Table 17. Verification of Methods used by Double Helix Students

Contact was made by telephone with 44 of the 248 students who participated in the Double Helix survey (=18%). They were asked about sampling and termite identification methods.

Student #	No. of Houses They Surveyed	State	% Survey Method		
			Friend or Relative	Street	Termite Identification Methods
16	13	Qld	100	0	CSIRO(2/2)
30	11	Qld	70	30	D, PCO, live
101	20	Qld	100	0	D,PCO,mud,CSIRO(2/2)
141	10	Qld	100	0	D, live, CSIRO(2/3)
215	10	Qld	0	100	D, mud
24	20	NSW	100	0	D, mud, live,CSIRO(1/1)
35	21	NSW	50	50	D, live
42	21	NSW	80	20	D, mud, live,CSIRO(1/1)
51	9	NSW	100	0	D
54	26	NSW	50	50	D, live
83	24	NSW	100	0	D, mound, live
95	7	NSW	50	50	D, PCO
111	16	NSW	100	0	D,PCO,mud,CSIRO(1/1)
118	10	NSW	100	0	D,PCO,mud
122	30	NSW	100	0	D, live, CSIRO(1/1)
124	11	NSW	70	30	PCO, live,CSIRO(1/1)
127	9	NSW	100	0	D,PCO,live,CSIRO(1/1)
132	40	NSW	100	0	D
142	8	NSW	50	50	D,PCO,live,CSIRO(1/1)
148	21	NSW	100	0	D,PCO,live,CSIRO(1/1)
151	24	NSW	100	0	D,PCO,live,CSIRO(1/1)
152	12	NSW	100	0	D
157	12	NSW	100	0	D, live,CSIRO(1/1)
158	23	NSW	0	100	D,TV,live

196	8	NSW	80	20	live
204	20	NSW	25	75	D,PCO

Table 17b. Verification of Methods used by Double Helix Students (cont.)

Student #	No. of Houses They Surveyed	State	% Survey Method		
			Friend or Relative	Street	Termite Identification Methods
25	31	Vic	70	30	D,PCO,CSIRO(1/1)
44	6	Vic	50	50	live
102	15	Vic	100	0	D
113	28	Vic	100	0	live
130	22	Vic	100	0	D,live
135	21	Vic	100	0	D,PCO,books
155	6	Vic	100	0	D,PCO
208	20	Vic	0	100	D,mud
4	40	SA	50	50	Drawings,CSIRO(1/1)
116	21	SA	100	0	Live
134	25	SA			D, live
109	59	WA	100	0	D
115	13	WA	100	0	Live,CSIRO(3/4)
120	24	WA	100	0	D,live,CSIRO(1/1)
128	32	WA	100	0	D,mud
138	20	WA	60	40	D,PCO
161	11	WA	100	0	D,live
201	19	WA	100	0	D,live
156	16	NT	100	0	PCO,live,mud
Mean	19.2		81	19	

Friend or Relative = percentage of house owners chosen on the basis that they were friends or relatives of the student.

Street = percentage of house owners chosen on the basis of door-knocking the neighbourhood streets.

Termite identification methods:

- CSIRO(3/4) = termite samples previously sent by student to CSIRO (and see Table 16) for identification, and three out of four samples were actually termites.
- D = Described damaged wood correctly over the telephone.
- PCO = They were told by a pest control operator that termites were present.
- Live = Live termites were described correctly over the telephone.
- Mud = Mud tubes or muddying was described correctly over the telephone.
- Mound = Termite mound/s were found on the property.
- Books = Student went to a library to look at pictures of termites and damage.
- Drawings = Student used the drawings in the Termite Tally kit to determine termite attack.
- TV = Some knowledge on recognition was obtained from a TV documentary.

Conclusions: The verification survey showed that 81% of Double Helix students interviewed friends and relatives. Only 19% of the interviews were conducted by door-knocking houses along streets and in the neighbourhood. During the door-knock surveys, students were often accompanied by a parent. One student indicated that he chose about 20% of his survey houses by cycling around his country town, looking especially for timber houses. All other student selections appear to have been made at random in respect to house type and its termite history. The students' main concern was to interview as many households as possible, while feeling safe about the interview process. Hence, the predominance of interviews with friends and relatives.

The original Termite Tally kit was designed to encourage a random survey. The kit guide stated that 'All entries will be judged on the highest number of houses interviewed and the widest geographical area covered by your research'. Therefore, it was clear that prizes were not being given based on those who could find most termite damage. Similarly, the list of interviewing instructions gave clear emphasis on interviewing houses at random.

The other main point to be determined was the level of accuracy in the recognition of termite attack. The termite identification methods used by the students (or their parents) in Table 17 relate to the termite activity that students found on their own property, and/or some of the respondents that they interviewed and were allowed to inspect. The most common methods of determination included finding damaged wood (36 students = 80%), live termites (25 students = 56%), told by a pest control operator (16 students = 35%) and finding mud tubes (9 students = 20%). None of the students interviewed determined termite presence based on discarded wings from alates. Some students improved their recognition of termite activity by obtaining further information from parents, books, a television documentary and the drawings provided in the Termite Tally kit.

As far as could be determined from the telephone interview, there was a high level of accuracy in the recognition of termite damage by Double Helix students. This accuracy may be due in part to the survey picking up mainly termite damage that was obvious, at a level sufficiently developed to be of concern. Many respondents probably overlooked minor termite activity, which might otherwise have been detected by experienced entomologists and pest control operators. Therefore, the incidence maps should be qualified by saying that they represent termite activity at a level noticeable to the general public. It is possible that homeowners in high termite hazard areas are more knowledgeable about termites and able to recognise their damage than homeowners in low hazard areas. However, this factor would simply reinforce the definition of high termite hazard areas.

Production of the Interim Termite Hazard Map

To estimate termite incidence, with a reasonable level of confidence within a given location, a sample number of at least 125 was considered adequate. A number of methods were explored for producing termite incidence and hazard maps. The termite incidence data could be plotted within certain subdivisions based on state boundaries, municipalities, or statistically significant subdivisions. However, all of these subdivisions arise from artificial factors such as human population and political decision. Also, the subdivisions needed to be of a size that would make most use of the termite data, so that most subdivisions would contain at least 125 samples. Another option was cluster analysis, where nearest neighbour groups in multiples of 125 are formed and analysed. However, such an approach could again produce artificial results. For example, results from Mount Isa could be linked with Cairns rather than Charleville where ecological conditions are more similar. Therefore, an approach similar to that used in the earlier production of a marine borer hazard map was employed. In that work, an established marine ecology map (Knox, 1963) was found, and marine borer species distributions and activities superimposed to produce a functional hazard map (Cookson, 1987).

The Agriculture Working Group on Ecologically Sustainable Development, with contributions from more than 10 participating authorities, divided terrestrial Australia into 11 agro-ecological regions (Commonwealth of Australia, 1991) (Figure 2). These regions are derived from important factors such as temperature, rainfall, soil structure, and vegetation type. This map was used as the basis upon which the termite survey data were plotted. Where sample number permitted, some of the agro-ecological regions were subdivided further (Figure 3, Table 18). Some agro-ecological regions were also separated based on existing knowledge about termite distribution. For example, Tasmania was separated from the Victorian agro-ecological region 1 (wet temperate coasts) because termite species there are few (Watson and Abbey, 1993). Also, the Western Australian portion of agro-ecological region 7 (Albany, Merredin) could be separated from the same eastern Australian region, even though sample number in the west is only 49. In either case, the termite incidence results for both zones were similar. Figure 3 shows the sample number associated with each termite analysis zone. Some zones were well represented so provide most reliable data. For example, 603 samples from Sydney zone 5, 591 samples from eastern Melbourne zone 3, 574 samples from Coffs Harbour zone 8, and 421 samples from the Perth zone 7. On the other hand, the arid interior was poorly represented with just 22 samples (zone 21) therefore providing results that are indicative, perhaps even unreliable. The arid zone could perhaps be combined with the semi-arid zone 18 (51 samples), to give a total sample size of 72. Indeed, both zones appear to have similar termite incidence levels. But again, the combined sample size is low so mapping representation of these regions should be viewed with caution. Further sampling that targets those areas poorly represented would improve the maps.

A further advantage of using agro-ecological regions already established, is that while the distribution of termite survey data will not be uniform across the region, the results can be reasonably extended across the region based on previously determined ecological data. For example, most of the results for zone 19 come from Darwin, but those results allow the whole of zone 19 to be identified as probably having high termite hazard as well. Indeed, for some locations within a region or along their borders, it is unlikely that 125 houses could be found to enable more precise evaluation.

The termite incidence map outside (Figure 4) was not adjusted according to house age because it is not clear if there would be a significant house age effect. House construction is not likely to affect the presence of termites in trees or fallen branches, especially if the block is large, a factor not measured in this survey. However, termite incidence inside is obviously affected by house construction time, and so appropriate adjustment to the standard 30-year old house was made (Table 18). This adjustment allowed different zones of different house age structure to be compared on a similar basis, to produce a map of termite incidence inside (Figure 5).

- In most zones termite incidence inside is about half or two-thirds the termite incidence noted outside. For example, termite incidence in Sydney (zone 5) is 33.5% outside and 17% inside. For Brisbane (zone 9) the comparison is 44.7% outside and 26% inside. See also zones 11-17.
- However, while Perth has a high termite incidence outside (49.2%), it has much lower termite incidence inside (16%). This greater difference between outside and inside incidence may be due to the greater use of jarrah in timber construction (a relatively termite resistant timber). Another reason may be that all councils in Perth required termite soil pretreatments to be carried out during building construction, which was not the case in other states (French, 1983).

- Several zones (Melbourne zones 2 and 3, and Canberra zone 20) have amongst the lowest termite incidence levels outside (6.9%, 11.5%, and 20.9% respectively). However, this benefit is not reflected in proportionately much lower termite incidence levels inside (7%, 12%, and 13%, respectively). Perhaps certain proportions of houses are easy for termites to penetrate, irrespective of termite hazard levels. There may be a background level of poor construction practice that will always allow houses to be attacked, even in low termite hazard areas. For example, old terrace houses in inner Melbourne were often built with minimal ground clearance and poor ventilation, so are easily attacked. Other poor building practices such as placing fill or piles of wood high against a house wall, or leaving wooden pegs in concrete slabs, can occur in any hazard zone. In Tasmania however, only four species of termites are known (Watson and Abbey, 1993), and are species that appear unable to attack sound timber. Therefore, even the century-old terrace houses surveyed in Tasmania have not been attacked by termites.

The interim termite hazard map (Figure 6) was constructed with the aid of the incidence maps. It was decided to use mainly the incidence outside map for hazard map construction. This would provide a background measure of hazard against which building construction practices will then add or detract from the hazard. The termites that can be found outside would include a wide range of species, including grass-feeding and detritus-feeding termites. Some of these were also collected from mounds etc as indicated in Table 16. However, the termite incidence outside data was based almost entirely on whether termites were found attacking trees or wooden structures. Entries for 'compost area' and 'compost bin' (possible detritus-feeders) occurred for only 5% of the houses surveyed (Table 8), and only 0.8% (12 houses) had termites only in the compost areas (the remainder had termites in trees or wooden structures as well as compost areas). Similarly, not all of the termites found attacking wood outside would belong to species considered economically important. However, for the purposes of the hazard map they were considered to indicate that conditions were suitable for termite 'pressure'.

The hazard descriptions provided are summaries for the whole of the zones indicated. Within a hazard zone there may still be 'hot spots', or other areas where termites are scarce or absent. Further, a Melbourne householder with heavy termite attack in their house might be hard to convince that they are living in what we class as a low termite hazard area.

Where there was doubt in the incidence outside map, the hazard map generally erred on the conservative side. That is, higher hazard ratings were given in some areas than might be suggested by the incidence map. The variations to the outside incidence map, made for the construction of the termite hazard map, were:

- Boundary lines were smoothed out on the conservative (higher hazard) side to reduce the apparent claim to precision in the exact placement of those boundary lines.
- The high incidence zone 19 (Darwin area) is adjacent to the arid zone 21 (low-moderate incidence). However, hazard is not likely to make such sudden changes from high to low-moderate, without an intermediate step. Therefore, a moderate hazard zone was inserted over some parts of the low-moderate incidence zone to provide a more realistic gradation.
- There was a lack of data for the Victorian coastal area in the Agro-Ecological map (Figure 2) near Wilsons Promontory and Lakes Entrance. Therefore, rather than include these areas with the low hazard zone of eastern Melbourne (zone 3), they were included with their adjacent higher hazard zone 20.
- The outside incidence map gave a jump in hazard zone gradation from moderate in zone 15 to very low in western Melbourne (zone 2). Most data for the western Melbourne zone 2 came from the western suburbs, Geelong, and some coastal towns such as Port Fairy and Warrnambool. Low-moderate and low hazard zones were inserted between these areas to improve the gradation of hazard. Along the coast, the very low termite hazard zone may be confined to the exposed heathland areas. Transition to the higher hazard zones probably begins in the forested regions.
- The outside incidence map suggests that the termite hazard near Bundaberg (zone 10) is lower than in Brisbane (zone 9) or Rockhampton (zone 11). However, this result is difficult to explain. Therefore, the hazard for the Bundaberg region was increased to match its adjacent zones.

The termite incidence outside map and the termite hazard maps suggest that the dominant factor influencing termite activity or hazard is temperature. For example, Tasmania has good rainfall and humidity, but is too cold to sustain significant termite hazard. The west Victorian coast (zone 2) is the next coldest region and has the second lowest termite hazard. The temperature trend follows, as the termite hazard increases through eastern Melbourne (zone 3) to Canberra and Bega (zone 20). Highest termite hazards occur in the hottest regions of northern Australia and Perth.

After temperature, the next most important factor determining termite hazard appears to be rainfall. Therefore in Queensland, the termite hazard decreases from high in humid coastal areas such as Cairns, to moderate and then low-moderate termite hazard in more arid locations. Vegetation appears to have less influence on termite activity than temperature and rainfall. Termite hazard tends to be higher in heavily treed areas, and may partly explain why the grassland areas of Geelong and the western suburbs in Melbourne have lower termite hazard than in eastern suburbs. However, removing trees will not avoid the termite hazard, as for example, termites are also active in areas such as Port Melbourne and other inner city areas where there are relatively few trees. Similarly in Sydney (high building density compared to tree density), the termite hazard appears to be no less than in the surrounding treed highlands. Differences observed are more likely to be due to the influence of house age. The influence of soil type also appears to be less important than temperature and rainfall, as termites are able to create the conditions they need within a wide variety of substrates. However, factors such as soil type, vegetation, and age of building development site are likely to combine to determine the location of ‘hot spots’ within the broader hazard zones provided in Figure 6.

This interim termite hazard map should not be seen as definitive, but rather a starting point that might encourage further research that can be used for its modification and improvement.

Table 18. Termite Incidence in Agro-Ecological Regions

Agro-Ecological Region	**Termite analysis zone** (approximate)	**Sample Number**	**Mean Age** (standard error)	**Incidence Outside %**	**Incidence Inside %**	**Incidence Inside** (30 year house %*)
1 (part)	1, Tasmania	98	37.8 (2.6)	1.0	0.0	0
1 (part)	2, Melbourne, west of 145°E	202	40.5 (2.2)	6.9	8.9	7
1 (part)	3, Melbourne, east of 145°E	591	29.5 (0.9)	11.5	11.3	12
1 (part)	4, Wollongong, south of 34.16°S	126	32.1 (3.4)	26.4	24.6	23
1 (part)	5, Sydney	603	39.8 (1.1)	33.5	22.1	17
1 (part)	6, Newcastle, north of 33.33°S	115	18.8 (1.5)	27.8	13.9	22
1 (part)	7, Perth	421	26.8 (1.1)	49.2	14.0	16
2 (part)	8, NSW portion	574	20.6 (0.8)	23.9	15.5	22
2 (part)	9, Brisbane	394	26.9 (1.3)	44.7	23.6	26
2 (part)	10, Bundaberg, north of 26.5°S	162	21.8 (1.6)	23.5	13.6	19
3	11, Cairns + Rockhampton	114	26.1 (2.0)	42.1	28.1	32
4	12, Townsville + Weipa	62	22.6 (2.1)	45.2	12.9	17
5	13, Toowoomba	260	33.1 (1.6)	26.1	14.6	13
6	14, Bathurst	241	32.6 (2.1)	31.5	17.0	16

7 (part)	15, Dubbo + Bendigo	348	33.7 (1.5)	31.6	17.2	15
7 (part)	16, Adelaide + SA portions	241	35.8 (1.7)	36.1	20.7	17
7 (part)	17, WA portion	49	30.8 (3.8)	32.7	16.3	16
8	18, Mount Isa + semi-arid	51	36.5 (3.6)	23.5	19.6	16
9	19, Darwin	85	14.4 (1.2)	67.0	17.6	38
10	20, Canberra +Bega	363	26.9 (1.1)	20.9	11.6	13
11	21, Arid interior	22	28.0 (5.6)	27.2	18.2	19

** Incidence inside after standardisation to a 30 year house age was determined graphically, by drawing a line from 0,0 (0 years = 0 incidence inside) to the mean house age and incidence for the zone, and determining the intercept at 30 years.*

Figure 2. Agro-Ecological Regions

The agro-ecological regions of Australia, provided by the Agriculture Working Group on Ecologically Sustainable Development (1991). This map was used as the basis for further development of the termite incidence and hazard maps.

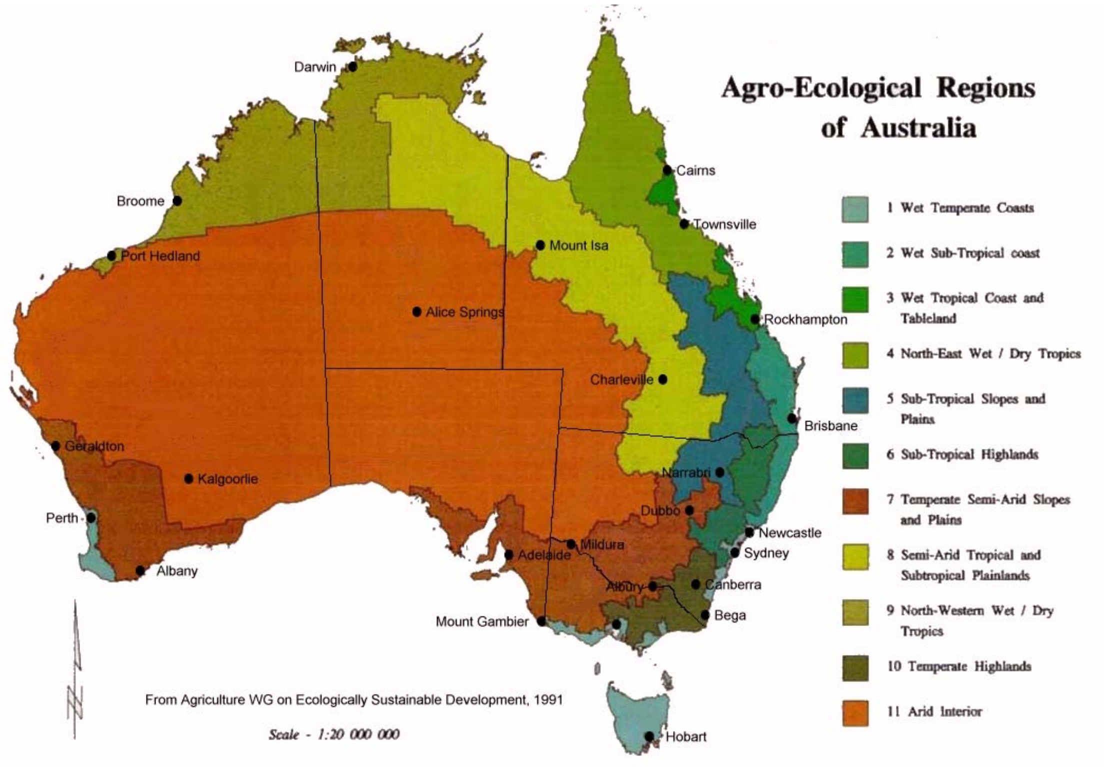


Figure 3. Termite Analysis Zones and Sample Numbers

The number of dwellings analysed, in each whole agro-ecological region, or where numbers allowed, subdivisions of those agro-ecological regions.

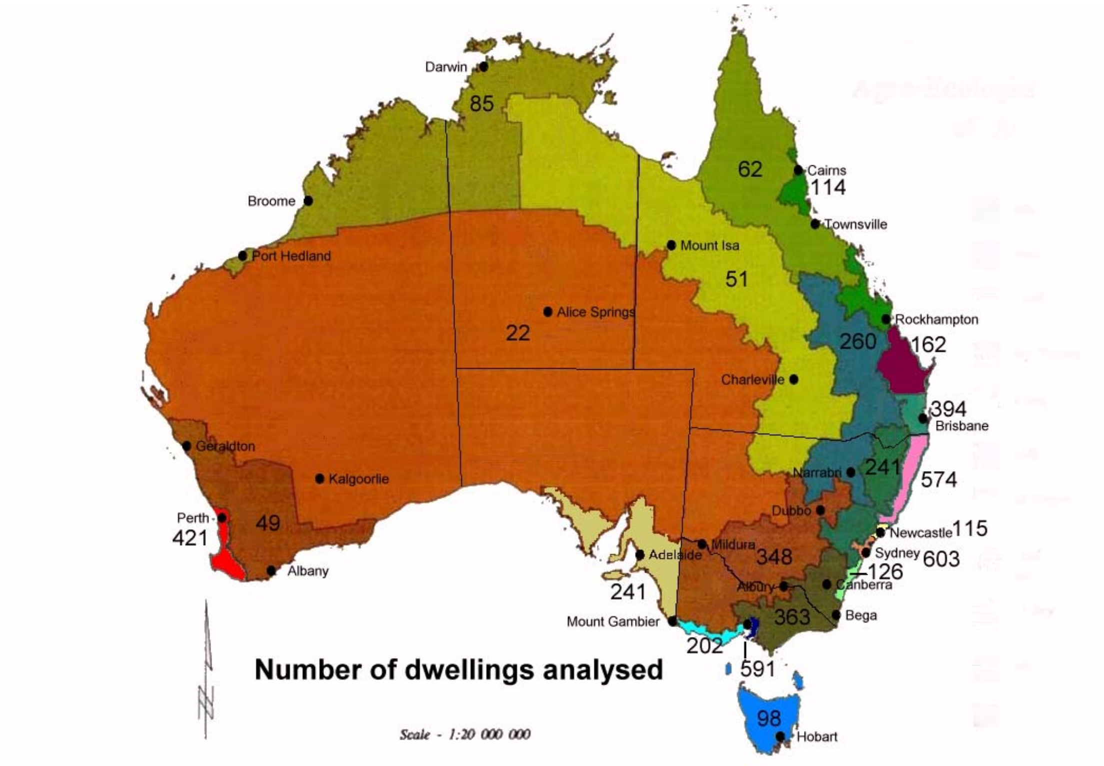


Figure 4. Termite Incidence Outside

Termite incidence outside, showing the percentage of dwellings in the regions shown in Figure 3 with termites found outside buildings.

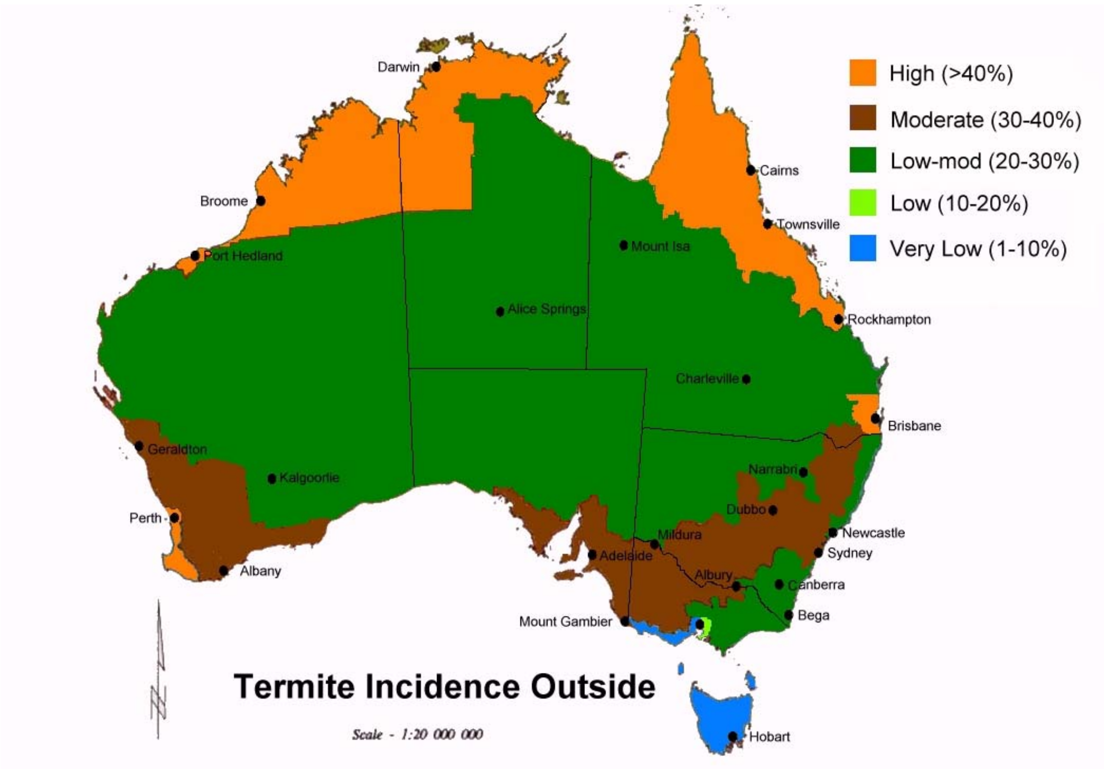


Figure 5. Termite Incidence Inside

Termite incidence inside, showing the percentage of dwellings in the regions shown in Figure 3 with termites found inside buildings, after those percentages were adjusted to a uniform house age of thirty years across the country.

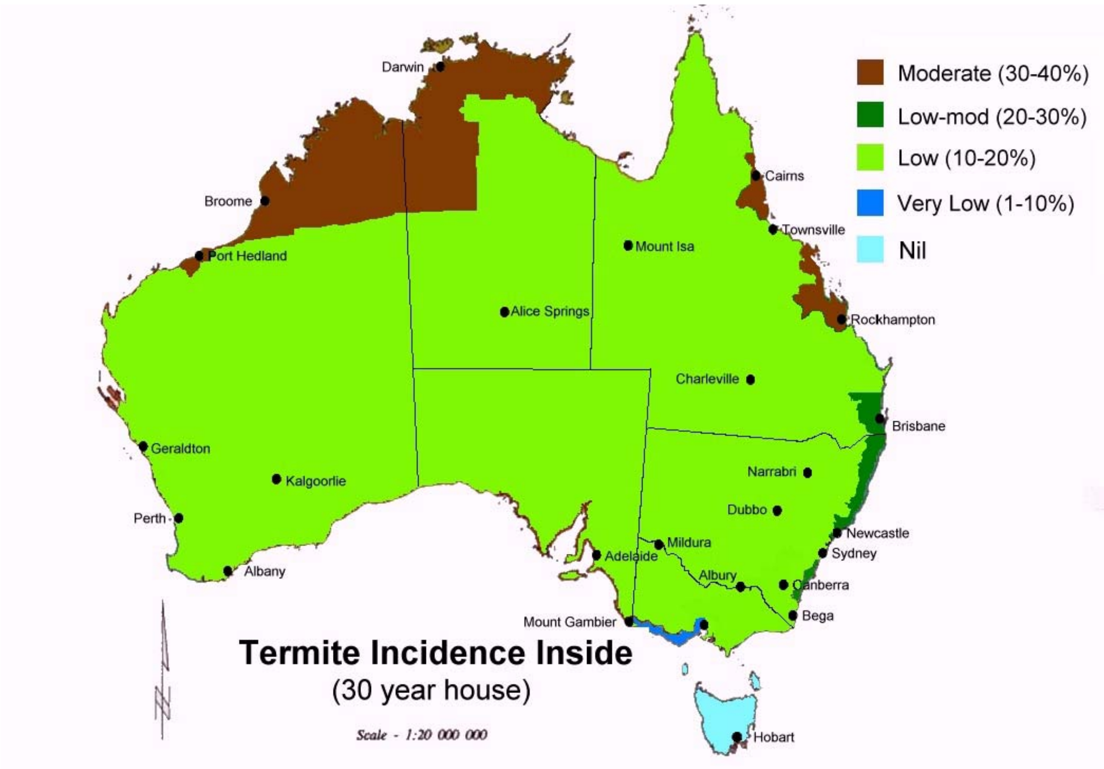
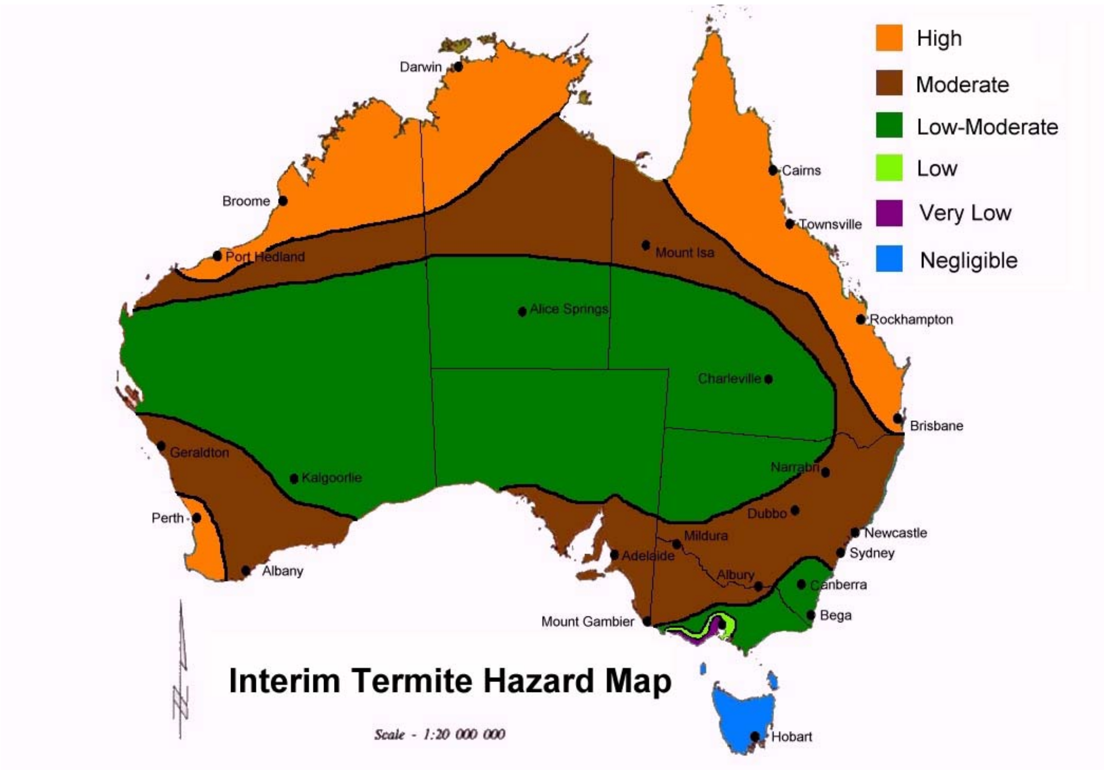


Figure 6. Interim Termite Hazard Map



References

Barnacle, J.E. and Cookson, L.J. (1995). Treated eucalypt and pine sapwood after 25 years in the sea. Part II. Major effect of wood type on the efficacy of some waterborne preservatives. J. Inst. Wood Sci. 13: 543-558.

Commonwealth of Australia (1991). Ecologically sustainable development working groups. Final report – Agriculture. Australian Government Publishing Service, Canberra, 240 pp.

Cookson, L.J. (1987). Marine borers and timber piling options, pp. 1-14. CSIRO, Div. Chem. Wood Technol. 1986 Annual Research Review. CSIRO Printing Centre: Melbourne.

French, J.R.J. (1983). A preliminary assessment of the costs of termite activity in Australia: a discussion paper. The Internat. Res. Group on Wood Preservation. Document No. IRG/WP/1207.

Howick, C.D. (1966). The incidence & distribution of termite attack in Melbourne & environs. The Quantity Surveyor 13: 18-19.

Knox, G.A. (1963). The biogeography and intertidal ecology of the Australasian coasts. Oceanogr. Mar. Bio. Ann. Rev. 1: 341-404.

Postle, A. and Abbott, I. (1991). Termites of economic significance in suburban Perth, Western Australia: A preliminary study of their distribution and association with types of wood (Isoptera). J. Aust. ent. Soc. 30: 183-186.

Reynolds, J.L. and Eldridge, R.H. (1973). The distribution and abundance of termites attacking wood in service in the Sydney area. 16th For. Prod. Res. Conf., Melbourne, Vol. 1, Topic 3/39, 7 pp.

Watson, J.A.L. and Abbey, H.M. (1993). Atlas of Australian termites. CSIRO Entomology, Canberra, 155 pp.