DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

THE IMPACT OF TIMBER HARVESTING AND ASSOCIATED ACTIVITIES ON MEDIUM SIZED MAMMALS IN THE JARRAH FOREST.

Interim Report Number 1

By

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1. INTRODUCTION

The use of native forests for timber production has given rise to one of the most intense environmental debates experienced in Australia. Conservation groups argue that logging and burning destroys or seriously degrades the forests natural integrity. On the other hand, forest managers argue that logging is compatible with conservation provided that sufficient areas are reserved and that appropriate measures are taken within production forests to mitigate the effects of logging.

Modern forest management policies are formulated around the concept of "ecologically sustainable development"' a concept which has been defined variously in the literature (eg. ESD Working Group Report 1991, RAC Inquiry 1992). According to the ESD Working Group (1991), ecologically sustainable forest use implies *optimising the tangible (material) and intangible (non material) social and economic benefits which forests can provide to the community with the goals of maintaining the functional basis of forested land, biodiversity, and the options for future generations.*

The principles of ecologically sustainable forest use require the development and implementation of policies which maintain ecological process, maintain biodiversity and optimise benefits to the community. CALM's Forest Policy Statement (CALM 1992a) embodies these principles, viz *To manage the native forests of the south-west of Western Australia, in consultation with the community, so that they provide the values required by society while sustaining indefinitely, their biological and social diversity.*

In order to implement this policy, CALM recognizes the need for basic ongoing research to gain scientific knowledge of forest ecosystem processes and how these are impacted by forestry operations (CALM 1992b). CALM also recognises the need to monitor the implementation and impact of these operations to gauge the success of its policies in regard to achieving sustainable forest use. Meaningful monitoring procedures can only be designed and implemented with a firm understanding of natural processes and of key ecosystem elements which should be monitored. Without this information, monitoring risks being "token" and a waste of valuable management resources.

The CALM Science and Information Division (SID) has a mission to provide up-to-date and scientifically sound information to support effective conservation and sustainable land management practices in Western Australia (CALM 1993). The structure of SID facilitates the establishment of formal links between the Division and operational branches within CALM. In 1993 a Native Forest Research Committee (NFRC) was established and comprised senior members of the Forest Management Branch, SID, and managers of operational branches. This group recognised gaps in knowledge concerned with timber harvesting and recommended that an integrated research program be established to address this issue. A team of scientists from SID and post graduate students, the Forest Ecology Research Team (FERT), was established to carry out this integrated program of research. The primary focus of this team was to examine, experimentally, the impact of logging and associated activities on the vegetation and flora, abundance of hollow bearing trees, small terrestrial vertebrates, medium sized mammals, and birds, over a 5 - 10 year period. This work became known as "The Kingston Study". It should also be noted that investigating the impact of timber harvesting on Chuditch and Woylie are actions in the respective recovery plans for those species (Orell and Morris 1994, Start *et al* 1995).

This report is the first in a series of Interim Reports on the Kingston study, spanning the period from April 1994 to May 1996. It relates only to the impact of timber harvesting and associated activities on populations of the medium sized mammals Brush-tailed Phascogale *Phascogale tapoatafa*, Quenda *Isoodon obesulus fusciventer*, Woylie *Bettongia penicillata*, Chuditch *Dasyurus geoffroii*, Brushtail Possum *Trichosurus vulpecula*, and Western Ringtail Possum *Pseudocheirus occidentalis*.

2. STUDY SITE

This study was undertaken in the Kingston, Warrup, and Winnejup forest blocks, approximately 25 km north east of Manjimup. These forest blocks cover approximately 15 000 ha and lie near the eastern edge of "the Jarrah forest", and comprise open forest dominated by Jarrah *Eucalyptus marginata* and Marri *E. calophylla*. Annual rainfall is approximately 900 mm and there is some evidence of a steady decline in annual rainfall since 1926. Soil is primarily lateritic with deeper loams in riparian zones. The area had been selectively cut for good quality Jarrah only, between 1950 - 1970. Prescribed fuel reduction burns on a 7 - 10 year rotation have been implemented since the mid 1960's.

This site was selected as previous fauna surveys had shown that several species of medium sized mammals occurred in the area at low abundances, and an extensive fox control program covering 30 000 ha had commenced in June 1993. Species known to occur in the Kingston study area include Chuditch *Dasyurus geoffroii*, Quenda *Isoodon obesulus fusciventer*, Woylie *Bettongia penicillata*, Brushtail Possum *Trichosurus vulpecula*, Western Ringtail Possum *Pseudocheirus occidentalis*, Brushtail Phascogale *Phascogale tapoatafa* and Numbat *Myrmecobius fasciatus*. Currently the Chuditch, Quenda, Western Ringtail possum and Numbat are threatened species under the WA *Wildlife Conservation Act* 1950. At the time of commencement of this study (mid 1993) the Woylie was also a threatened species but has since been removed to a lower, more secure conservation status (Start *et al* 1996).

Based on studies elsewhere in the Jarrah forest (Morris *et al* 1995), fox control was expected to result in an increase in medium sized mammal abundances before logging treatments were imposed, thus enabling any impact due to the logging to be detected. It was unlikely that any impact could have been detected if low mammal abundances had been retained through not implementing a fox control program. The site was also suitable because timber harvesting over the next decade or so would focus on similar landform types as found in Kingston.

Timber harvesting coupes were selected by CALM's district and regional staff during 1993 using standard departmental prescriptions. Trapping and grid site selection and establishment followed this process and were completed by March 1994. Within the Kingston block, sampling sites were located in areas to be harvested to gaps and shelterwood. All attempts were made to sample a range of typical medium rainfall jarrah forest habitat types found within that landform/soil unit. Control sites were established both within Kingston block and in adjoining Warrup and Winnejup forest blocks that were to be withheld from harvesting for the duration of this study. Timber harvesting was programmed to commence at the end of 1994.

The study was launched by the Minister for the Environment in April 1994 and sampling commenced immediately thereafter. This report provides interim results of the study into the impacts of timber harvesting on the medium sized mammals only, excluding the Numbat *Myrmecobius fasciatus*. Reports on other aspects of the Kingston study will be provided elsewhere.

3. METHODOLOGY

3.1 Fox Control

Fox control using dried meat baits impregnated with 4.5 mg of sodium flouroacetate (1080) commenced in the Kingston, Walcott, Winnejup, Dudijup, Mersea, Yardup, Warrup and Corbal forest blocks in June 1993. Until May 1996 baits were laid from the ground at intervals of 250 m along the network of forest tracks. After May 1996, fox baits were dropped from an aircraft at a density of 5 baits per square kilometre. Baiting is undertaken every three months.

The effectiveness of fox control was estimated in September 1996 using fox activity as an index A network of sand pads at 200m intervals and baited with a non toxic lure, were established throughout the baited study area and in the unbaited Yornup, Alco and Thornton forest blocks to the west of the study site. Fox activity in the baited study area was only 12 % that of the activity in the unbaited area.

3.2 Sampling

The overall study design is of the BACI (Before, After, Control, Impact) type, with replicates of each of four treatments. The four treatments imposed were: (i) Control, (ii) Shelterwood harvesting in 5 - 50 ha patches, (iii) Gaps of up to 10 ha created with 3 marked habitat trees retained per hectare, (iv) Gaps of up to 10 ha created without marked habitat trees retained. The controls were further divided into external controls some distance from the impact sites (no logging or burning), internal controls close to impact sites (no logging or burning) and buffer controls adjacent to impact sites (no burning).

Trapping grids to sample medium sized mammals and smaller vertebrates were established in impact and control sites and each given an alphanumeric code based on the logging block number (Table 1). Each treatment was replicated and all normal prescriptions pertaining to follow-up silvicultural work and prescribed burning were to be applied.

Treatment	Grid
External control (no logging or burning)	Warrup1 (C1), Warrup 2 (C2), Winnejup 1 (C3), Winnejup 4 (C4)
Internal control (no logging or burning)	Kingston KC-5, KC-6
With-in coupe control - buffers (no logging)	K1-3, K5-3
Shelterwood harvesting	K3-1, K5-6 (central) K3-2, K5-7 (ecotonal)
Gap creation with habitat trees	K1-5, K2-1, K5-4, W3-1 (central) K1-4, K2-2, K5-5, W3-2 (ecotonal)
Gap creation without habitat trees	K1-1, K5-1 (central) K1-2, K5-2 (ecotonal)

Table 1. Treatments and sampling grids used in the Kingston study.

Each trapping grid (Figure 1) comprises a core area of 80 x 80m in which a 3 x 5 grid of pitfall traps (20 litre Rheem buckets) was established. Superimposed over this is a 3 x 5 grid of medium Elliott mammal traps at 40m spacing and a further 3 x 3 grid of Sheffield wire cage traps at 80m intervals. Total grid area is 2.56ha. These grids were placed either in the above treatments or unlogged buffers and undisturbed areas as controls. Grids were also positioned across impact boundaries into buffer zones to sample transitional areas. A total of 24 grids were established necessitating a staggered sampling regime that split the sites into northern and southern groups with sampling undertaken over a two week period. Internal control grids (KC-5 and KC-6) were sampled at both times in the two week period to provide an intra sample comparison. Each sampling period comprised three consecutive nights trapping and 12 samples have been obtained on each grid in the first 24 months of the study.

In addition to grid sampling, medium sized mammals are sampled at a broader scale using road transects. Sheffield wire cage traps are set at 20m intervals for 36 kilometres along tracks throughout the study area and operated for four consecutive nights during the same period as grid sampling. Nineteen percent of trap points are adjacent to recently logged areas. This technique is particularly suitable for sampling the wide ranging Chuditch.

Because Western Ringtail Possums rarely enter cage traps, the study into the impact of timber harvesting on this species will rely on a radiotelemetry study in the Kingston 4 area. Standardised driven spotlight transects covering 22 kilometres of forest track are also been undertaken through the study area to provide information on Ringtail Possum (and other species) abundance and habitat use.

All captured animals are individually marked with ear tags, sexed, measured, weighed and released. Selected individuals are fitted with radio-transmitters (Biotrack two stage transmitters) to determine home range, den usage, movement pattern and mortality data. Abundance estimates using KTBA (Known To Be Alive) and percentage trap success rates have been determined. The KTBA method is highly suitable for studies such as this where capture and recapture rates are high, and frequent long term sampling is undertaken Field data has been stored on a Microsoft Access database.

A major objective of the study is to monitor the effectiveness of remnant habitat trees and to determine the size, density and distribution of these required to sustain arboreal fauna populations. In this regard substantial effort has been made in combining radio-telemetry observations with detailed assessment of animal refuge sites. Preliminary results of this work are presented in this report.

4. TIMBER HARVESTING OPERATIONS

All harvesting prescriptions were set by operational staff according to standard CALM silvicultural guidelines, except that at two sites (K1-1 and K5-1) all marked habitat trees were removed so that this study could examine the benefits of habitat tree retention. Influence by researchers was limited to minor timetable adjustments to allow finalisation of pre-impact data collection. Contact with logging contractors was limited to general observation and collection of anecdotal information. Contractors were advised to ignore any flagging or other signage that did not relate to harvesting so that no effort to avoid sites or refuge trees was made.

Timber harvesting commenced in the summer of 1994/1995. Most work ceased with the onset of rains during April/May 1995. The following summer saw some continuation of activity in coupes that had not been completed with major new activity concentrated on grids within the K2 area. All timber harvesting relevant to grid sampling was completed during early 1996. No post harvesting burning (tops burns) has yet been undertaken and logging has not yet occurred in the K4 area where the Ringtail Possum pre-logging data collection is underway.

5. RESULTS

The results presented below do not cover all species on all grids but have been selected to show trends in areas where significant visual harvesting impact occurred and/or a particular species was abundant. They include up to 12 months pre-harvesting data and up to 12 months post-harvesting data. Detailed statistical analysis has not yet been performed.

All species of medium sized mammals considered in this study have remained widespread throughout the study area (Table 2) and abundance has increased since fox control was implemented in 1993 (Figure 25). Other mammal species recorded on the trapping grids include the Dunnart *Sminthopsis dolichura*, Bush Rat *Rattus fuscipes*, Black Rat *Rattus rattus* and House Mouse *Mus domesticus*.

5.1 Brushtail Possum (*Trichosurus vulpecula*)

5.1.1 Refuge sites

Radiotracking of up to 20 Brushtail Possums in the K5 coupes prior to logging showed that up to 73 % of refuge sites selected were hollows in standing trees and 27 % were ground sites such as hollow logs, burrows and hollow stumps (Figure 2). An average of 3.2 trees were used by each possum during the period March 1994 to October 1995, however estimates of the extent of tree sharing with other Brushtail Possums and Western Ringtail Possums have not yet been determined. Analysis of site selection post harvesting has not been completed.

5.1.2 Mortality

Because of its arboreal nature and daytime use of hollows in standing trees, timber harvesting might be expected to impose some mortality on Brushtail Possum populations. Mortality at the K2, K3 and K5 was assessed by radiotracking individual Brushtail Possums before, during and after logging operations. Some monitoring was also undertaken on distant control grids. The results are shown in Table 3.

Grid	Number of BTP radiotracked	Number dead before logging (%)	Number dead following logging (%)
Control 16/3/94-22/8/96	5	0	0
K2 22/11/95 -22/8/96	15	2 (13%)	5 (33%)
K3 21/9/94 - 22/8/96	9	0	6 (67%)
K5 16/3/94 - 22/8/96	20	1 (5%)	7 (35%)

Table 3. Mortality of Brushtail Possums.

Actual causes of death have been difficult to determine because of delays in locating the body and/or disturbance by scavengers. Known causes of death included predation, broken limbs due to falls and being crushed or buried by machinery.

5.1.3 Abundance

KTBA estimates for Brushtail Possums on grids subject to timber harvesting impacts are shown at Figures 3, 4, 5 and 6. KTBA estimates at internal and external controls are shown at Figures 7, 8 and 9. At all sites, the KTBA over the first few trapping periods until most animals on the grid had been marked. Possum abundance in gaps created with 3 marked habitat trees retained (Figure 3) and in gaps where habitat trees were removed does not appear to have declined compared with adjacent unlogged areas. Similarly, shelterwood harvesting does not appear to have detrimentally impacted possum abundance (Figure 6). Brushtail Possum abundances have remained relatively constant in the control areas (Figure 8 and 9). The density of Brushtail Possum in the Kingston study area can be derived from KTBA and known movement areas, which are used to correct for the "collecting" area of each grid. Estimates of between 0.6 and 1.1 possums per hectare have been obtained and these are amongst the highest recorded in Australia (Kerle 1984).

At a broader scale, Brushtail Possum abundance throughout the study area has increased significantly. Trap success rates along the road transects has increased from 3 % (3 captures per 100 trapnights) to approximately 24 % since August 1992 (Figure 10). This is primarily in response to fox control throughout the Kingston study area which commenced in June 1993.

5.1.4 Physical condition

If timber harvesting was having a detrimental impact on Brushtail Possum populations it would be expected that the physical condition or well being of the population would also decline. A condition index can be derived by dividing the cube root of body weight by the pes (foot length) measurement (Short and Turner 1989). Using this, the physical condition of possums in the gap with no habitat trees retained (K5-1) has not declined since logging and is no different to possums in the adjacent control (Figure 11). It should be noted that a condition index difference of 0.01 equates to approximately a 10 % change in body weight in an average adult possum.

5.2 Woylie (*Bettongia penicillata)*

5.2.1 Refuge sites

Between March 1994 and October 1995 up to 10 Woylies at a time were radiotracked to refuge sites (89 sites located). All used above ground nests as refuge sites (Figure 2) and an average of 7.4 nests were used by each Woylie in this period. Post logging sites used include the "tops" debris left behind after the harvesting operation.

5.2.2 Mortality

No Woylie mortality was recorded during timber harvesting operations.

5.2.3 Abundance

Woylie abundance on the K1-4 and K1-5 grids (gap creation) showed some decline post logging, however this also occurred in the buffer control (Figure 12). Abundance after the first logging period at K3-1 and K3-2 (shelterwood) increased before declining again to pre-harvesting levels following the second logging period (Figure 13). These grids have the highest Woylie abundance in the study area. Some variation in abundance is also evident on the control grids (Figure 14, 15 and 16).

At a broader scale, Woylie abundance has increased throughout the study area since fox control was implemented. Trap success rates of approximately 3 % were achieved in August 1992 before fox control was implemented. These have increased ten fold to 31 % in December 1995, after 30 months of fox control (Figure 17).

5.3 Quenda (*Isoodon obesulus)*

5.3.1 Refuge sites

Because of the difficulties associated with fitting radiocollars to Quenda for extended periods of time, only small numbers (up to four individuals) were radiotracked at any one time. Fifty four refuges were located between April 1994 and October 1995. Two thirds of these were above ground nests, often under shrubs; 20.4 % were burrows; and 13 % were hollow logs (Figure 2).

5.3.2 Mortality

Two mortality events were recorded. One was before logging occurred near the K5-1 grid and was believed to have been Chuditch predation. Another following logging was believed to have been cat predation.

5.3.3 Abundance

Quenda abundance at K1-4 and K1-5 (gap creation) has fluctuated markedly both during and following timber harvesting. However this has been no more significant than in the adjacent buffer control, K1-3, (Figure 18) or the other controls (Figure 21). Declines in abundance at K5-1 and K5-2 are repeated in the adjacent control (Figure 19). Similarly a decline at K5-4 is repeated in the buffer control K5-3 (Figure 20). It should be noted however that these reduced abundances are similar to abundances recorded before logging occurred.

At a broader scale, Quenda abundance has increased throughout the study area since fox control was implemented. Trap success rates of approximately 1 % were achieved in August 1992 before fox control was implemented. These have increased to between 10 - 15 % after 30 months of fox control (Figure 22).

5.4 Chuditch (*Dasyurus geoffroii*)

5.4.1 Refuge sites

Up to 12 Chuditch have been radiotracked at any one time during the period of April 1994 to October 1995. Because of the large areas covered by this species, much of the radiotracking has been from aircraft. Forty three refuge sites have been located; 67.4 % of these were in hollow logs, 30.2 % were in burrows and 2.3 % were above ground nests. Interestingly, Serena and Soderquist (1989) record approximately 37 % of refuge sites as hollow logs and 63 % as burrows - the reverse of this studies findings.

5.4.2 Mortality

Five Chuditch mortality events have been recorded during this study. All were located in unlogged forest and none are known to have been associated with logging activities. One was predated (either as a live animal or a carcass) by a Wedge-tailed Eagle, the others were found relatively intact with no obvious cause of death.

5.4.3 Abundance

Due to the relatively low numbers of Chuditch recorded in the Kingston study, all captures from road transects and grid trapping were combined to determine KTBA estimates (Figure 23). The female population appears somewhat constant over the study period whilst the male figures show some fluctuation. This variation may be due to the increased home range requirements of males (1500 ha vs 900 ha) and a seasonal increase in male activity at breeding time. The overall trend indicates a stable population.

It is possible that the low Chuditch trap success rates at Kingston (0.8 - 1.4 %) are an artefact of the high abundance of other medium sized mammals (Figure 24). Since fox control was implemented at Kingston, trap success rates for all medium sized mammals has increased to approximately 70 % (Figure 25). Most other medium sized mammals such as Woylies, Quenda and Brushtail Possums encounter cage traps early in the evening and most traps are occupied by 2000 hrs. Because of their larger movement areas, Chuditch are more likely to encounter a trap later in the evening, and if 70 % are occupied the chances of finding an empty trap are reduced.

5.5 Brush-tailed Phascogale *(Phascogale tapoatafa)*

The life history strategies (seasonal male die off) and highly arboreal nature of this species make BACI type research difficult to undertake. When captures from all grids are combined, phascogale abundance was high in the initial phases of the study, until August / September 1994, but drastically declined thereafter (Figure 26). A similar trend in phascogale abundance during 1995/6 was noted in adjacent areas (Sue Rhind *pers comm*). Abundance declined on both impact and control grids and the reasons for this are not clear. It may have been related to the unusually dry winter in 1994 and a loss in environmental productivity which impacted on this primarily insectivorous species.

Radio-tracking during the timber harvesting period revealed phascogales actively foraged amongst the logging debris in coupes during the night however none were recorded using diurnal refuges in disturbed sites. All retreated to unlogged buffers to seek diurnal refuges in standing trees.

5.6 Western Ringtail Possum

Because the Western Ringtail Possum does not readily enter wire cage traps, little information has been obtained on this species during the trapping program. A program is currently underway in the Kingston 4 area using darting techniques to capture ringtail possums for radiocollaring.

Three ringtail possums have been trapped and radiocollared to date, and 31 refuge sites have been identified in the period March 1994 to October 1995. Seventy three percent of these were in standing trees, 13 % were above ground nests, 10 % were hollow logs, and 7 % were burrows and hollow stumps. There is significant similarity to Brushtail Possum refuge requirements and considerable overlap and sharing of resources probably occurs. The extent of this has yet to be evaluated.

One ringtail possum was followed through the logging operation at K5-5. The possum survived the felling of its refuge tree and started using "tops" debris as refuge sites. This individual was still surviving 12 months after timber harvesting.

Spotlighting transects were commenced in November 1995, specifically to provide information on ringtail possum abundance and habitat utilisation. These data suggest that the Western Ringtail has persisted in the study area following timber harvesting and is probably as abundant as the Brushtail Possum in the area. (Table 4).

	22/11/95	8/3/96	9/3/96	15/3/96	25/3/96	26/3/96	29/6/96	30/6/96	23/7/96	30/9/96	1/10/96
RT POSS	6	6	6	10	4	6	6	4	1	6	10
BT POSS	14	7	7	6	5	3	2	2	5	6	9
TOTAL	20	13	13	16	9	9	8	6	6	12	19

Table 4. Numbers of Western Ringtail Possums and Brushtail Possums seen during driven spotlight surveys at the Kingston study site.

DISCUSSION

The results of this study indicate that, in the short term (up to 12 months post harvesting), timber harvesting in medium rainfall Jarrah forest does not impact detrimentally on populations of Woylie, Quenda, Chuditch, Brushtail Possum, Western Ringtail Possum and Brushtail Phascogale. Trapping and radiotelemetry studies indicate that many of the medium sized mammals continue to use logged areas for both refuge and feeding. Whilst some mortality resulted from the harvesting operations, particularly among the arboreal Brushtail Possums, population abundance of this species has not declined. The significant decline in the Brushtail Phascogale population that occurred throughout the Kingston area was not the result of timber harvesting as it occurred in all sites including those controls that are distant from any timber harvesting. The abundance of the other species has increased in response to fox control and this trend was not interrupted by timber harvesting.

The retention of unlogged buffers is probably an important strategy in maintaining populations of medium sized mammals in production forest. Where mortality occurs in adjacent areas these buffers provide the recruits to rapidly recolonise vacant territories. For species such as Quenda, retention of dense vegetation along stream buffers is important. Current timber harvesting practices probably only impact on a small part of any single Chuditch home range area, and the heterogenous habitat produced through logging may benefit this species. The continued supply of adequate den sites, either hollow logs or burrows is crucial to the long term conservation of Chuditch in these areas.

It is important that this study continues so that population responses over the longer term (5-10 years) can be assessed. The impacts of post logging prescription burns have not yet been assessed and further information is required on the response of the Western Ringtail Possum to timber harvesting.

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TRAPPING GRIDS

Species	K 1.1	K 1.2	K 1.3	K 1.4	K 1.5	K 2.1	K 2.2	K 3.1	K 3.2	K 5.1	K 5.2	K 5.3	K 5.4	K 5.5	K 5.6	K 5.7	W 3.1	W 3.2	KC 5	KC 6	C1	C2	C3	C4
Woylie	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
BT Possum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RT Possum			X	X*						X*			X	X	X	X		X	X			X*		
Quenda	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chuditch	X		X								X	X	X				X	X			X	X	X	X
BT Phascogale				X	X		X	X	X				X	X	X					X		X	X	X

X* = sighting on grid

TABLE 2. DISTRIBUTION OF MEDIUM SIZED MAMMALS ON TRAPPING GRIDS AT THE KINGSTON STUDY AREA

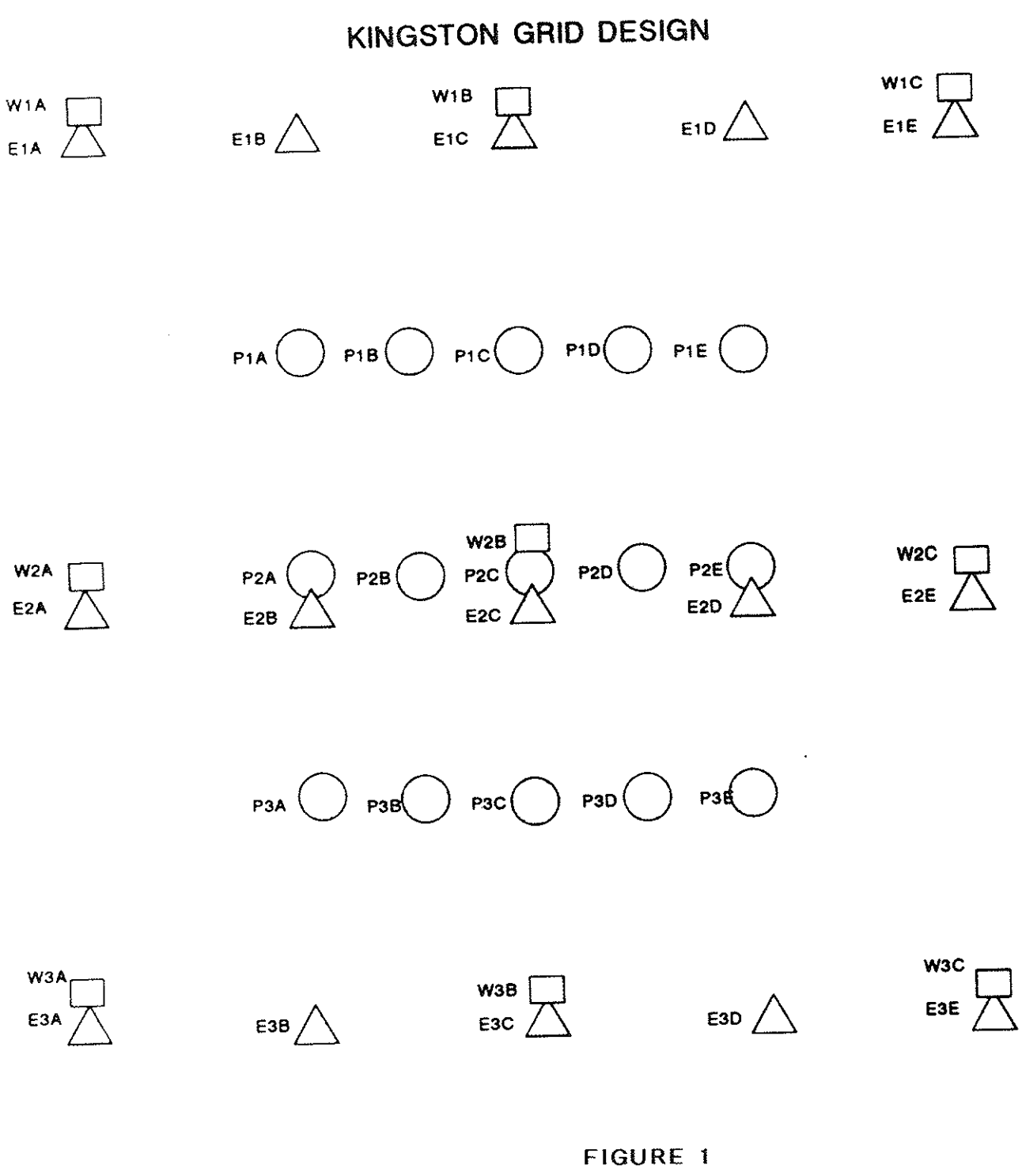

KINGSTON GRID DESIGN
W1A
E1A
E1B
W1B
E1C
E1D
W1C
E1E
P1A
P1B
P1C
P1D
P1E
W2A
E2A
P2A
E2B
P2B
W2B
P2C
E2C
P2D
P2E
E2D
W2C
E2E
P3A
P3B
P3C
P3D
P3E
W3A
E3A
E3B
W3B
E3C
E3D
W3C
E3E
Elliott traps x 15
Wire cage traps x 9
Pitfall traps x 15
Pit grid = 0.64ha
Elliott grid = 2.56ha
Cage grid = 2.56ha
Scale (metres)
0
20
40
N

FIGURE 1

KINGSTON STUDY - USE OF DIFFERENT REFUGE TYPES BY MEDIUM SIZED MAMMALS.

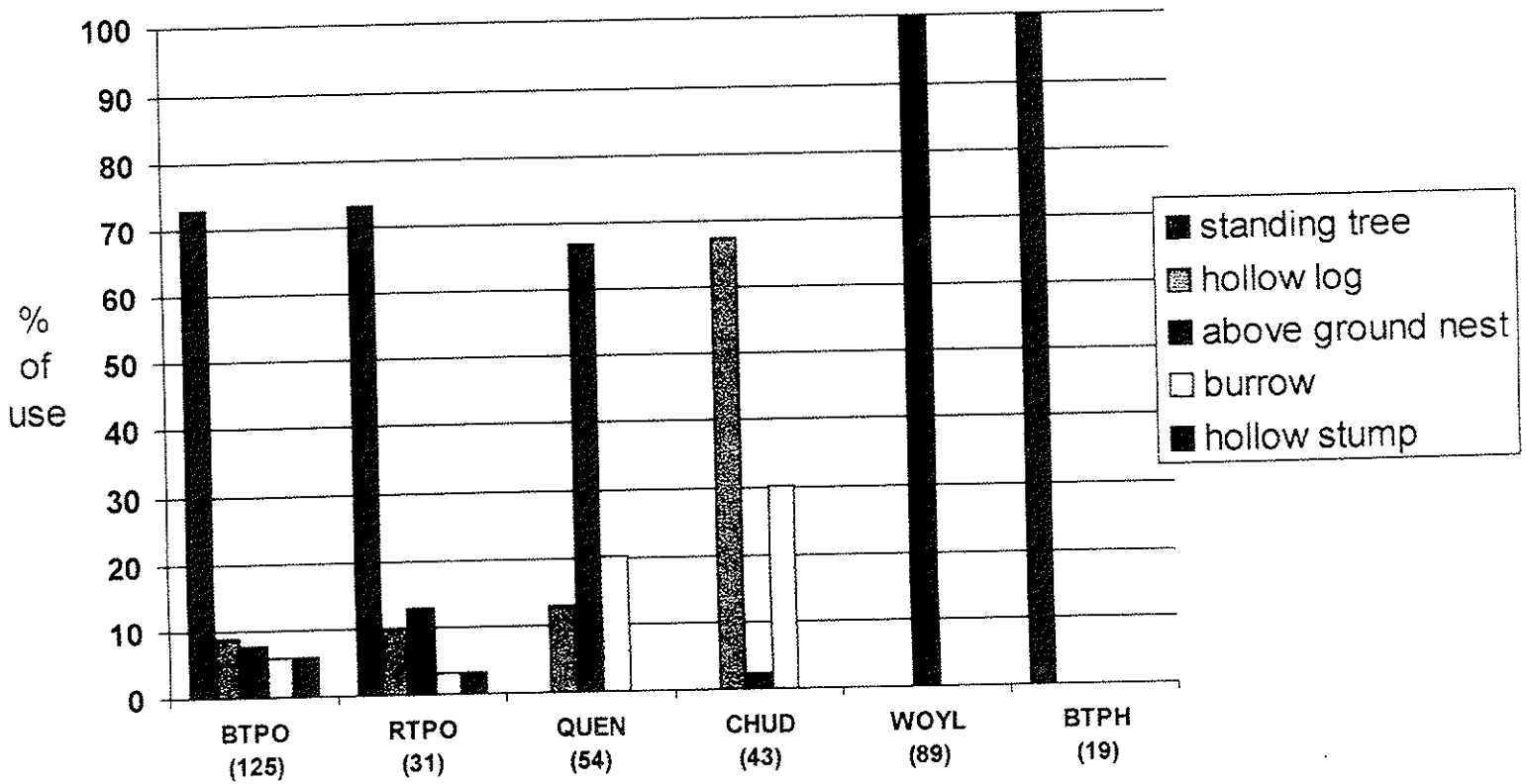
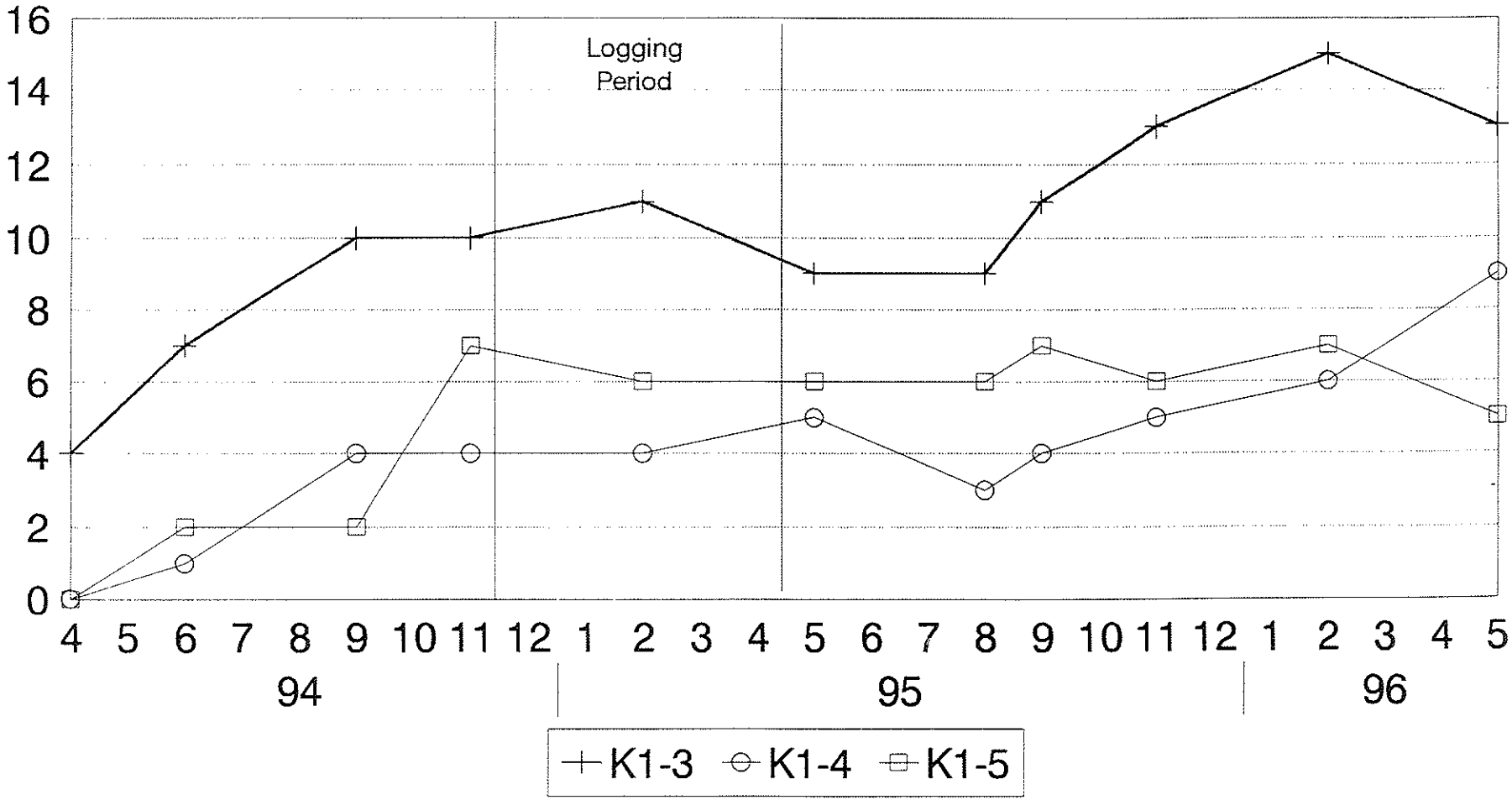


FIGURE 2

POSSUMS KTBA

K1-4/5 & K1-3(control)

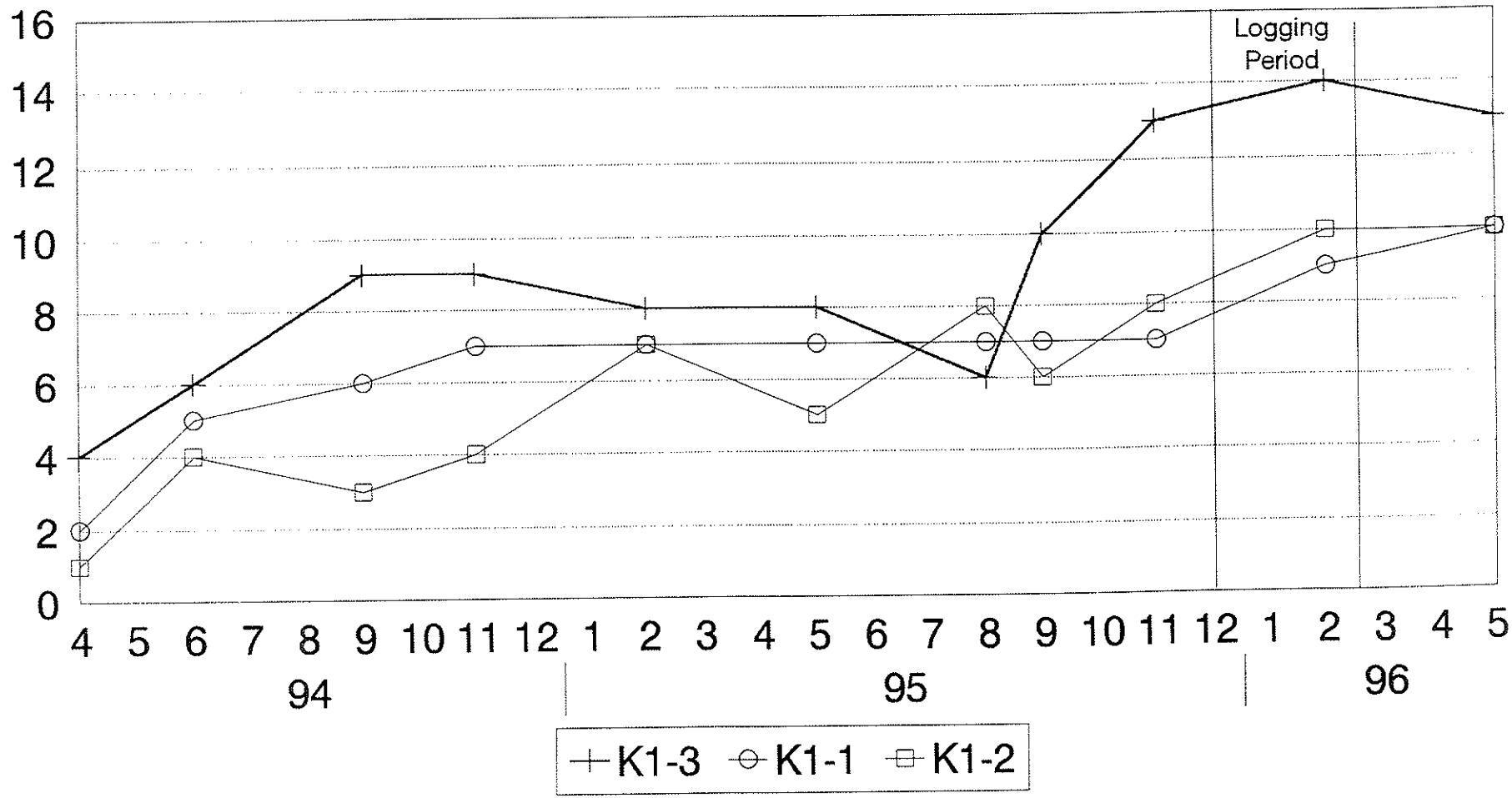


First 24 months of study

FIGURE 3. GAPS WITH HABITAT TREES

POSSUMS KTBA

K1-1/2 & K1-3(control)

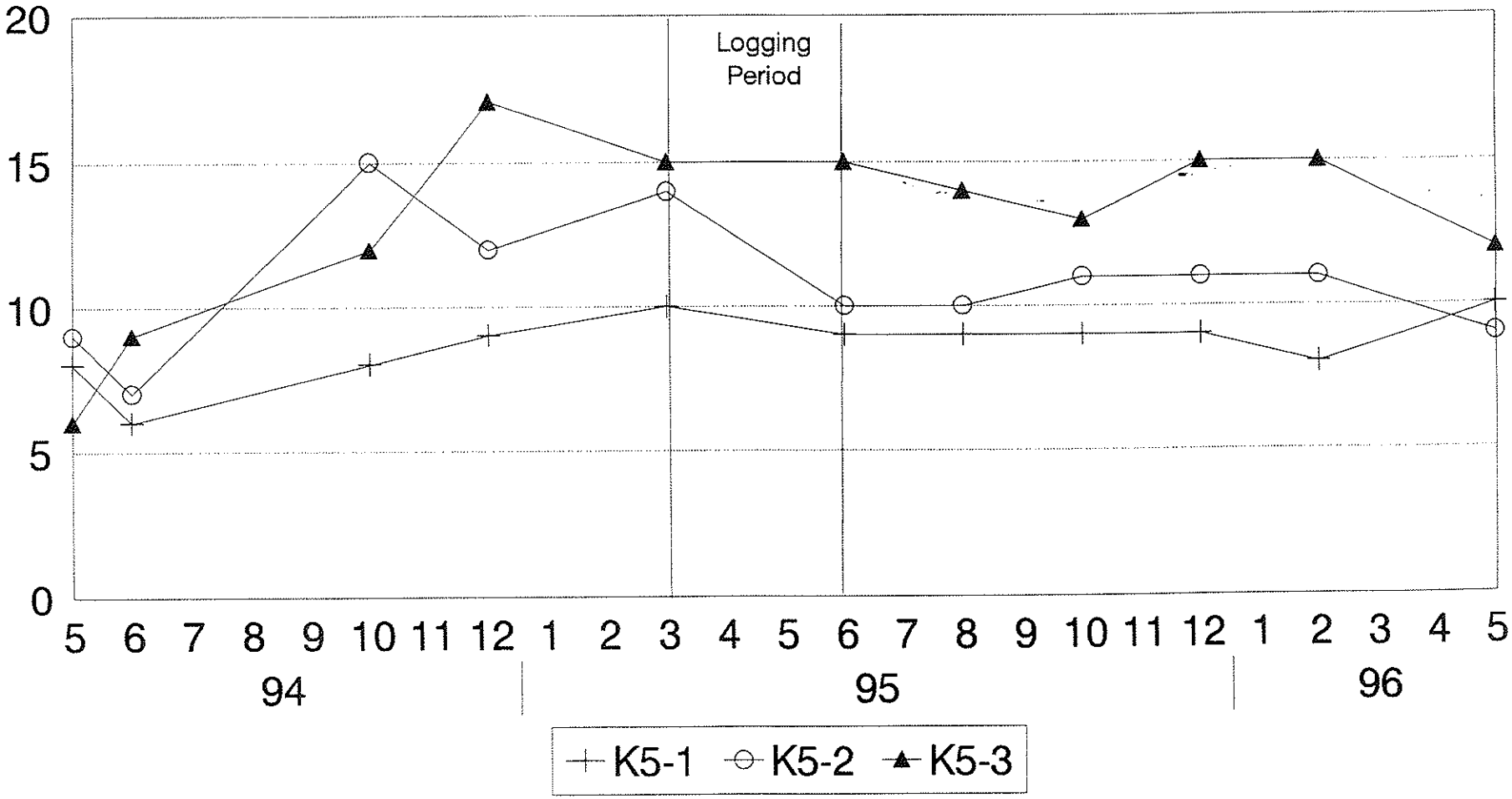


First 24 months of study

FIGURE 4. GAPS, NO HABITAT TREES

POSSUMS KTBA

K5-1/2/3

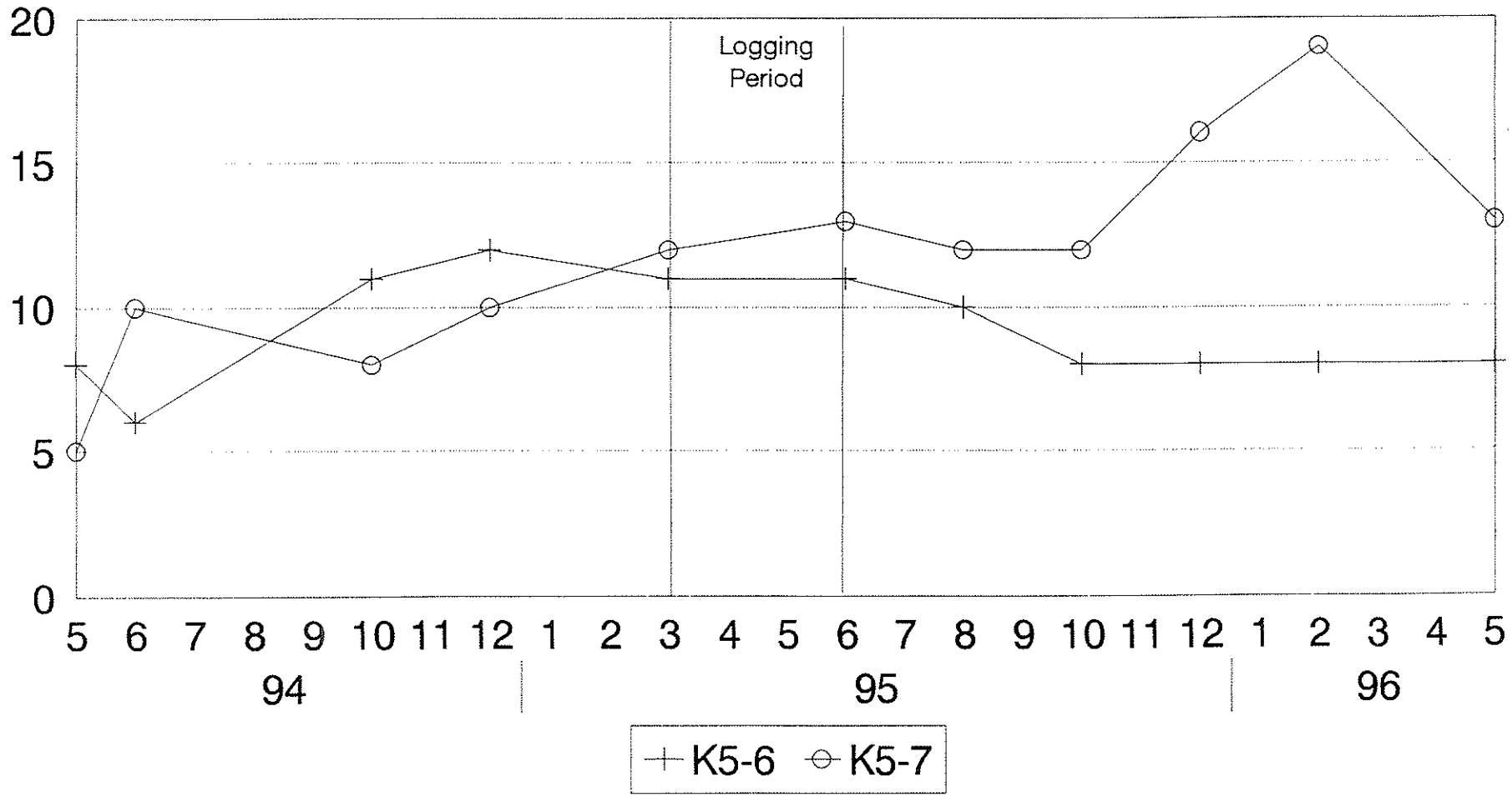


First 24 months of study

FIGURE 5. GAPS WITHOUT HABITAT TREES

POSSUMS KTBA

K5-6/7

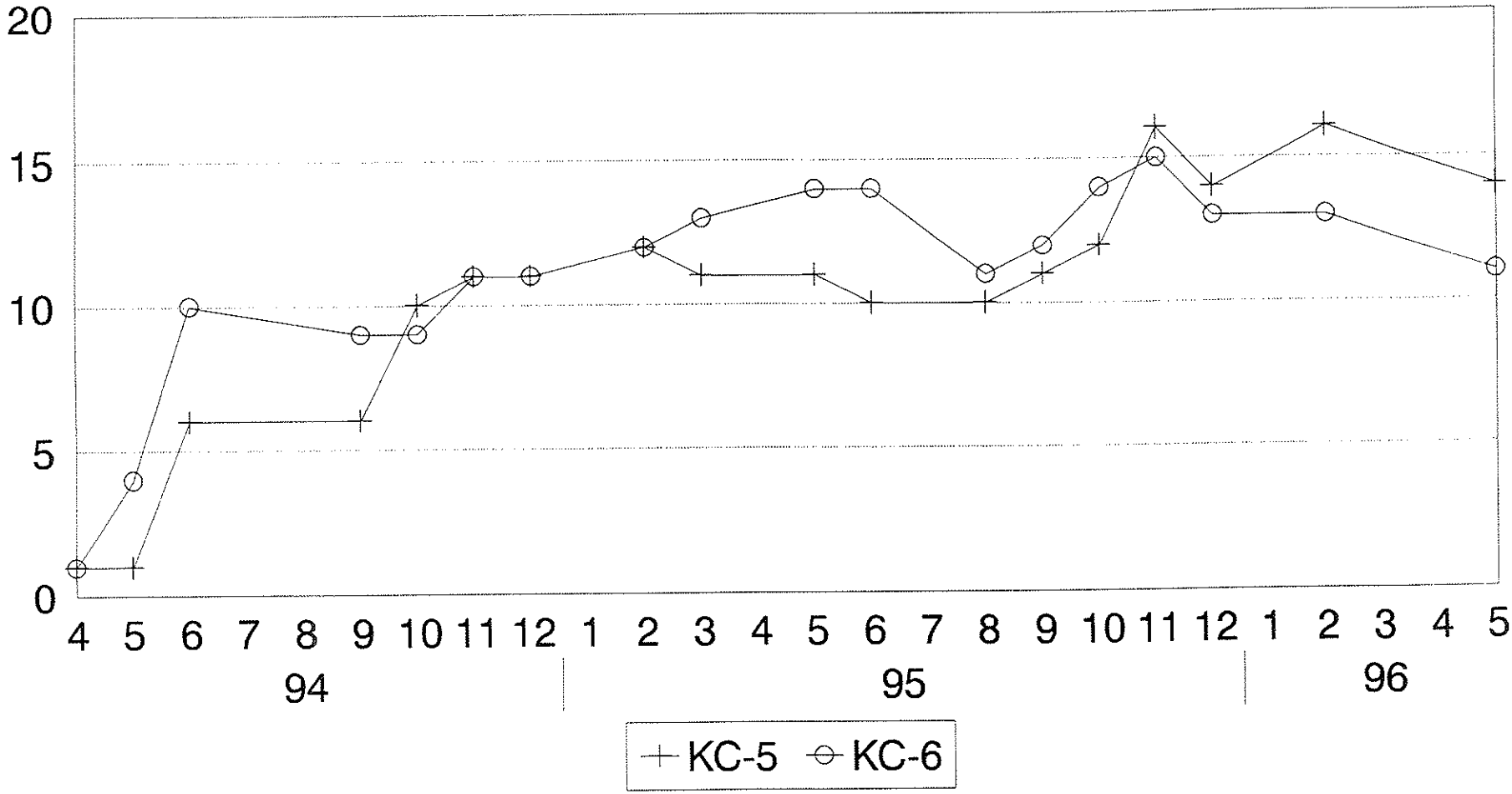


First 24 months of study

FIGURE 6. SHELTERWOOD

POSSUMS KTBA

KC 5/6 UNLOGGED INTERNAL CONTROLS

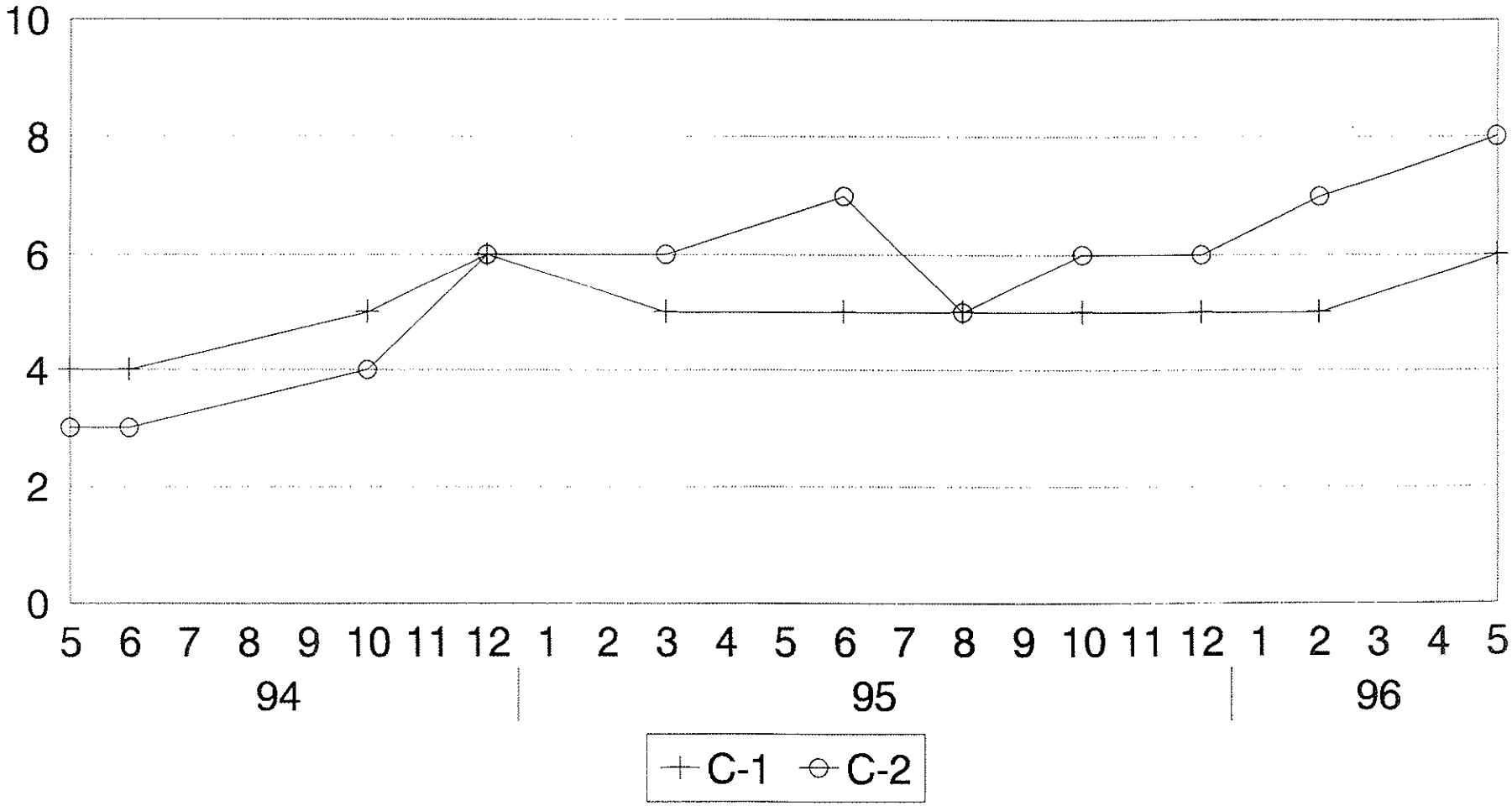


First 24 months of study

FIGURE 7.

POSSUMS KTBA

EXTERNAL CONTROLS - SOUTH

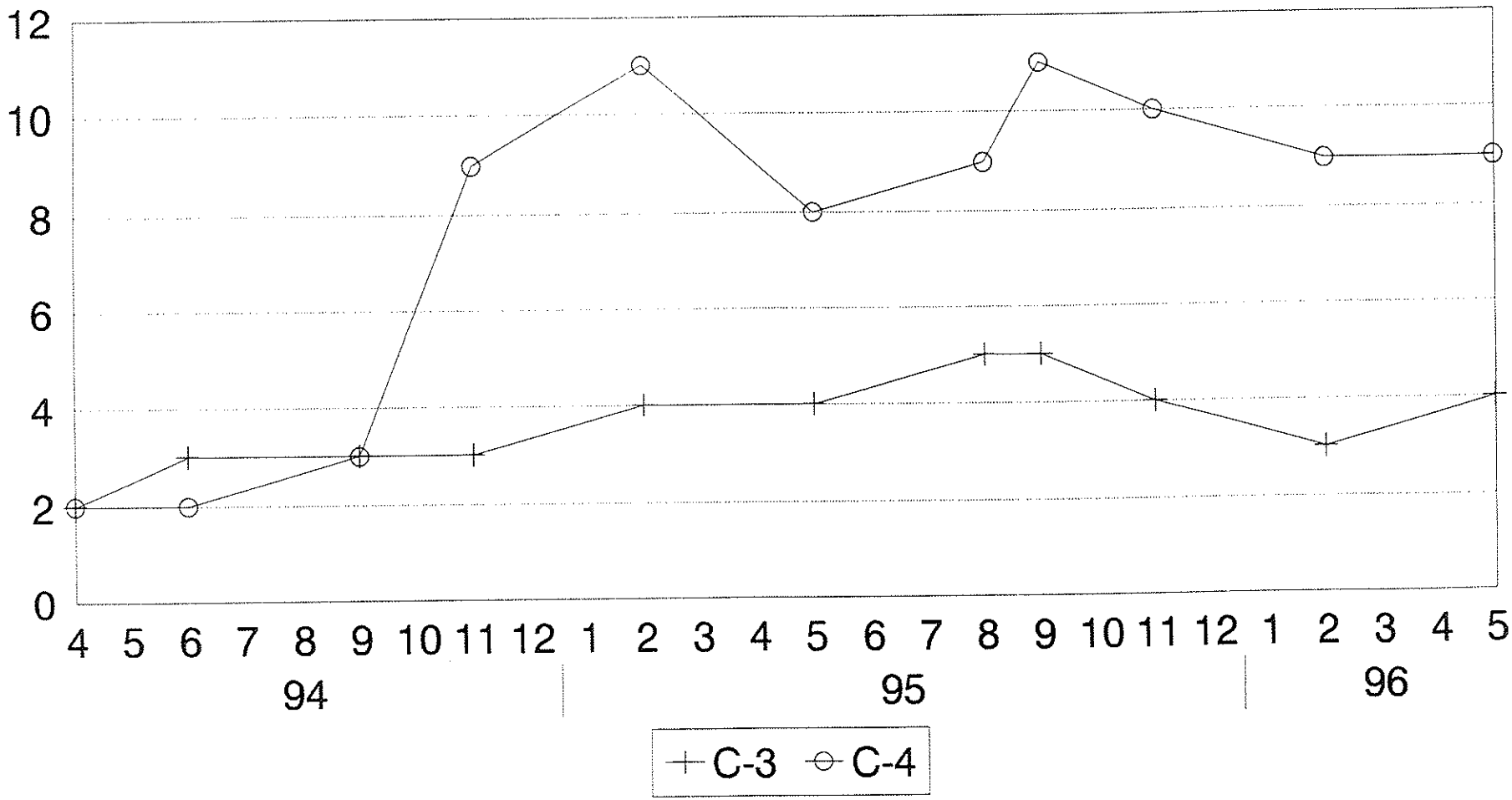


First 24 months of study

FIGURE 8.

POSSUMS KTBA

EXTERNAL CONTROLS - NORTH



First 24 months of study

FIGURE 9.

KINGSTON TIMBER HARVESTING STUDY - TRAP SUCCESS RATES FOR BRUSHTAIL POSSUMS ALONG ROAD TRANSECTS

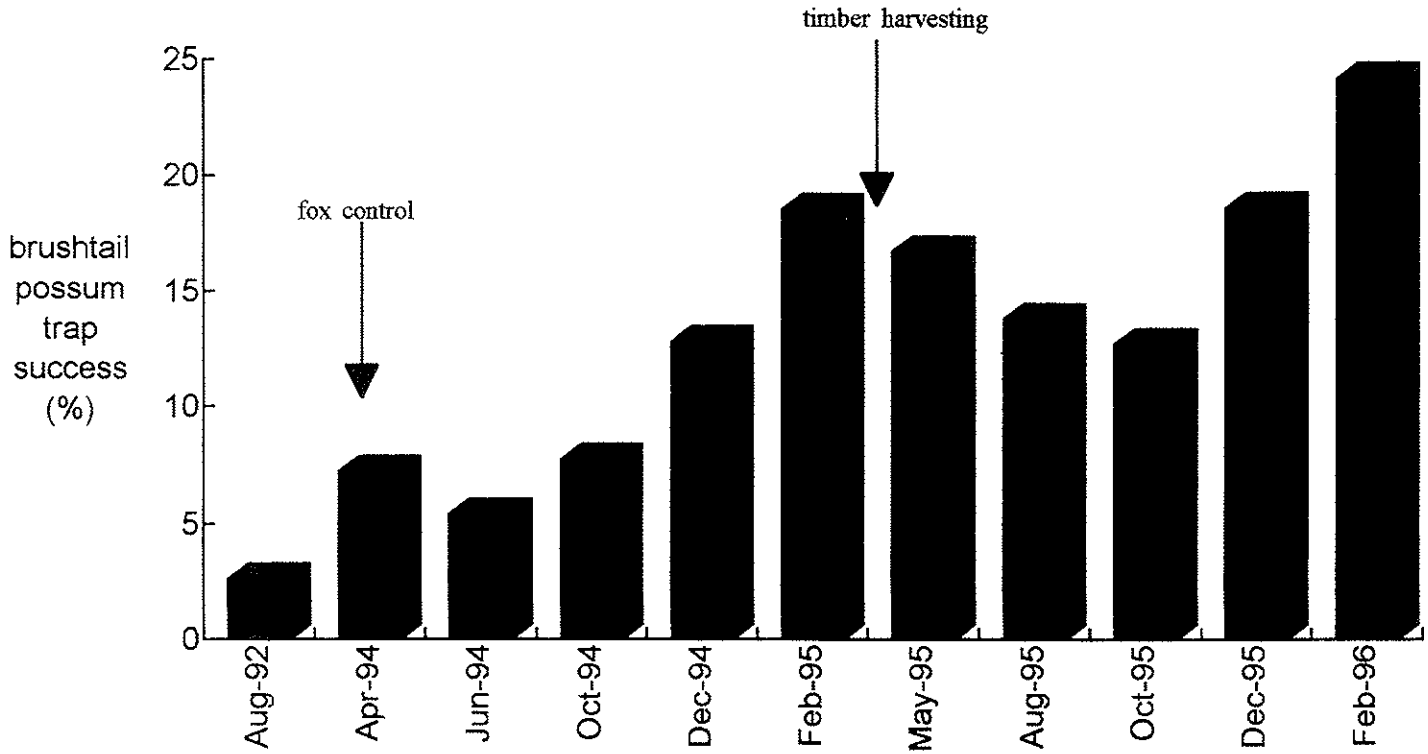
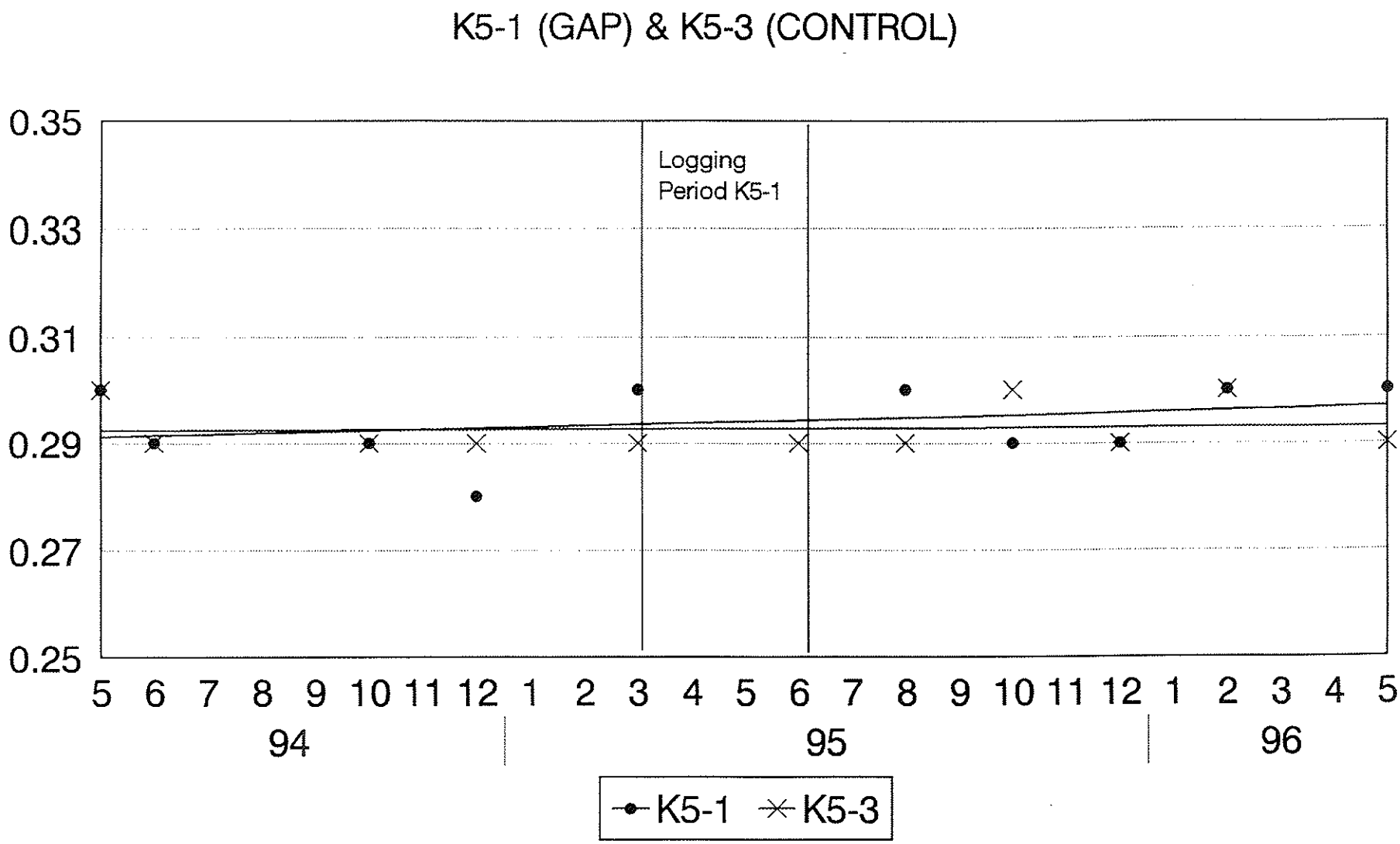


FIGURE 10.

POSSUM CONDITION INDEX

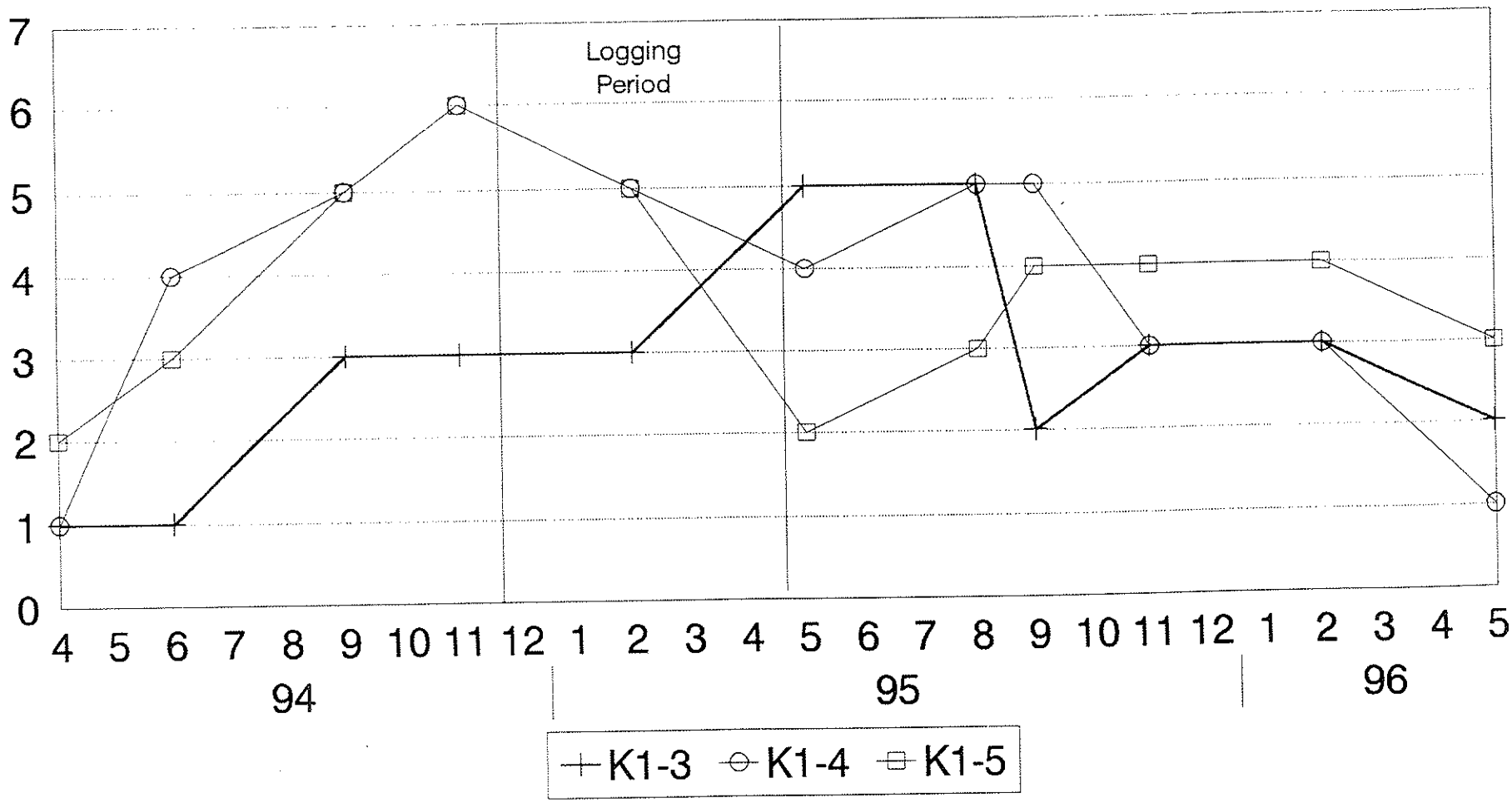


Kingston Study 24 months. (Cube root weight /short pes)

FIGURE 11.

WOYLIES KTBA

K1-4/5 & K1-3(control)

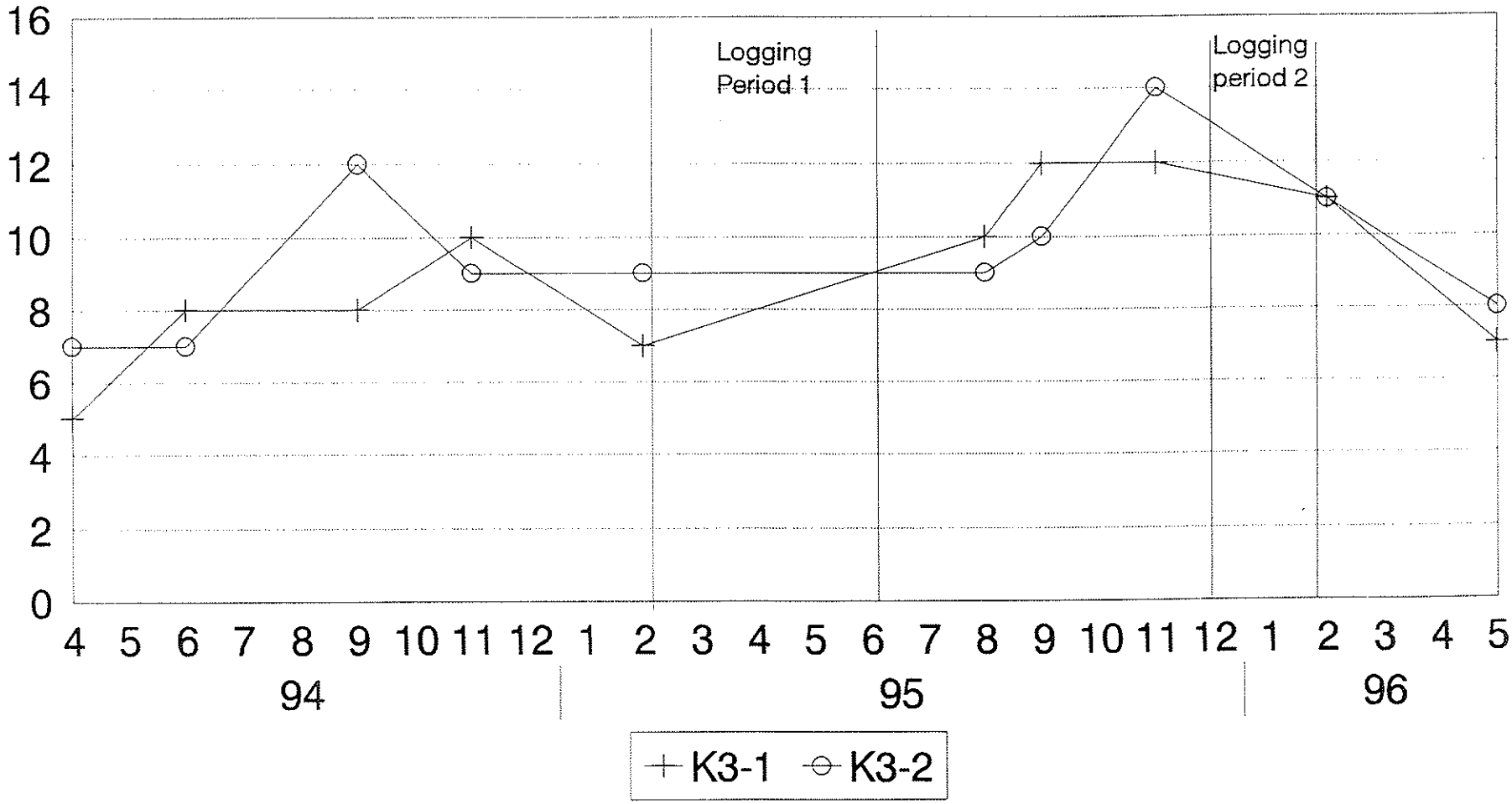


First 24 months of study

FIGURE 12.

WOYLIES KTBA

K3-1/2

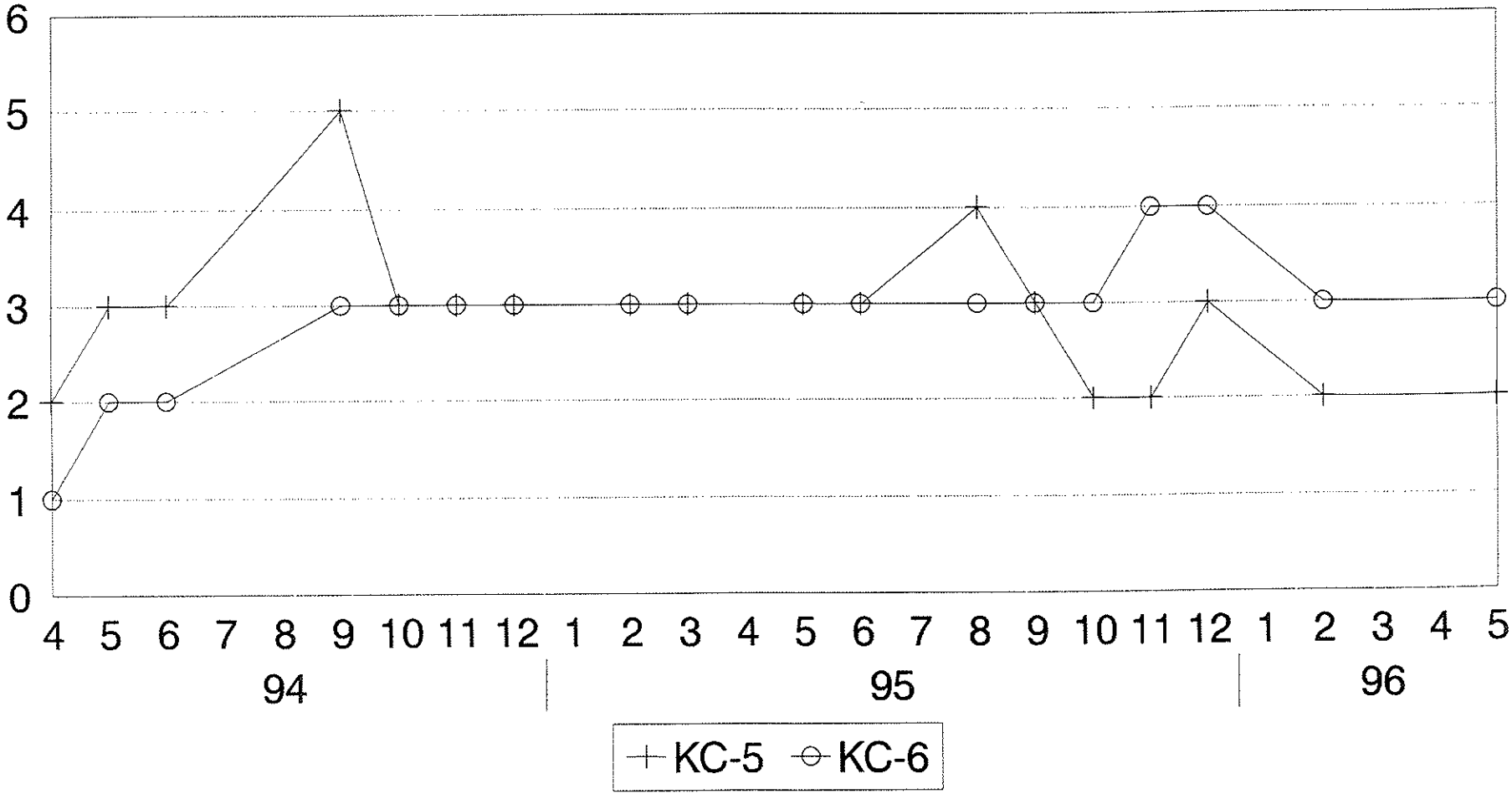


First 24 months of study

FIGURE 13.

WOYLIES KTBA

KC 5/6 UNLOGGED INTERNAL CONTROLS

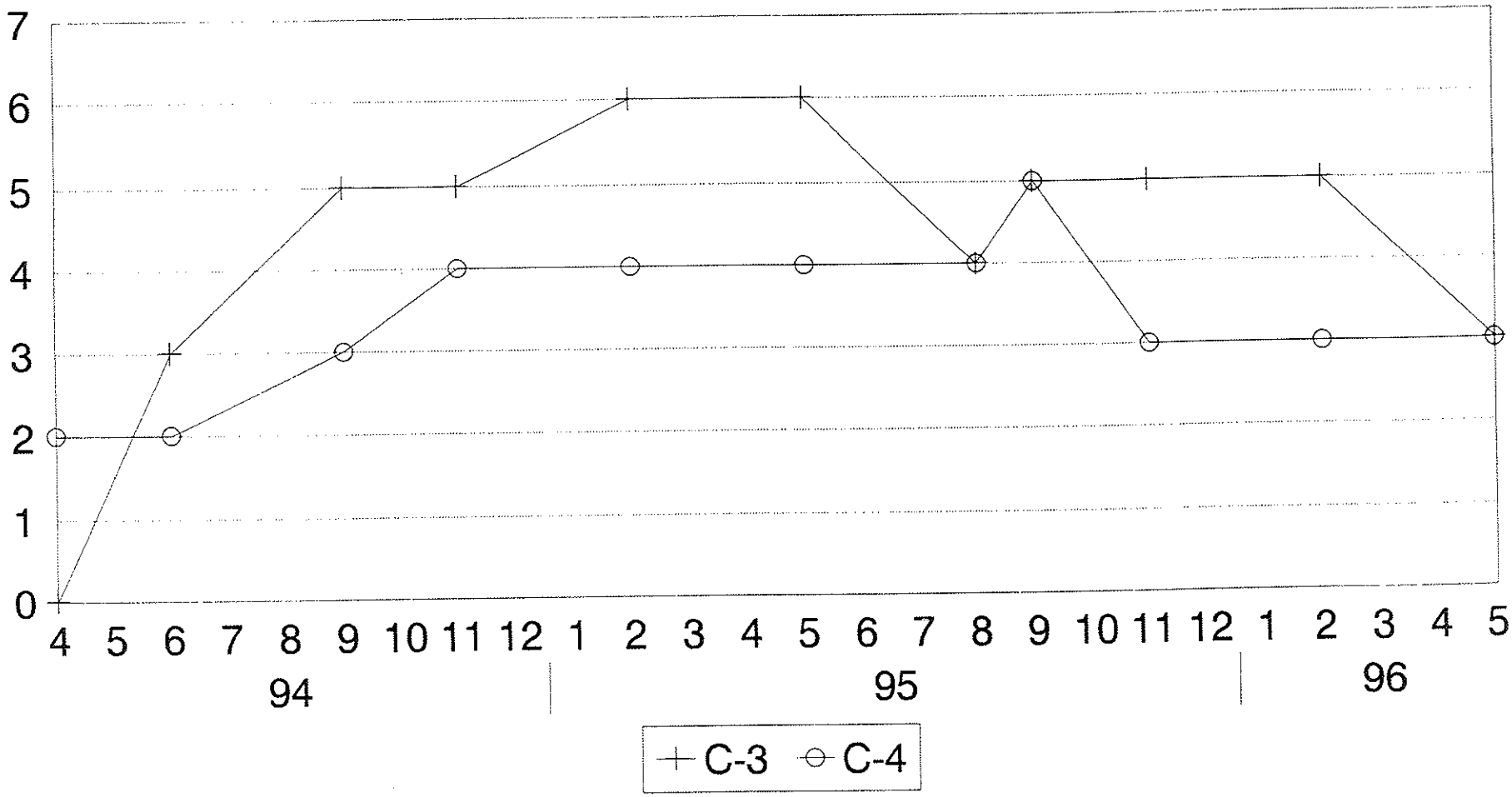


First 24 months of study

FIGURE 14.

WOYLIES KTBA

EXTERNAL CONTROLS - NORTH

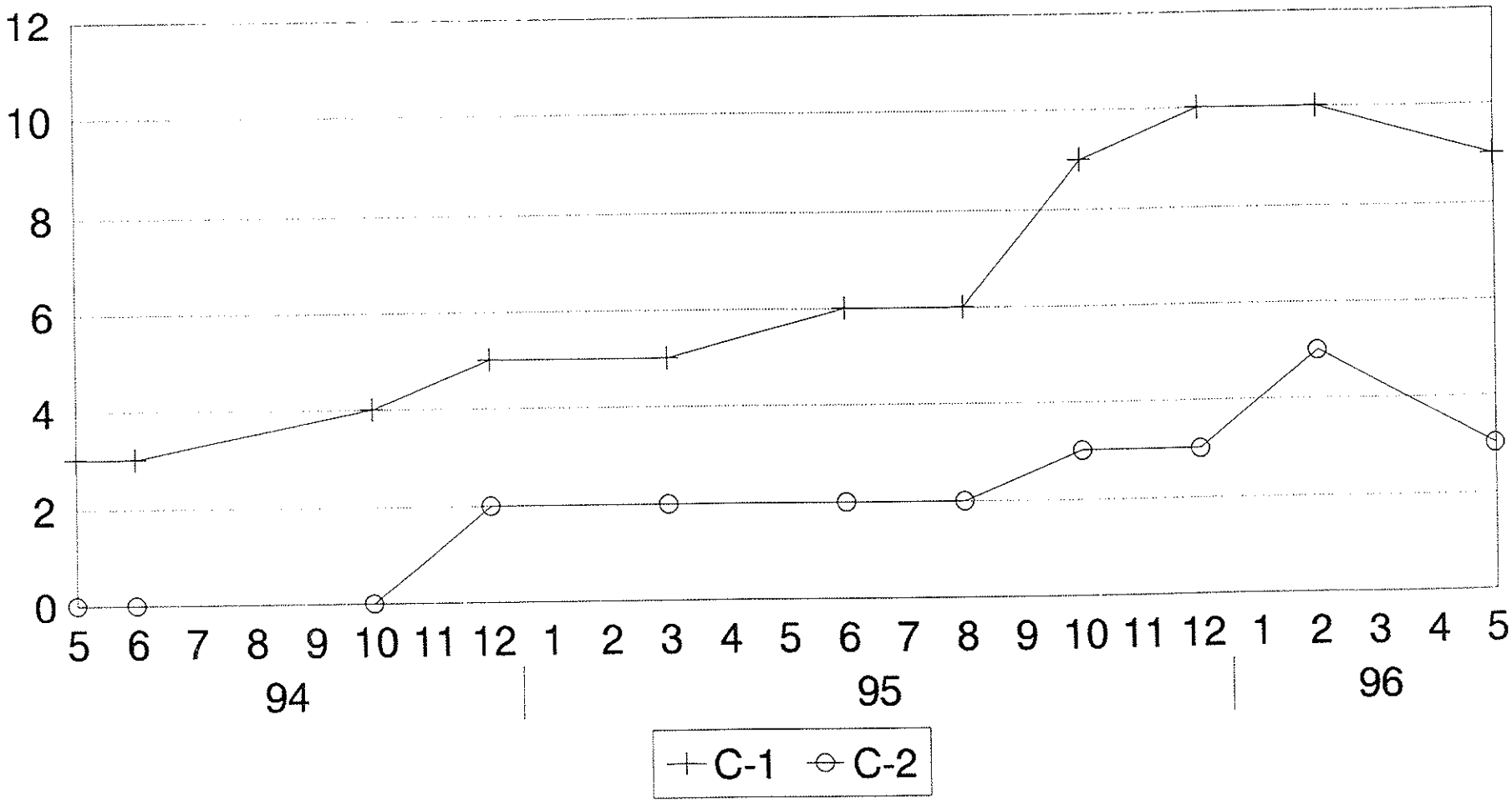


First 24 months of study

FIGURE 15.

WOYLIES KTBA

EXTERNAL CONTROLS - SOUTH



First 24 months of study

FIGURE 16.

KINGSTON TIMBER HARVESTING STUDY - TRAP SUCCESS RATES FOR WOYLIES ALONG ROAD TRANSECTS

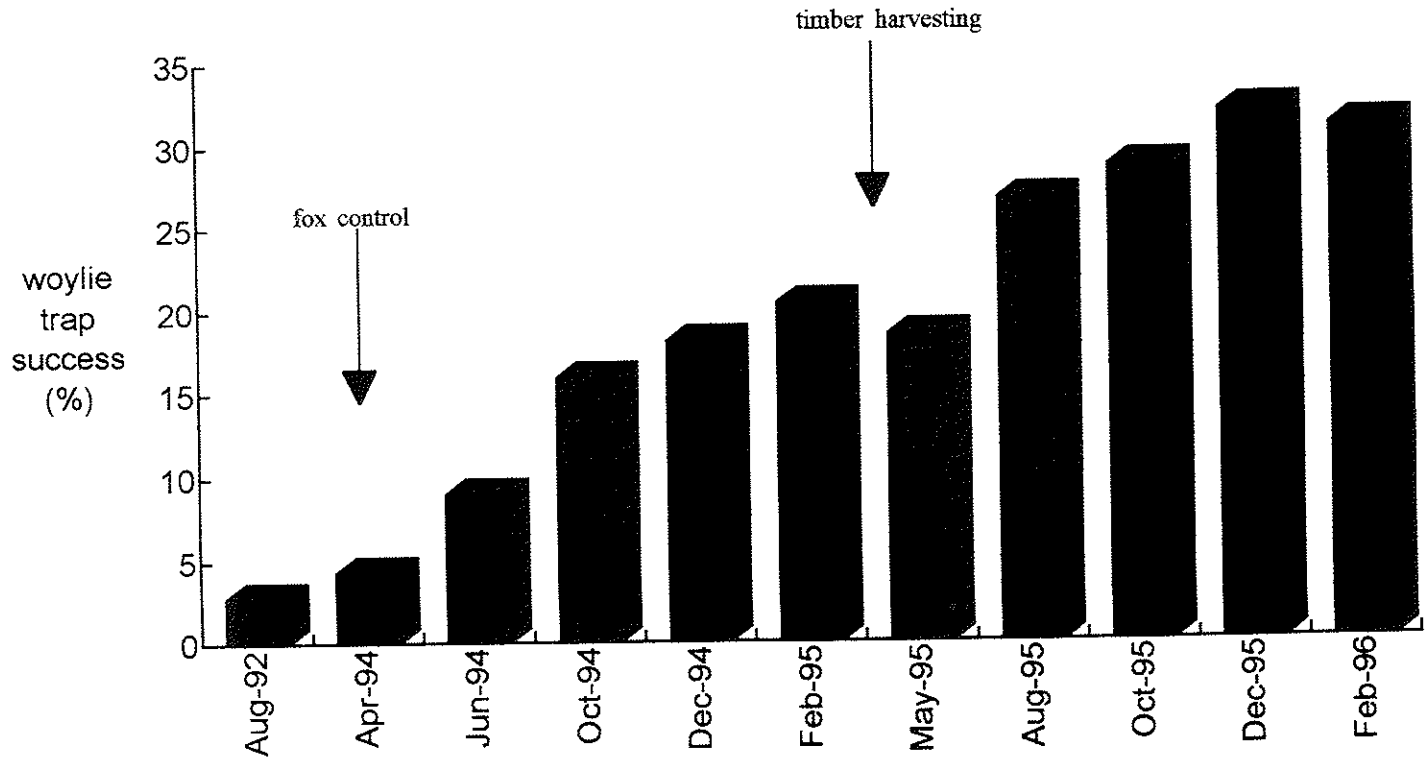
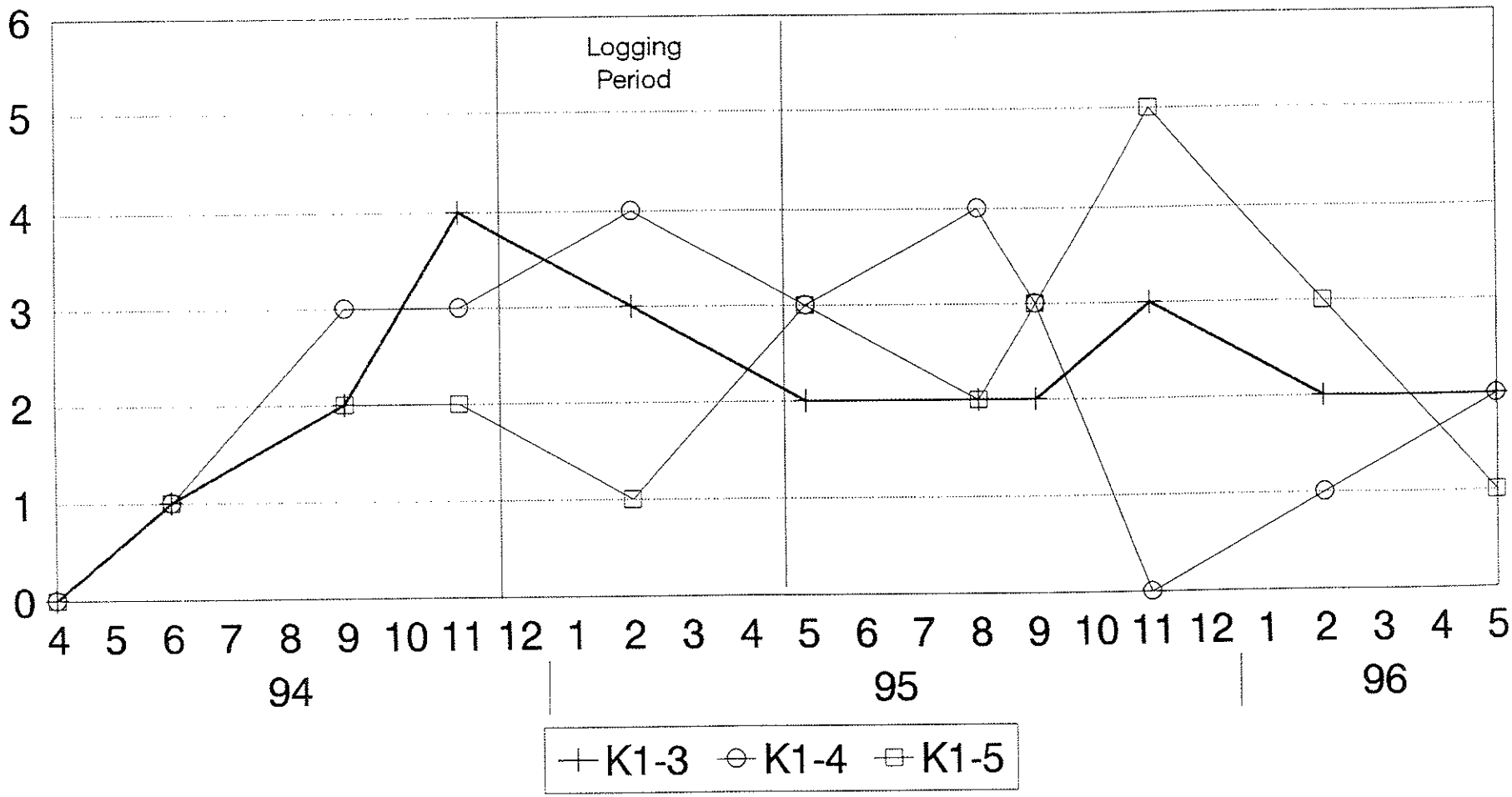


FIGURE 17.

QUENDA KTBA

K1-4/5 & K1-3(control)

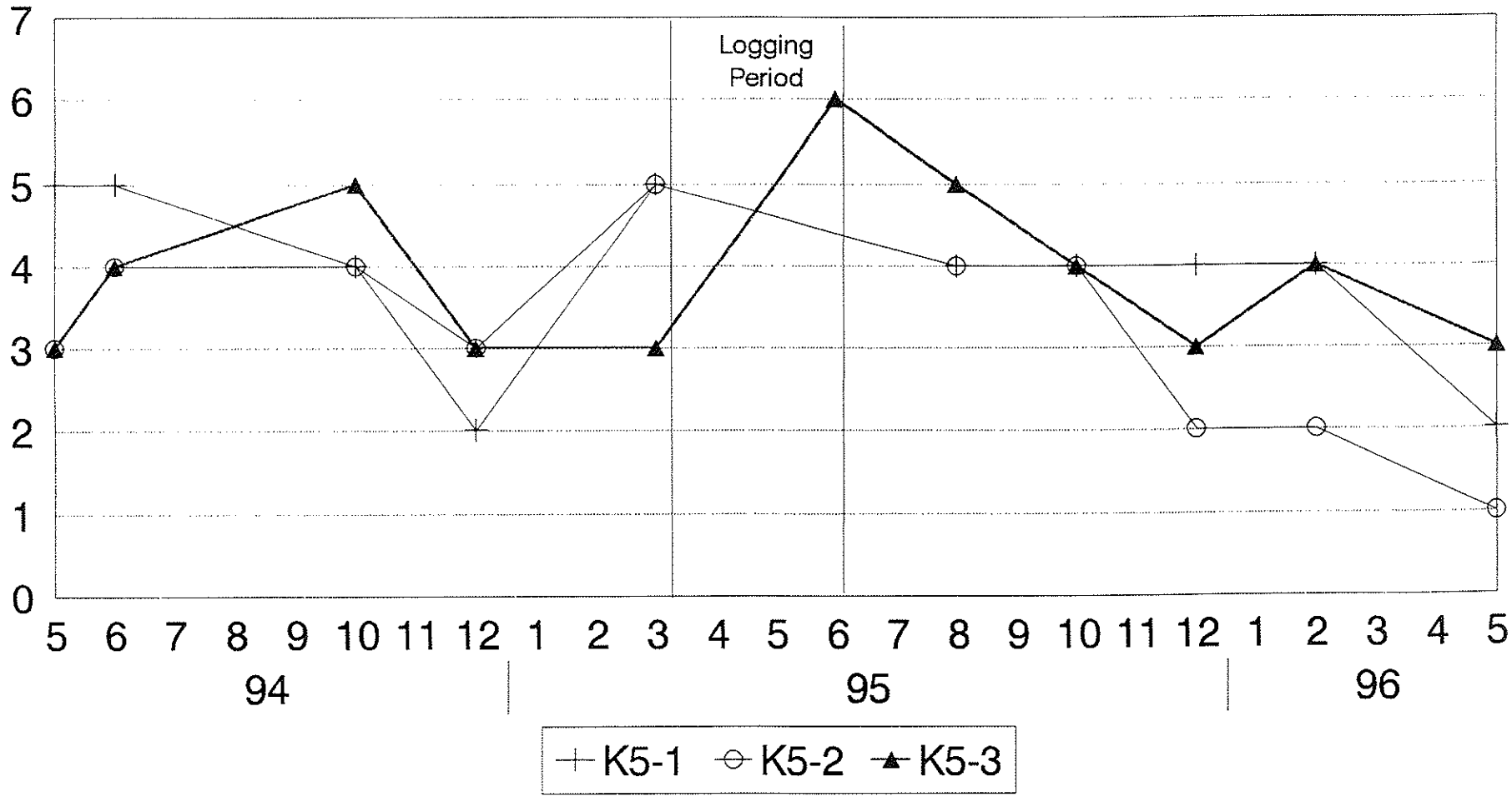


First 24 months of study

FIGURE 18.

QUENDA KTBA

K5-1/2/3

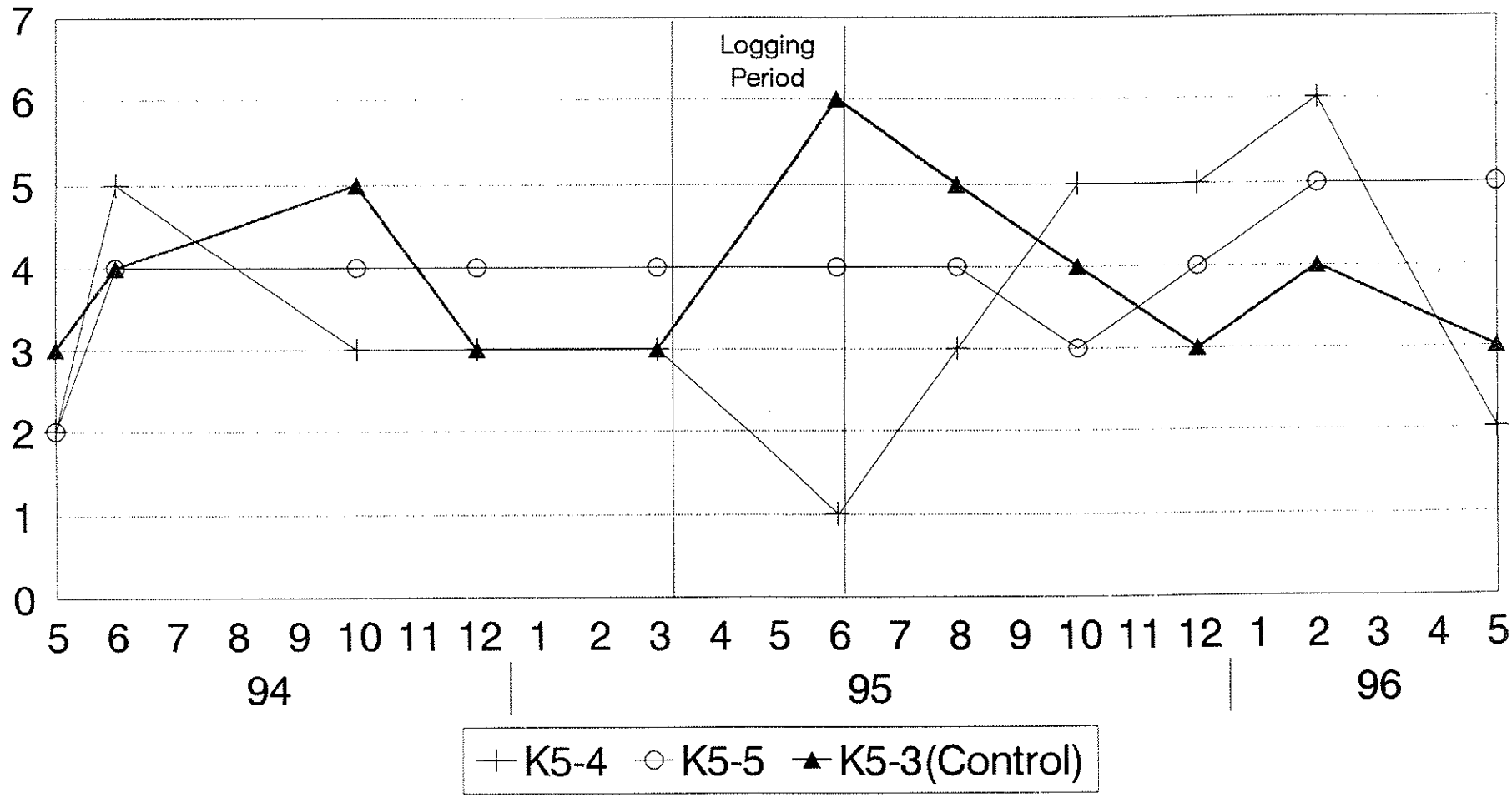


First 24 months of study

FIGURE 19.

QUENDA KTBA

K5-4/5/3

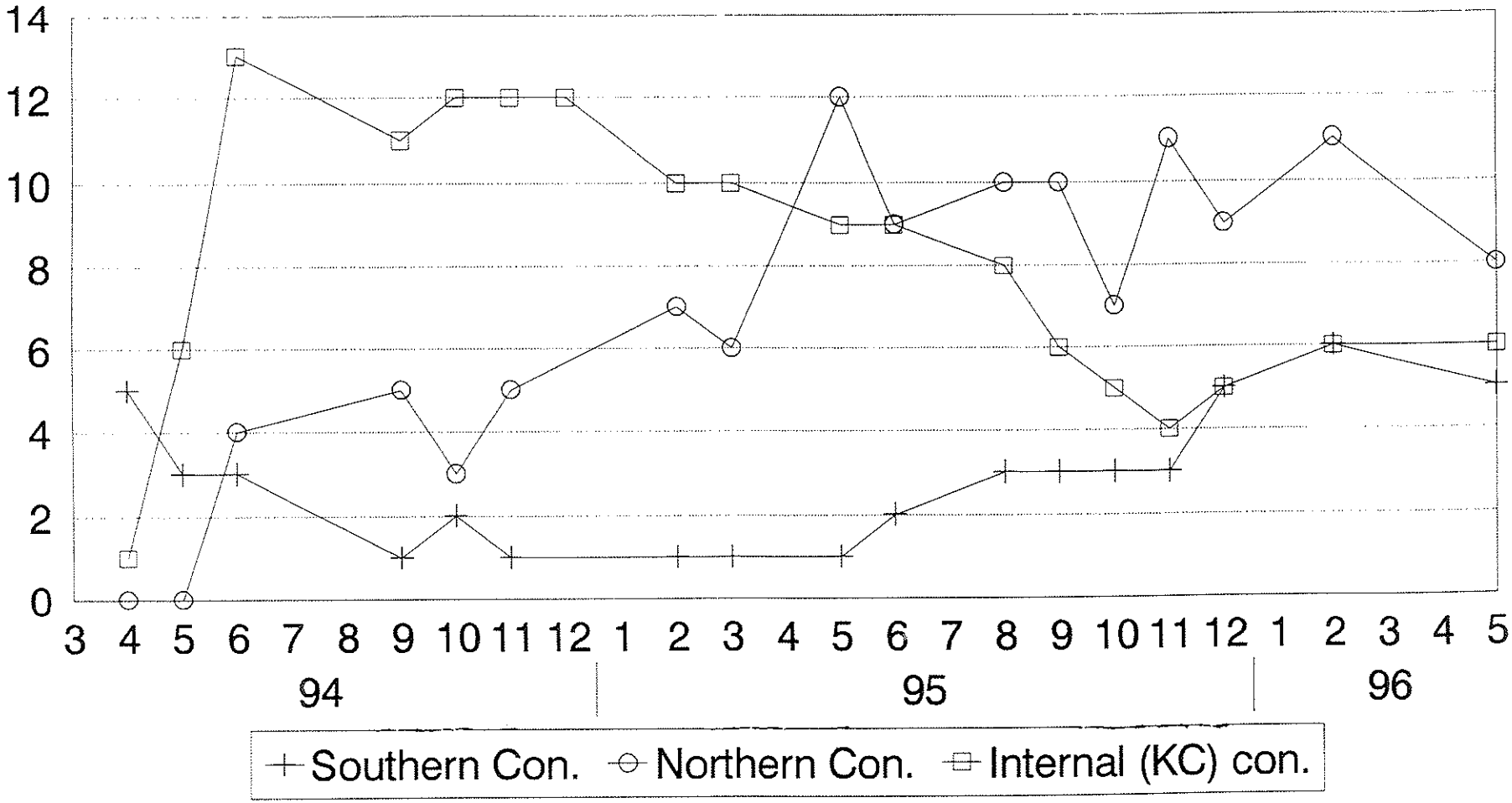


First 24 months of study

FIGURE 20.

QUENDA KTBA

INTERNAL AND EXTERNAL CONTROL GRIDS



First 24 months of study

FIGURE 21.

KINGSTON TIMBER HARVESTING STUDY - TRAP SUCCESS RATES FOR QUENDA ALONG ROAD TRANSECTS

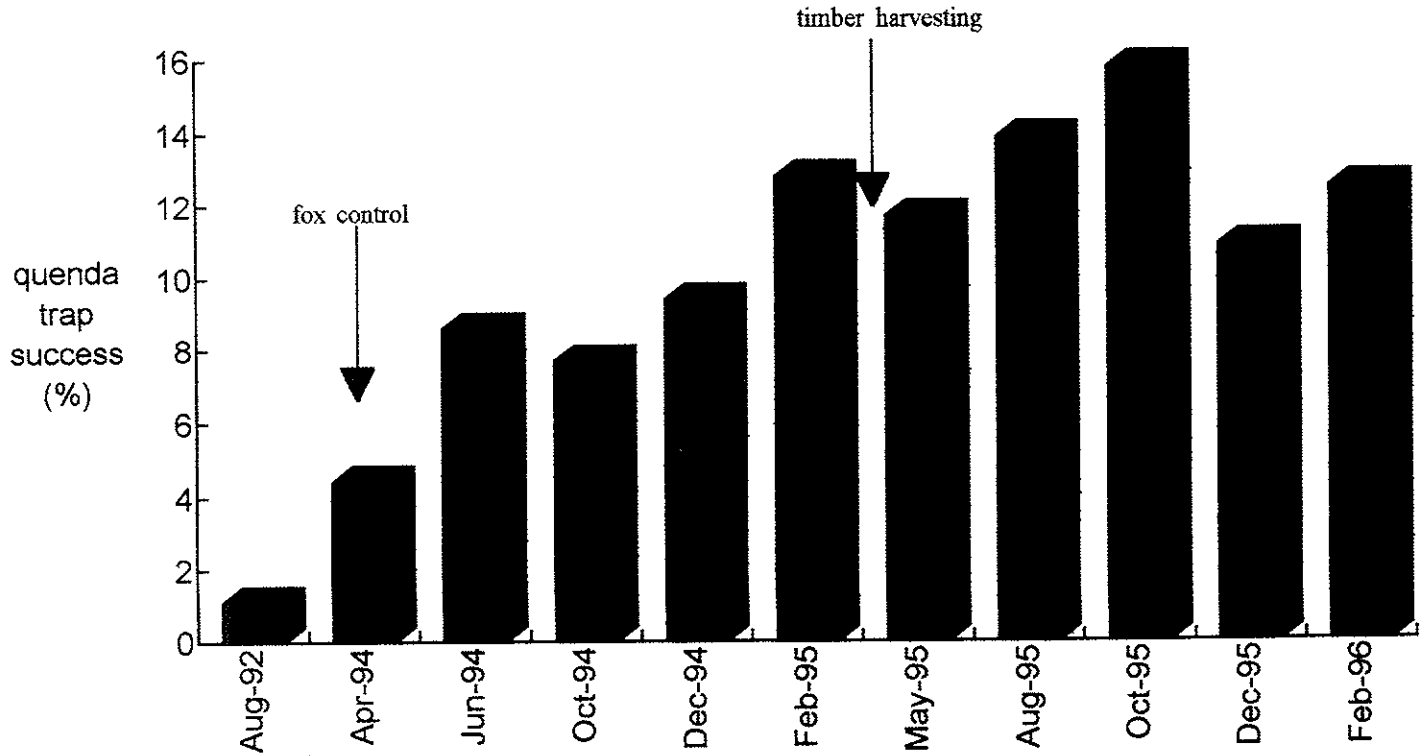
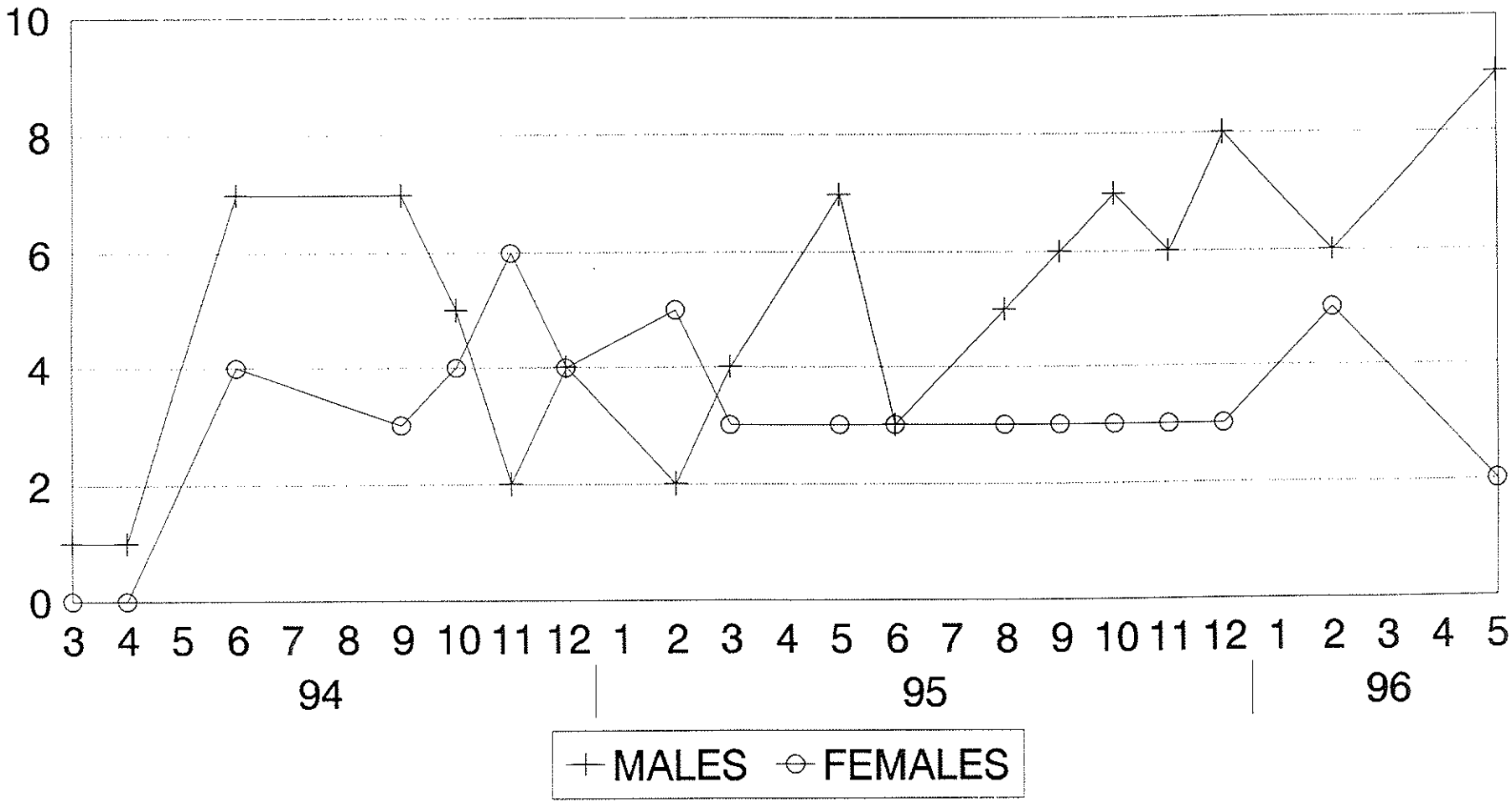


FIGURE 22.

CHUDITCH KTBA

ALL GRIDS AND ROADS



First 24 months of study(42 individuals)

FIGURE 23.

KINGSTON TIMBER HARVESTING STUDY - CHUDITCH TRAP SUCCESS RATES (%) FOR NORTH AND SOUTH ROAD TRANSECTS COMBINED

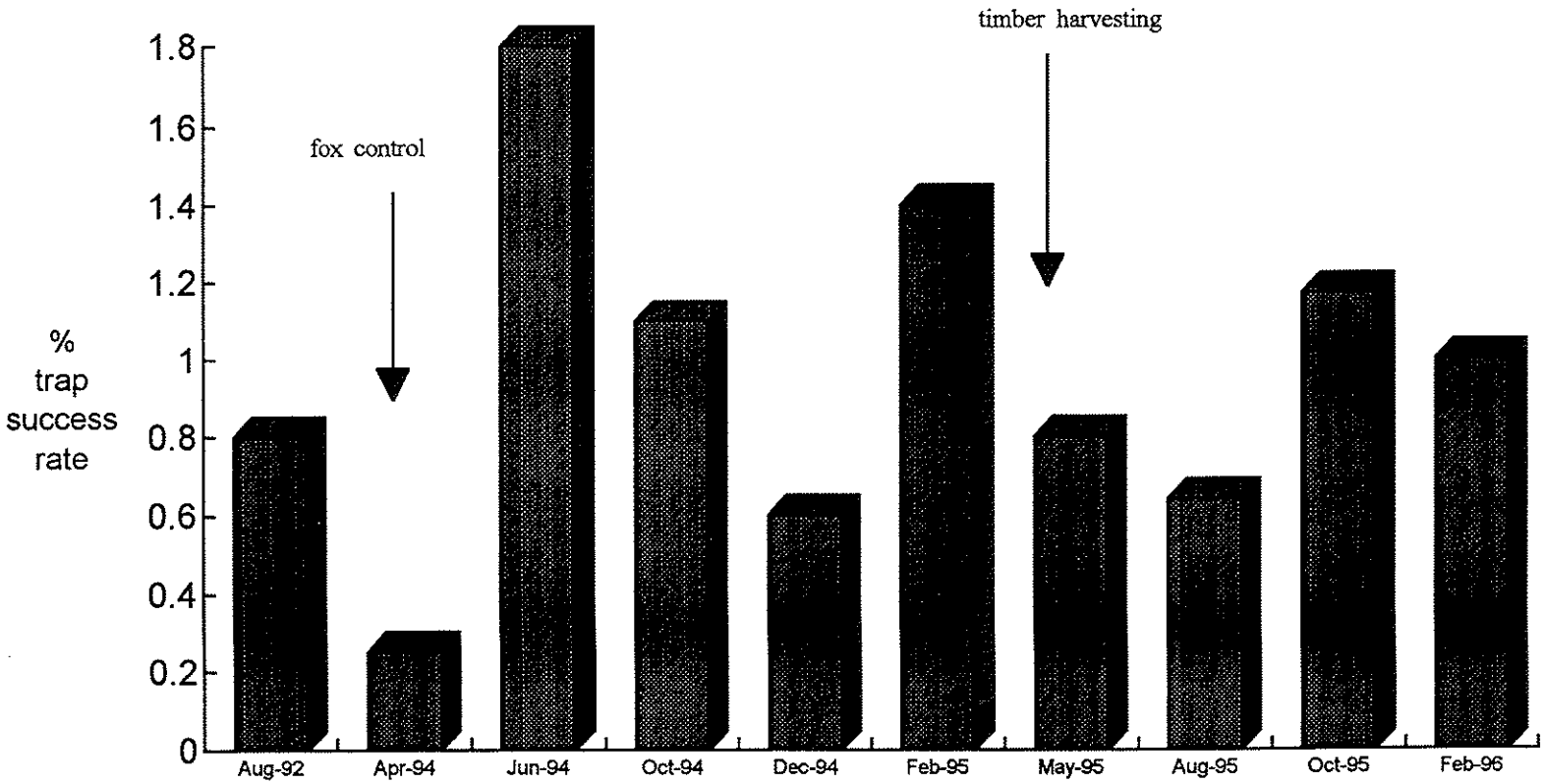


FIGURE 24.

KINGSTON TIMBER HARVESTING STUDY - TRAP SUCCESS RATES FOR ALL MEDIUM SIZED MAMMALS ALONG ROAD TRANSECTS

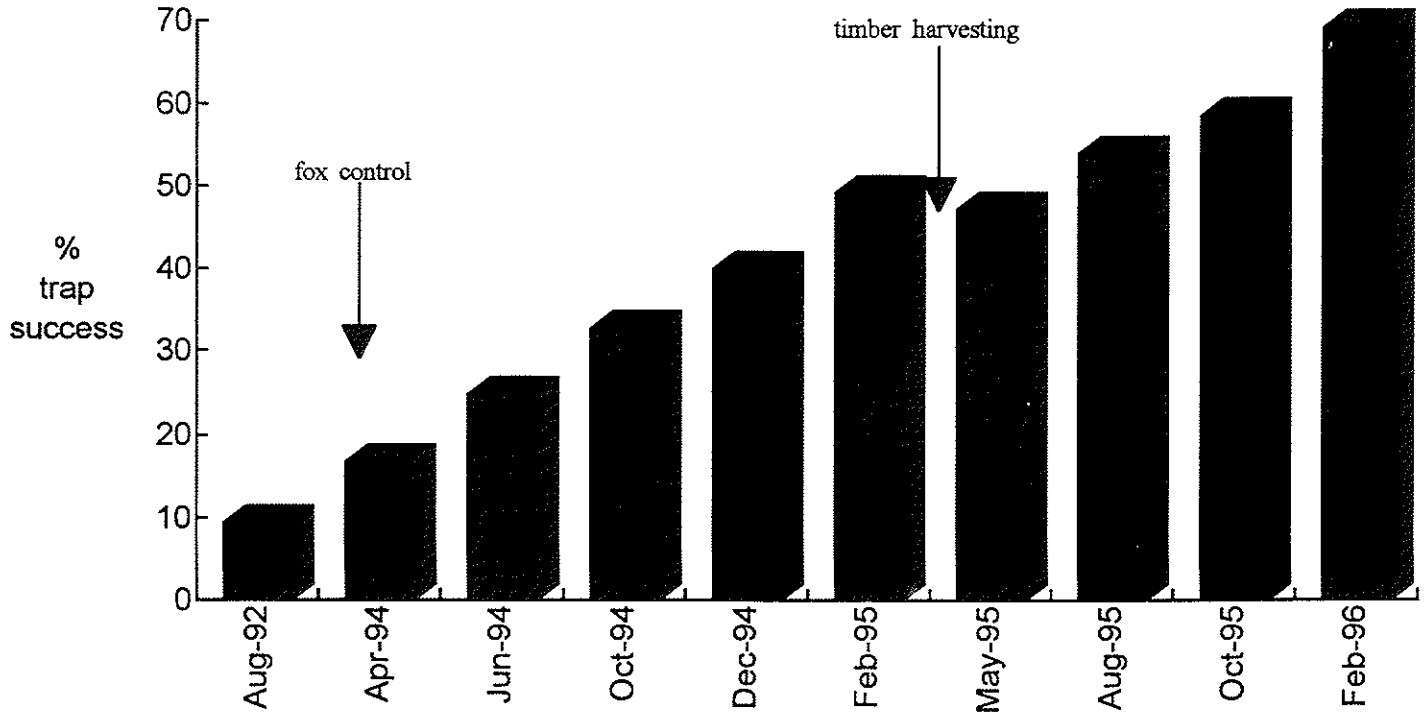
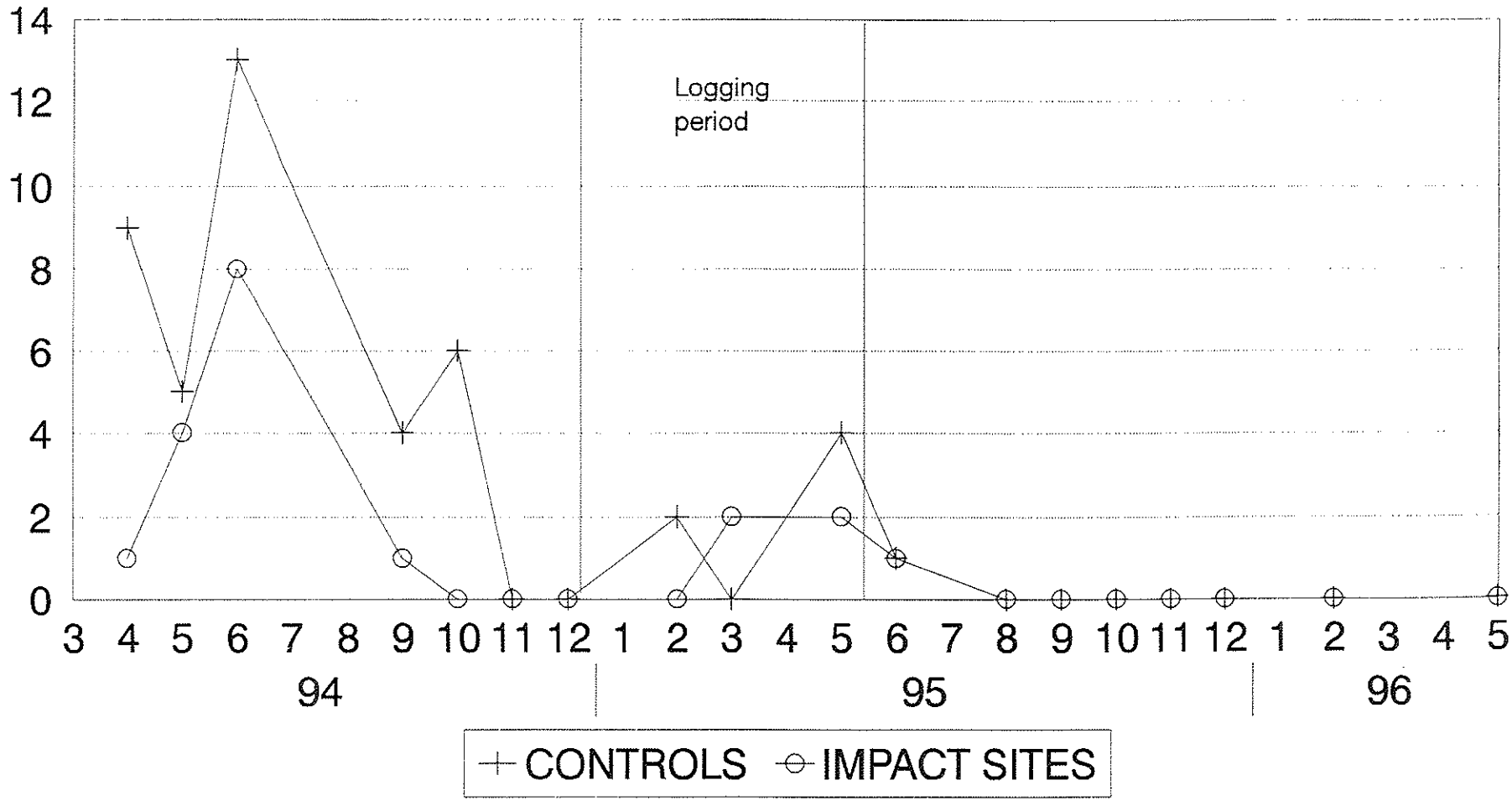


FIGURE 25.

PHASCOGALES KTBA

CONTROL & IMPACT GRIDS



First 24 months of study

FIGURE 26.