PNG/85/001
Field Document No. 4
December, 1989

PAPUA NEW GUINEA

Sepik River Fish Stock Enhancement Project
PNG/85/001

Preliminary report on population statistics and socio-economic data for the Sepik and Ramu River catchments

Compiled by

DAVID COATES
(Chief Technical Adviser)

and

BENOIT M. F. MYS
(Associate Professional Officer)

FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS
Rome, 1989

This report was prepared during the course of the project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

FORWARD

This work is based in part on the inputs of the late Benoit Mys, who was killed in an accident whilst endeavoring to improve on the content and scope of the main database upon which this report is founded. His name is kept as joint author in recognition of his memory and in tribute to the enthusiasm and ability he showed.

CONTENTS

1. INTRODUCTION

Phase One of the Sepik River Fish Stock Enhancement Project aims to address the potential for fish stocking of the Sepik and Ramu River systems. The aim of stocking is to improve the fishery resource available to be exploited by local people living within the river basins. Much attention has been given to biological and ecological aspects of both the native fish fauna and fish species considered appropriate for introduction. However, the purpose of stocking is to assist the people of the region. This report attempts to analyse certain socioeconomic aspects relevant to the project based on a consideration of the population distribution of people and related factors.

The ultimate goal was to combine our database, described below, with additional socioeconomic data collected by B. Mys, in particular relating to present fishing activities within the region. The unfortunate circumstances outlined in the forward to this report have necessitated that the existing database be analysed in its present form. It is hoped that the project will be able to account for certain of these discrepancies in the future. This report is, therefore, preliminary in nature.

2. METHODS - THE DATABASE

A database has been compiled using standard micro-computer software with the following contents and notes relevant to the interpretation of the results and any possible future analyses undertaken from the database (underlined titles refer to database field names). The "Rural Community Register" refers to the PNG National Statistical Office booklets for the Provincial Data System/Rural Community Register based on the PNG population census figures of 1980 - published at various times following that census:

Village - village name as per Rural Community Register Note - only villages occurring in the catchment basins of either the Sepik or Ramu Rivers are included. The database does not include villages occurring in any other river catchment including those villages considered to be "Sepik" or "Ramu" but which are in fact in the catchment of rivers draining directly to the coast.

Mapno. - Map number on which the village occurs based on the PNG Topographic Survey maps at 1:100,000 scale. These maps were drafted from aerial photographs taken in 1974. Certain villages do not occur on these maps or have moved and, if so, their location was estimated from sketch maps provided in the Rural Community Register.

Prov, Dist, Cend, Cenu, - Province, District, Census Division and Census Unit numbers for each village as per the Rural Community Register.

Alt - altitude of village in meters calculated from the topographic maps mentioned above.

Pop80 - population of the village as recorded in the 1980 census. Note the resident population is used (not total) - see Rural Community Register for explanation of this.

Pop90 - population for 1990 extrapolated from Pop80 allowing for growth increases as per Scenario B2S1 - SIN/SIN projection as per National Statistical Office published figures. This was averaged between the Provinces involved to be in the region of 2.3% per annum which over ten years was rounded to a 25% increase overall.

Vegmain - the main vegetation type occurring in the immediate vicinity of the village (vicinity means within 2 km of the village).

Vegsup1 - supplementary vegetation type in the vicinity of the village in cases where more than one vegetation type occurs.

Vegsup2 - supplementary vegetation type in the vicinity of the village in cases where more than two vegetation types occur.

Vegetation types are as per listed on the above mentioned topographic maps. The following types occurring in the catchments are, as stated on those maps:

FPF - floodplain forest
NIP - Nipa forest
TS - tree swamp
SWP - swampland
RF - rainforest
MF - medium forest
SG - secondary growth
PLT - plantation
SAV - Savanna
GRL - grassland
URB - urban

In very limited areas the maps list mangroves as occurring in the catchment. However, mangroves do not occur above the coastal regions at the river mouths. Inland "mangroves" were renamed floodplain forest in this database.

Road - distance to nearest road calculated from the topographic maps. A road was considered as having to lead into a network of other roads leading at least 20 km elsewhere. Tracks of limited length between villages are not included as roads. If the distance to a road was greater than 20 km the default value of 99 km applies which effectively means "no road"

Allweath - applies to whether the road (above) is all-weather or dry season use only. This is a logical database field. "True" means the road in question is all- weather, "false" means it is dry season only. Roads are labelled as such on the maps.

DLR, DMR, DSR, DLA - distance to nearest large river, medium river, small river and lake respectively. Distances are recorded from the topographic maps to the nearest km. 0 km = village is by, or within 0.5 km of the appropriate river or lake. Note - distances only recorded if less than 20 km. If greater than 20 km the default value of 99 km applies. These water bodies are defined as:

Large River - greater than about 75 m wide.

Medium River - between 10 and 75 m wide

Small River - less than 10 m wide but not including first or second order streams and creeks etc. which cover most areas of the maps in all regions with a noticeable gradient.

The above categories are subjective and it is difficult to estimate widths of smaller rivers from the maps.

Catchment - catchment in which the village is located. S = Sepik, R = Ramu.

3. APPLICABILITY AND LIMITATIONS OF THE DATA

All population figures used in this report refer to those extrapolated for 1990. A major point is only villages occurring directly in the catchments of the Sepik and Ramu Rivers are included. Data for vegetation and roads are based on maps produced in 1974. A certain degree of change is expected to have occurred, particularly due to human activity in densely populated regions. In addition, road networks might be considered to have improved since 1974. However, the latter limitations are not thought to have a great affect on the broad conclusions arising from this database that are presented here.

4. POPULATION DISTRIBUTION BY CATCHMENT AND PROVINCE

Table 1 summarises the data. The project has been unable to locate population figures for the very small area of catchment of the Sepik River located within Irian Jaya. However, according to the most recently available maps, this area is very sparsely populated.

A total of 785,320 people live within the catchments of the Sepik and Ramu Rivers. This does not include any of the villages occurring in coastal drainages. Of particular note also is the fact that nearly all major towns in the Provinces in question (except Kainantu - Eastern Highlands Province) are not located directly in the catchments. These include the much more densely populated Provincial centers of Vanimo, Aitape, Wewak, Madang and Lae on the coast and Goroka, Kundiawa and Mount Hagen in the highlands. These centers are situated close to the catchments and would provide a significant increase in people affected by fish stocking of the Sepik/Ramu if fish were to be transported outside the catchments to be sold. Such a factor also applies to most inland areas in coastal drainages along the northern coast of PNG and the areas adjacent to the rim of the catchments further inland.

For the purposes of following sections Sepik and Ramu catchments are combined.

5. POPULATION NUMBERS OF VILLAGES

5. 1 General

Mean size (population number) of villages in the basin is 273 ($\pm$ 331) people. Fig. 1 shows the distribution of the population into various size classes of villages. Villages are predominantly small. About 52.8% of people live in villages of less than 200 people, 69.4% in villages of less than 300 people and 81.3% in villages of less than 400 people. Less than 18% of people occur in villages (towns ?) which contain more than 1000 people; only 3% (92 of the 2878) villages/towns being larger than this.

5. 2 Affects of altitude

In general, mean village size increases with altitude (Fig. 2). Mean village size is significantly correlated with the altitudinal range as categorised in Fig. 2 ($r^2 = 0.48$, $p < 0.001$). Villages on or near floodplains (less than 100 m altitude) tend to have an average population of about 200 people whereas those in highlands regions (e.g. 1400 to 2400 m.a.s.l.) tend to have an average population of about 500 people. Further details of such distributions are given in Fig. 2.

Total populations occurring in these altitudinal zones are shown in Fig. 2. The following is a summary of the distribution based on broader altitudinal zones than given in Fig. 2:

Altitude range (m)	Number of people	Percentage population
0 - 100	155,976	19.7
101 - 500	190,948	24.3
501 - 1000	40,551	5.2
1001 - 1500	100,979	13.0
1501 - 2000	199,070	25.3
2001 - 2500	97,919	12.5
<500	346,924	44.2
501 - 1500	139,151	17.7
>1000	397,968	51.0
>1501	299,368	38.1

Of particular note in the above data are the following:

(i) no people live above 2,500 m.a.s.l. However, the Sepik/Ramu basin extends to 4508 m.a.s.l.;

(ii) large populations occur in the region 0 to 100 m.a.s.l. which corresponds to in or near floodplain regions;

(iii) foothills at 101 to 500 m.a.s.l. are also well populated;

(iv) few people inhabit the region between 500 and 1000 m.a.s.l.; and

(v) the highlands regions above 1000 m.a.s.l. support the majority of the population.

Statistical treatment of the data is hindered because, obviously, the altitudinal zones listed need to be expressed in terms of area available to be inhabited. Unfortunately, accurate data on the areas these altitudinal ranges encompass are lacking. However, some provisional figures for five altitudinal zones were presented by Coates (1989) based on a catchment area for both rivers estimated at 148,844 km^2. Population figures based on the rough approximations of Coates (1989) are as follows:

Altitude (m)	Area (km^2)	Population	Population density (people km^{-2})
0 - 120	14,884	179,711	12.1
121 - 300	44,643	105,799	2.4
301 - 1500	55,072	200,390	3.7
1501 - 3000	28,280	299,341	10.6
>3000	5,953	0	0.0

Based on these figures, highlands regions (above 1501 m) are densely populated by PNG standards. However, Sepik/Ramu lowlands (<120 m) are more densely populated. This contradicts the commonly held view that PNG highlands are the most densely populated regions, although a consideration of more narrow altitudinal zones within the highlands belt may give higher estimates of population density. Regions between 121 and 1500 m are sparsely populated.

5. 3 Discussion

The reasons for the population distributions are no doubt complex. Accurate analysis of these factors cannot be made without further data on the activities undertaken by people living within these areas which are not presently available. However, in terms of relevance to fisheries and agriculture the following broad generalisations can be made:

(i) Sepik/Ramu villages are small and there is a general tendency not to live in social units (villages) greater than 400. This, perhaps, is because of the existing subsistence nature of livelihood of the majority of the population. Under a subsistence lifestyle social units would need to be small in order to allow sufficient space for hunting, fishing and food gathering activities etc.;

(ii) floodplain regions are known to have the highest abundance of fish stocks and support the highest density of population within the whole catchment, although villages remain small, generally less than 200 people each on average. Again, this predominantly subsistence activity may greatly influence village size in this region. Potential for cultivation is generally limited below 120 m because much of the area in question is subject to seasonal inundation;

(iii) subsistence farming/agriculture is known to be the predominant activity in highlands regions. This, perhaps more productive and co-operative activity, may account for the increase in mean village size with altitude. There are negligible fish stocks above 1000 m (Van Zwieten 1989) and fish distributions, therefore, cannot have a significant bearing on the distributions of populations in this region;

(iv) although subsistence farming/agriculture is the predominant highlands activity, above 2200 m frosts may occur and are common above 2500 m (Coates 1989). This, undoubtedly, is a major factor limiting human inhabitation of areas above this altitude due to crop damage occurring;

(v) the region between 121 to 1500 m is perhaps the most interesting with the lowest density of population. In particular, very low numbers of people occur in the region between 500 and 1000 m. Amongst the factors that might help to explain this are the following:

(a) severe malarial strains, amongst these being cerebral malaria, are known to occur primarily within this belt. During fieldwork within the Sepik/Ramu, project staff have often noted entire villages have moved out of this region to higher or lower ground, the specific reason reported as being to avoid severe malaria; and,

(b) this region is generally steep and densely forested, making subsistence food gathering or agriculture difficult and fish stocks are limited, in lower sections, or negligible towards the upper limit of this zone.

Based on the above factors, it is hardly surprising that this region is less densely populated and people probably either prefer higher ground, offering better land for farming, or lowlands where better fishing is available together with a greater availability of carbohydrate in the subsistence diet, particularly sago.

Figures for mortality within the various altitudinal zones have not been calculated but this factor may be relevant to the distribution as witnessed by arguments relating to the affects of malaria in the zone 500 to 1000 m. The absence of malaria in the highlands is often used as one argument for higher population densities there, in addition to the availability of cultivable land. However, the lack of cultivable land and predominance of malaria (except cerebral malaria) in floodplain regions at lower altitudes contradicts this argument since these regions are the most densely populated.

Further reference to the population distributions in the Sepik/Ramu outlined here are made later when their relevance to fisheries development and stocking options are highlighted in the Discussion in this report. In effect, the data presented here, together with other factors outlined below, and a knowledge of fish distributions, indicate which altitudinal zones are the priorities for stocking in terms of where people are living.

6. POPULATION DISTRIBUTIONS RELATED TO WATER TEMPERATURES

The relationship between populations of people and water temperatures, although perhaps not directly related themselves, are highly relevant to fish stocking. Population densities and distributions vary throughout the catchments as do water temperatures. Water temperature itself is a major consideration when choosing a species of fish suitable for stocking any particular region.

Data on water temperatures within the catchment were provided by Coates et al. (1989). Water temperatures vary somewhat according to local conditions of the particular water body but there is a significant negative correlation with altitude.

Table 2 summarises data on water temperatures and population distributions. These data are referred to in other reports dealing with areas of priority for stocking and species suitable for stocking them. Some interesting points arise. Some 56% of the population occur in regions where water temperatures are equal to or less than an approximate mean of 21.0 ^{o}C. About 38% live in regions where water temperatures are equal to or less than about 17.0 ^{o}C and about 13% with temperatures of nearby waters less than 14.0 ^{o}C. These figures support the conclusions of the project, outlined in other reports, relating to the importance of fish stock enhancement in cooler waters at higher altitudes.

It is also worthy of note that less than 1.0% of the population live near waters of less than about 11.0 ^{o}C. It is known that trout prefer cooler waters, although the temperature requirements of trout stocks presently used for stocking PNG highlands have not been quantified. The data in Table 2 certainly endorse the conclusion of Coates (1989a) relating to trout stocking in that trout stocks, or a different species, adapted to warmer waters would be more beneficial. In addition, were a species (or stock) to be found that would utilise waters less than 11.0 °C it would presumably be very lightly fished. However, were such a stock to also extend its range into lower altitudes (warmer waters) this would have the considerable advantage of maintaining a breeding stock in lightly fished areas thus enabling re-population of any regions at lower altitudes that might be overfished or destroyed by local fishing practices (e.g. using derris root). A similar argument applies to any species or stock occupying waters of about 21.0 °C but the range of which extends beyond this since that region is also lightly populated and stocks would be under less fishing pressure.

Data on water temperatures and population distributions, apart from indicating types of fishes suitable for specific regions, also illustrate the usefulness of stocks with wide temperature tolerances at mid- to high altitude ranges.

7. VEGETATION TYPES

Vegetation types refer to those existing in 1974. There has been a minimal increase in urbanisation since that date (data below refers). An increase in deforestation due to logging might be expected since 1974 but this is thought to be minor within the Sepik/Ramu at present. Vegetation types also refer only to those types occurring in the vicinity of villages. However, this is probably representative of the area surrounding villages more generally but this aspect is covered in more detail later.

7. 1 Vegetation types occurring

Table 3 summarises the data on the numbers of villages, total numbers of people and percentage of total population living near or within the various vegetation types. The vegetation types can be grouped as follows:

7. 1. 1 Floodplain forest, tree-swamp and swamp

77,306 people live in this ecotype (9.8 % of the total population)

7. 1. 2. Nipa

No people live in the immediate vicinity of Nipa palms.

Nipa stands do, however, occur more frequently as supplementary vegetation types 1 and 2 suggesting the plant does occur further from villages. The same situation probably exists for the sago palm, Metroxylum spp, which is perhaps utilised more extensively. This situation may be because either these palms are used extensively by villagers and, therefore, eradicated near villages, or they grow in areas unsuitable for constructing villages since both palms grow in dense and swampy stands. It is likely that such types of vegetation would be included under the general ecotypes "floodplain forest", "tree swamp" and "swamp". Unfortunately, vegetation types listed on maps are not specific enough to elaborate further.

7. 1. 3 Rainforest, medium forest and secondary growth

403,256 people (51.5% of the total population) live in areas with such types of forest cover.

7. 1. 4 Savanna and grassland

285,072 people (36.4% of the total population) live on grasslands or Savanna. The distinction between these two vegetation types is not clear from the maps available. Coates (1989) noted the absence of "Savanna" from the Sepik/Ramu basins based on the vegetation classifications used by other workers. The problem here appears to be one of definitions and differences in the sources of data. To some extent, for present purposes, Savanna and grassland might be considered equivalent vegetation types.

7. 1. 5 Plantation and urban

These two categories are important because they indicate activities perhaps related more to commercial/urban undertakings. Only 0.7% of the population live on plantations. Based on this figure plantation income can be disregarded as an alternative activity to subsistence level livelihood for the majority people in the basin. Since 1974, plantations have probably increased due to increased attention to primary production, particularly to coffee, tea and other crops. However, this increase is considered minimal in terms of the whole of the basin. Particularly in the highlands regions, coffee plantations occur mainly in areas outside of the Sepik/Ramu catchment due to the better infrastructure of roads there. As of 1974, all Sepik/Ramu plantations occurred only in the Western or Eastern Highlands Provinces and only at an altitude of between 1365 and 1900 m.

Only 1.6 % of people live in an urban environment. Even a great increase in urbanisation since 1974 would still result in the vast majority of people living in rural environments. The population figures produced from data obtained in 1980 also support the view that an increase in urbanisation has been minimal within the basins. There are only five urban centers in the entire Sepik/Ramu catchments:

Town	Altitude	Number of people
Angoram	50	2288
Maprik	220	1414
Aiyura	1609	2106
Kainantu	1620	4761
Wabag	2082	1898

7. 2 Vegetation types and altitude

There is obviously a close relationship between vegetation type and altitude. Coates (1989) has summarised the vegetation types occurring at different altitudes in the Sepik/Ramu basin. The relationships between numbers of people and surrounding vegetation type at different altitudes are summarised in Fig. 3 to which the following comments refer.

Floodplain forest, tree swamp and swamp occurs as a vegetation type within the vicinity of villages only at altitudes of less than 200 m. Such lowlands are obviously the main areas subject to flooding. Flooded land in the vicinity of villages is absent above 200 m. The main reason for this is, of course, that areas away from the floodplain belt have a much greater gradient and swamps do not generally form. It is also obvious that villages at higher altitudes would not be built on swamps of any kind if better land were available, which it is. Despite this, there is little doubt that swamps are negligible above 200 m although limited areas in highlands valleys are known to be inundated with water at certain times. The major point is that habitats above 200 m consist of rivers/streams with either dense forest cover or in areas of savanna/grassland, not swamps.

Savanna/grassland as a vegetation type surrounding populations of people predominates in regions from 1400 to 2500 m, the limit of habitation. However, approximately half of the people living within this region still inhabit environments predominantly forest covered. A large amount of grassland elsewhere is evident only in Sepik/Ramu lowlands at between 101 to 200 m elevation. These are mainly the grass plains along the Ramu valley and the Sepik plains encountered along the Toricelli/Bewani foothills. It is highly likely that "grasslands" below 100 m listed on the maps are in fact flooded grasslands and part of the river floodplain belt.

People living in foothills above the floodplain (>100m) to the lower highlands (>1400m) live almost exclusively in areas of forest cover. Areas of forest along the fringe of the floodplain (e.g. less than about 125 m elevation) may also be seasonally inundated with floodplain waters.

7. 3 Relationships between people and vegetation

Population densities in various types of vegetation are difficult to estimate accurately due to a lack of data on total areas of the various types of vegetation. Coates (1989) made some approximations of the areas of various vegetation types within the Sepik/Ramu basin. However, the data sources used in that report and the present one differ and vegetation types are not directly comparable. A rough approximation based on the two data sources is summarised in Table 4. Population densities in vegetation types occurring in Sepik/Ramu lowlands appear slightly higher but similar to those in vegetation types occurring in highlands regions. This observation agrees with that made previously in relation to population densities calculated by altitude alone. Again, the very low population densities in mid-altitude forest regions is evident.

The degree to which vegetation type and land area limit population size amongst the data is not known. Population densities appear to be similar in Sepik/Ramu highlands and lowlands, perhaps marginally higher in the latter. Low population densities in mid-altitudes also support the view that such regions are difficult to inhabit for the reasons already stated above; i.e., possibly these regions offer few fish resources whilst not offering the benefits of easier cultivation of higher land.

There has been insufficient time to analyse the possible effects of people on vegetation types. It is widely thought that highlands grasslands and Savanna have been produced by long-term intensive human activity via repeated burning of primordial forest. Extensive forest cover still exists within highlands regions at equivalent altitudes, and above, to areas where the populations centered around existing savanna/grasslands occur. However, it is interesting to note that the data suggest that mean village size does not increase in areas where savanna/grassland occurs - as might be expected if such activity was to create larger areas for cultivation and, hence, increase food availability. A preliminary analysis of the data suggests that mean village sizes in the various vegetation types do not differ significantly from the expected mean based on altitude alone (Fig. 4). For example, Savanna/grassland does not support larger villages than rainforest/medium forest in the regions of equivalent altitude. It is tempting to speculate that the large scale destruction of forest for subsistence purposes does not result in increased benefits of food availability, if food availability limits village size. It is possible that other reasons account for the occurrence of grasslands in highlands regions, amongst these being the likelihood that highlands forest is probably much more vulnerable to subsistence gardening activities than forest in lowlands regions, or it is destroyed for little logical reason. It is also apparent that different tribes within the catchment have different traditional approaches to subsistence agriculture and the degree to which they slash and burn forest and/or leave areas alone for forest recovery. Alternatively, factors other than human activity may account for the occurrence of savanna/grasslands in highlands regions.

The effect of human activity on vegetation types, apart from being interesting itself, is also relevant to fisheries. Modification of forest environments, creating in particular gardens, areas for agriculture and savanna/grasslands, will greatly influence riverine habitats in terms of reduction in forest cover, allochthonous food inputs and increased siltation due to increased soil erosion. At present, it is not possible to calculate the effect of such activities on future habitat availability for fishes and the project has to consider the situation based on knowledge of the existing situation.

8. ROADS

Presently, only allweather roads are considered, i.e. those normally passable during both the wet and dry seasons. Distances to roads have been calculated here in terms of numbers of people living within 2.0, 5.0, 10.0 km of an allweather road and those people living further than 10 km from such a road; mean distance to road cannot be calculated since distances greater than 20 km were entered as the default value of 99 km.

In general, access to roads is reasonably good (Table 5). Almost 50% of the population live within 2.0 km of an allweather road, 57.7% within 5.0 km and 65.6% within 10.0 km. However, 270,144 people (34.4%) do not have access to a road within 10.0 km. Mean distance to roads in the latter category is probably much higher than this since this group includes all people living in remote areas long distances from roads.

The distribution of access to roads by altitudinal categories is shown in Fig. 5. Access to roads is particularly good between altitudes of 1400 and 2200 m. However, access to roads at mid-altitudes, 300 to 1300, is much reduced. Access to roads is poor at altitudes below 300 m, particularly so below 100 m where more than 80 % of people do not have access to a road within 10 km.

To some extent, the distribution of roads reflects the difficulty of construction of roads at low altitudes, mainly floodplain regions where they are almost impossible to build, and at mid-altitudes where the terrain is step and unstable. Good road networks in the highlands probably arise through better geological conditions, land is more stable and, often, more level along highland valleys. In addition, more attention to road networks in the highlands has probably been given because these are the main areas of primary production, particularly coffee, and road networks are more feasible to construct on economic grounds.

It is obvious that roads are constructed to give access to villages. This accounts for the close proximity of many villages to roads. However, it is also believed that villages move to within the vicinity of roads in order to derive benefits that road access can provide. This probably accounts for the limited differences in percentages of people living within 2.0, 5.0, and 10.0 km of a road.

Table 5 suggests that villages have a larger mean population size if they are closer to roads. However, mean village size correlates with altitude and road networks are better at higher altitudes. Fig. 6 plots mean village size at different altitudes for people living within 2.0 km of a road or more than 10.0 km from a road. The data show that in the proximity of a road, mean population size of villages increases slightly. When altitude is taken into account in this fashion, villages are significantly larger when within 2.0 km of a road, compared with either the mean village population expected at that altitude or the mean population of villages greater than 10 km from a road at the same altitude. The explanation of this is that either roads are constructed to the larger villages or, more likely, the proximity of roads increases mean village size. This relationship is one reason promoting larger villages in the highlands since highlands areas have more roads. However, altitude alone still affects mean populations of villages since the mean population number of villages greater than 10 km from a road is still significantly correlated with altitude ($r = 0.68$, $P < 0.001$). The relationship between access to roads and village size is no doubt due to a multitude of complicated factors.

Roads no doubt, in theory, bring increased benefits in terms of cash earning opportunities by means of increased potential for the sale of primary products, access to employment, schools, health services etc. However, the data suggest that if such benefits do not apply to all people living near a road, or moving to a road, problems may occur because roads promote village sizes larger than is the norm for any particular altitude. Such increased village size may increase pressure on the local environment above that occurring in areas where no roads exist, i.e. above the "natural" level since roads have only recently appeared. If the majority of the population in most areas are still living a subsistence way of life, it is possible that roads may increase population pressure in areas resulting in greater hardship through less food production per person. Of course, the availability of roads does give people increased opportunity to do things other than subsistence activities. Data presented later, however, suggest that, at present, such opportunities are limited. Access to other socio-economic data relating to roads is necessary to evaluate these factors further. The point is, however, that the availability of roads does not necessarily mean that people need less subsistence food, because they have alternative sources of income and food. On the contrary, if roads increase village size and people do not derive increased food supply via road access, then villages near roads, perhaps, need even greater assistance in terms of subsistence food production due to increased population pressure. The latter applies, in theory, at least until the benefits of socio-economic developments associated with roads outweigh the increased pressure on the environment that their construction causes. The importance of this factor is reliant upon the degree of socio-economic development within the region which is discussed further below.

9. WATER RESOURCES: RIVERS AND LAKES

There is obviously a close relationship between the type of river, large, medium or small, and altitude within the catchment. As the catchment is ascended, rivers get smaller. Such a factor is overwhelmingly evident in the data. However, the number of people living near the various categories of river, or a lake, within the catchment is highly relevant because it indicates the proximity, size and type of water resource the population has access to in order to fish.

9. 1 Special note on the database for floodplains (altitude <100 m)

A significant number of villages in floodplain regions (<100 m elevation) do not occur within a reasonable distance, e.g. 2.0 km, of any river or lake category. However, such villages are, in the main, considered to be on "floodplain" and have access to floodplain water resources such as swamps, flooded forest etc., but such resources are not defined under the present database categories, i.e. river or lake. For this reason people living at altitudes equal to or below 100 m are excluded from certain of the following analyses.

For present purposes it is considered that approaching 100% of people living below 100 m altitude occur within 1.0 km of, and more generally live adjacent to (i.e. 0 km), water resources of one kind or another.

9. 2 Numbers of people with limited access to rivers or lakes

Only 29,060 people (i.e. 4.6%) living above 100 m do not live within 5.0 km of either a river, any category, or a lake. Only 99,467 people (15.8%) do not have a river, any category, or lake within 2.0 km and 194,870 people (30.1%) do not have such water resources within 1.0 km. These data, conversely, show that about 70% of people live in the immediate vicinity of a river or lake, i.e. within 1.0 km - most would be living adjacent to the water body, i.e. 0 km. Similarly, about 84% live within 2.0 km and over 95% live within 5.0 km of such water bodies.

The database only records rivers down to "small rivers" which are approximately less than 10 m wide but this category does not include rivers smaller than about 2.0 to 3.0 m wide. The classification of rivers was highly subjective since it is difficult to measure the width of small rivers from the maps used. Within the database, people not living within a defined distance from any river in fact do. They live near smaller rivers - including first, second, third and perhaps fourth order streams, depending on the location. Project personnel have never seen a village in PNG that is not within 0.5 km, at the most, of a stream/river/creek of some sort.

9. 3. Distribution of lakes and classes of rivers

As outlined above, there is a close relationship between altitude and class of river (Table 6). People with access to large rivers predominate in lowlands, in terms of percentage of the population living at that altitude. People living near medium rivers are fairly evenly dispersed throughout the altitudinal ranges and those living near small rivers predominate at higher altitudes (Table 6).

The distribution of people living near lakes (Table 6) reflects the distribution of lakes themselves. Lakes predominate at altitudes below 100 m and these are, in fact, floodplain lakes, i.e. ox-bow lakes or shallow depression lakes along the Sepik and Ramu meander belts. Few people living above 100 m live near a lake. This fact is obvious, of course, when consideration is given to the geology and topography of the catchment (Coates 1989). It is, however, important because it indicates that fisheries and potential fisheries within the basin are river fisheries. Lake fisheries are, and will be, negligible outside of floodplain regions.

9. 4 Numbers of people living near lakes, or categories of rivers, related to altitude

Table 6 gives a summary of the numbers of people with access to the various types of water body at different altitudinal zones. The effects of altitude on the availability of categories of water bodies are self-evident and have already been discussed.

9. 5 Mean population numbers of villages

The full analysis of relationships between mean village size and water body is difficult to undertake because of a multitude of factors, especially river categories and mean population of villages both relating to altitude. However, a preliminary analysis suggests that within altitudinal zones there are differences in mean village size between the categories of water body to which they are adjacent (Table 7).

For present purposes floodplains (less than 100 m) should be discounted because this particular region is somewhat amorphous in terms of water body types and "lakes" are floodplain associated types. The similarity in mean village sizes between the various types of water body in this region supports this conclusion (Table 7). However, villages near lakes are consistently smaller than those near medium or small rivers at all altitudinal zones above 100 m. In such regions, lakes tend to be glacial and occur in areas of steep and densely forested terrain. This environmental factor may limit village size near lakes (c.f. village sizes in similar terrain on lower montane slopes). However, it is also likely that non-floodplain lakes contain reduced fish stocks compared with rivers at the same altitude. Villages near large rivers appear to be smaller than those near medium or small rivers at altitudes above 100 m; the exception to this is the zone 1501 to 2000 m where village size for large rivers is based on only five observations and these are abnormally large villages, or towns, by Sepik/Ramu standards. Villages near small rivers are smaller than villages near medium rivers above 1500 m elevation.

There is, no doubt, a multitude of reasons why such relationships exist. Fish as a causative factor can certainly be excluded above altitudes of about 1000 m because negligible fish stocks exist there. Such data are, however, relevant to fisheries because village size and adjacent water body type relate to fishing pressure on those water bodies. It is particularly relevant that mean village size is lower near small rivers, as opposed to medium rivers, in highlands regions. It might be expected that fish production from rivers would relate to river size. Small rivers, therefore, might be considered less important. However, the data suggest that population distributions might, to some extent, compensate for this because small rivers have smaller villages and, hence, in theory, will exert less fishing pressure. In addition, a much larger total area for potential fish production probably exists with small rivers because such are much more numerous. In any event, the potential usefulness of small rivers for fish production should not be under-estimated.

10. OTHER SOCIO-ECONOMIC DATA

10. 1 Economic activities

A summary of economic data for the population of PNG is provided in the 1980 population census publications and some relevant data are summarised in Tables 8 and 9. Unfortunately the data summarised in that census are not directly comparable to the data presented in this report. In particular, the Sepik/Ramu database applies only to populations living within the Sepik/Ramu catchment. The census data apply to Provinces and include coastal areas and many areas outside of the Sepik/Ramu. Therefore, only general observations can be made. For present purposes, Morobe Province has been excluded from the considerations because only a very small percentage of the population occurs in Sepik/Ramu catchments.

Economic activities are summarised in Table 8. Averaged for the six Provinces involved, only about 5.9% of the population were working for a salary or wage in 1980 and about 3.5% had their own business. Farming or fishing for money or subsistence purposes are the major economic activities. Unfortunately, these census data do not distinguish between fishing and farming. There is little doubt that the majority of economic income would be from farming, not fishing, throughout the region as a whole. However, in floodplain regions, fishing may be more important than farming as a source of income. Neither do the census data clearly define the difference between subsistence farming (or fishing) and farming (or fishing) for money. In PNG the distinction is difficult to make since a good deal of subsistence crops, or fish catches, are not necessarily sold but used for barter. In addition, the amount of money received from the sale of primary produce is not detailed. Therefore, the relative importance of subsistence farming or fishing and products arising from these activities for sale is difficult to evaluate. The category "other" in Table 8 refers to those people either too young or old to undertake the economic activities, "looking for employment" (generally less than 2.0% of the population in any Province) and the category "other" in the census figures which is not defined. It might be assumed that the majority of people in the category "other" (Table 8) are also engaged in subsistence activities, if able.

The data in Table 8 also includes coastal regions (in Provinces with a coastline) and, perhaps more importantly, the major urban centers within the Provinces. Urban centers are very limited in the Sepik/Ramu catchment itself, as stated above, and the major towns in Provinces, including Madang, Wewak, Goroka, Mount Hagen, are not situated there. Therefore, the categories "working for a wage" and "own business" would be expected to be much reduced in the Sepik/Ramu catchments themselves. Perhaps the best way to view Table 8 is to conclude that a good deal less than 9.8% of the population in the catchments obtain money through employment or business activities. The remainder, certainly over 90%, undertake subsistence activities or limited, semi-commercial farming, or fishing.

Table 9 refers to the percentage of households obtaining income from the sale of fish versus other non-wage earning activities. Because the table refers to households, not numbers of people, the percentage activities must be viewed with caution. The size of households and numbers of people within them, undertaking economic activities, are not provided in the census data. In addition, certain economic activities can be shared between a number of households in PNG. For such reasons, again, perhaps the best way to view Table 9 is to consider those households with no non-wage earning income which averages to about 31% for the region.

This figure, although large itself, also under-estimates the lack of cash earning opportunities since only one person within a household earning money from non-wage sources would exclude that household from the no non-wage earning sector in this table. A similar viewpoint relates to the consideration of the number of households obtaining money from fishing. However, within households, fishing is obviously an important activity in those Provinces encompassing lowlands, East and West Sepik and Madang Provinces. Fishing as a source of household income is negligible in the highlands Provinces which is hardly surprising as they generally have negligible fish stocks. Income from selling fish is nil in Eastern Highlands Province because fish stocks there are particularly depauperate. Rivers in the majority of this Province encompass the upper Ramu River catchment which is devoid of native fishes, except eels, possibly because it is above Yonki gorge which may form a fish barrier.

Even a cursory look at associated economic data for populations living with the Sepik/Ramu can leave little doubt that the vast majority lead a subsistence way of life or obtain limited funds from agricultural or fishing activities. In particular, cash earning through employment is negligible; even with a great increase in employment since 1980, it would still be negligible.

10. 2 Nutritional status

Unfortunately we have limited information available on protein intake amongst the Sepik/Ramu population. Protein obtained from fish might be expected to be significant in Sepik/Ramu lowlands. In such regions there are few alternative sources of animal protein and potential for agriculture is limited. Coates (1985) estimated per capita fish consumption for people living on Sepik floodplains to be between 120 and 200 g per day, noting, however, that this was likely to be an overestimate. Although this value is surprisingly high, it is noted that there are negligible alternative sources of animal or even plant protein in this region. The only other significant food source is sago which is entirely carbohydrate (Curtain 1978). Floodplain fish stocks are substantial, compared with non-floodplain areas in the Sepik/Ramu, and it is interesting to note that protein malnourishment appears to increase with altitude within the catchment.

At mid-altitudes hardships increase. A study by Heywood et al. (1986) provides a good insight into conditions in the Wosera area (Maprik District - East Sepik Province). Soil fertility is poor and consequently crop yields are low.

Thus, the nutritional status is poor as are financial returns for their limited cash crops of coffee, peanuts, tobacco, cocoa and some vegetables. The main diet in this region is taro and sago with very limited protein intake since fresh meat and fish are said to be in short supply. Tinned fish is popular, although poverty levels in this area enable the average family of six people to consume only one 15 ounce tin per week. The incidence of malnutrition in children up to five years of age in this region is amongst the highest in the country. This situation is not untypical of many mid-altitude regions in the Sepik/Ramu. To some extent the Wosera people are more fortunate than others; there are roads in the vicinity and people (e.g. Heywood et al.) can get there in order to try to assist them !

In highlands regions, protein intake from fish sources would be expected to be negligible due to negligible fish stocks. Howard (1987) estimated per capita fish consumption in a highlands region of Irian Jaya to be about 50 g per year. The fish distributions in Irian Jaya and PNG might be expected to be similar (Allen and Coates 1989) and Howard's data confirm just how little fish is produced from rivers in New Guinea highlands regions.

11. DISCUSSION

Data from this database are extracted for use in several other project reports. The following is a more general summary of populations within the Sepik/Ramu.

Sepik/Ramu villages are generally small. They are also quite widely dispersed, as reference to maps of the area will indicate, although the degree of "dispersion" cannot be calculated from the present database. Large concentrations of people, by Sepik/Ramu standards, probably only occur in the Torricelli/Bewani ranges to the north of the Sepik River (areas around Maprik/Dreikikir) and in certain areas in the Sepik/Ramu highlands. Major concentrations of people by altitude occur in Sepik/Ramu lowlands (<120 m elevation) and in regions between 1400 and 2200 m.a.s.l. Above 2500 m populations of people do not occur. Mid-altitudes are sparsely populated.

No matter where within the catchment people occur they nearly all have access to water resources. Details on the vegetation types occurring within the vicinity of such water bodies, their size and other geological, limnological and climatological factors (Coates 1989 and Coates et al. 1989) indicate that all such water bodies are capable of sustaining increased fish resources.

Income from wage earning is negligible within the catchment. All other factors analysed can leave little doubt that the greater majority of the population lead a subsistence lifestyle or obtain limited income from the sale of products produced on a small scale. Problems of protein malnourishment are self-evident. It is unlikely that there will be a rapid change in these circumstances. Even if there were, it would be envisaged that a considerable number of people would still lead a subsistence lifestyle in remote regions for the foreseeable future.

The availability of roads within the basin is quite reasonable. It should not be concluded, however, that the availability of roads will reduce the degree to which a subsistence lifestyle predominates in the immediate future. A large number of people still have limited access to roads, and the benefits they might bring.

The justification for stocking fish in the Sepik/Ramu catchment is discussed at length elsewhere (Coates 1989b). Present fish distributions relate to altitude with floodplain regions having the best stocks and stocks becoming negligible, or even non-existent, above 1000 m altitude where 397,968 people live. The socio-economic value of stocking rivers in such regions with fish to provide a readily available protein source to supplement the subsistence diet needs little illumination. Those who doubt the potential value of stocking fish should visit, for example, the Wosera region.

Results from the database also indicate the types of environment where fish stocking can have an impact on the greatest numbers of people. They also indicate areas, and environments, where perhaps fewer people live but where perhaps greater hardships exist. Deciding which fish species to stock is not simply a matter of biological/ecological considerations but also has to be related to population distributions and sociological considerations. Such factors are addressed in future reports dealing with fish species proposed for stocking and assist with justifications for such stocking and the estimation of potential benefits arising from stocking.

Much attention is often given to floodplain regions of such river systems. It is true that the greatest fish production will, in theory, occur in Sepik/Ramu floodplain regions, as occurs in other such river basins (e.g. Welcomme 1985). However, the database clearly shows the importance of water resources in non-floodplain areas in terms of both their extent and the numbers of people living there. When the extent of non-floodplain aquatic habitats and the number of people having access to these are considered there can be little doubt as to the importance of such areas. Potential yields achievable from rivers and streams at higher altitudes are difficult to estimate. They would be expected to be much lower than fish yields from floodplains. However, they would have to be absurdly low for potential yields from these regions not to rival yields from floodplains on the basis of total amount of fish caught.

Fish stocking might be viewed as, at the least, only of modest benefit. Population figures, however, refute this perception. The benefits of stocking would be distributed amongst a total population of 752,320 people. Coates (1989c) has already pointed out the advantage in PNG of fisheries developments with modest benefits, but involving a large number of people.

The database provides information on the distribution of people within the Sepik/Ramu catchments in relation to vegetation, roads, altitude, village size and proximity to water resources. The database may be used in future to estimate fisheries yields, and potential fisheries yields, based on population distributions in various aquatic habitat types and altitudes. A reasonable understanding of fish distributions in the various water bodies, and by altitude, is already available. In other reports, knowledge of fish distributions will be related to the distribution of people in order to calculate access to various kinds of fishery resources throughout the whole catchment. It is unfortunate that sufficient data on fishing effort in various locations could not be obtained at the time of writing due to the unforeseen circumstances outlined in the forward to this report. A limited amount of data is, however, available in Mys and Van Zwieten (1989). It is hoped that this data can be improved in order to combine population data with data on fish and fishing activities throughout the whole basin. If so, accurate data on fish catches and potential fisheries yield would be available, perhaps for the first time, for a complete river basin.

12. ACKNOWLEDGEMENTS

L. Mase compiled much of the database and E. Winrow entered much of the data onto the computer.

13. REFERENCES

Allen, G. R. and Coates, D. (1989) An ichthyological survey of the Sepik River system, Papua New Guinea. Records of the Western Australian Museum. In press.

Coates, D. (1985) Fish yield estimates for the Sepik River, Papua New Guinea, a large floodplain system east of 'Wallace's Line'. Journal of Fish Biology 27: 431-443.

Coates, D. (1989) Summary of the geology, geomorphology, climate and vegetation of the Sepik and Ramu River catchments with notes on their relevance to fisheries. FAO, PNG/85/001, Field Document no. 2. In press.

Coates, D. (1989a) Preliminary report on trout stoking. FAO, PNG/85/001 Field Document (unpublished). Pages var.

Coates, D. (1989b) Sepik River Fish Stock Enhancement Project Phase One Report. Part I. Recommendations relating to stocking and options to stocking. FAO, PNG/85/001 Field Document (unpublished). Pages var.

Coates, D. (1989c) Review of Aquaculture and Freshwater Fisheries in Papua New Guinea. FAO, PNG/85/001 Field Document No. 1. 30 p.

Coates, D., Osborne, P. L. and Van Zwieten, P. A. M. (1989) Preliminary report on limnological work undertaken in the Sepik Ramu. FAO, PNG/85/001 Field Report (unpublished). Pages Var.

Curtain, R. (1978) A study of out-migration from fourteen villages in the East Sepik Province. IASER Discussion Paper no. 3. Port Moresby, Papua New Guinea

Heywood, P. Allen, B., Fandim, T., Garner. P. Hide, R. Joughlin, J., Junamberry, J., Mathie, A., Numbuk, S. Ross, J. and Yaman, C. (1986) A rapid appraisal of agriculture, nutrition and health in Wosera sub-district, East Sepik Province, Papua New Guinea. Institute of Medical Research - Internal Report.

Howard, K. T. (1987) Inland Fisheries Development - Irian Jaya. UNDP/IBRD Project INS/83/013 Regional planning investment preparation and experimental area development project Nusa Tengarra, South-East Sulawesi and Irian Jaya. 154 p.

Mys, M. A. F. and Van Zwieten, P. A. M. (1989) Subsistence fisheries in lower-order streams: Notes on species preference, fishing methods, catch composition, yield and dietary importance of fish. FAO/PNG/85/001 Field Document No. 11. Pages var.

Van Zwieten, P. A. M. (1989) Preliminary analysis of biomass, density and distribution of fish in tributaries and hillstreams of the Sepik-Ramu River system (Papua New Guinea). Proceedings of the Second Asian Fisheries Forum, Tokyo, Japan, April, 1989 (Asian Fisheries Society). In press.

Welcomme, R. L. (1985) River Fisheries. FAO FISH. Tech. Pap., 262:330 p.

Table 1. Populations of the Sepik/Ramu by Province and catchment.

Province	No. villages	Total Population	Catchment Sepik		
			No. villages	Total popn.	No. v
ENGA	182	120,955	182	120,955	0
WESTERN HIGHLANDS	199	95,136	199	95,136	0
EASTERN HIGHLANDS	408	137,750	0	0	40
MOROBE	7	1,022	0	0	7
MADANG	598	111,849	56	12,447	52
EAST SEPIK	936	224,890	936	224,890	0
WEST SEPIK	548	93,718	548	93,718	0
TOTAL ALL AREAS	2878	785,320	1921	547,146	95

Table 2. Water temperatures (from Coates et al. 1989) and population distribu[illegible] basin.

Altitude range (m)	Number of people	Percentage population	Water temperat[illegible] approx. range	m[illegible]
0 - 100	155,976	19.7	34 - 26	[illegible]
101 - 500	190,948	24.3	32 - 22	[illegible]
501 - 1000	40,551	5.2	24 - 20	[illegible]
1001 - 1500	98,600	12.5	22 - 18	[illegible]
1501 - 2000	199,070	25.3	16.5 - 17.5	[illegible]
2001 - 2500	97,919	12.5		about 1[illegible]
>2500	2,379	<1.0		<[illegible]

Table 3. Vegetation types occurring within the vicinity of villages in the Sep

VEGETATION TYPE (VEGMAIN)	CODE	No. VILLAGES	TOTAL POPULATION	% TOTAL POPULATION
Floodplain forest	FPF	367	63,686	8.1
Nipa	NIP	0	0	0
Tree-swamp	TS	53	10,295	1.3
Swamp	SWP	16	3,325	0.4
Rainforest	RF	1211	276,482	35.3
Medium forest	MF	155	46,188	5.9
Secondary growth	SG	293	80,584	10.3
Plantation	PLT	16	6,203	0.7
Savanna	SAV	234	121,216	15.5
Grassland	GRL	522	163,856	20.9
Urban	URB	5	12,467	1.6

Table 4. Population densities in three major vegetation type areas (data combi[illegible] present statistics).

VEGETATION TYPE	AREA (km^2)	No. PEOPLE	DENSITY (people km^{-2})
Freshwater swamps and wooded freshwater swamp	18,096	285,072	15.7
Lowland forest and montane forest to 3000m (excluding floodplain forest and tree swamp)	95,160	77,306	0.81
Savanna, grassland and gardens	18,096	403,254	14.9

Table 5. Numbers of villages and total numbers of people living within various allweather roads.

DISTANCE TO NEAREST ROAD	No. VILLAGES	No. PEOPLE	% TOTAL POPULATION	MEAN POPULATION OF VILLAGES
<= 2.0 km	1108	391,348	49.8	353.2
<= 5.0 km	1318	453,278	57.7	343.9
<= 10.0 km	1522	515,176	65.6	338.5
> 10.0 km	1356	270,144	34.4	199.2

Table 6. Numbers of people living in the Sepik/Ramu catchment within either 1.0 or 2.0 km of a large, medium or small river or lake. (Percentage N refers to the percentage of the population living within that altitude range).

Distance to water body less than or equal to 1.0 km

Altitude	Large river		Medium River		Small river		Lake	
	N	%N	N	%N	N	%N	N	%N
<100 m	33,579	21.5	42,389	27.2	52,452	33.6	28,028	17.9
101 - 500 m	5,680	3.0	28,238	14.8	72,097	37.8	3,419	1.8
501 - 1000 m	1,523	3.8	6,131	15.2	19,946	49.2	1,871	4.6
1001 - 1500 m	2,614	2.6	12,928	13.1	59,621	60.5	1,527	1.5
1501 - 2000 m	8,078	4.0	44,294	22.3	140,412	70.5	1,371	0.7
>2000 m	2,904	2.9	21,767	21.7	77,822	77.7	3,396	3.4
>100 m	20,799	3.3	113,767	18.1	369,898	58.8	11,584	1.8

Distance to water body less than or equal to 2.0 km

Altitude	Large river		Medium River		Small river		Lake	
	N	%N	N	%N	N	%N	N	%N
<100 m	37,390	23.9	48,878	33.3	60,840	39.0	35,506	22.8
101 - 500 m	6,125	3.2	42,458	22.2	109,539	57.4	6,481	3.4
501 - 1000 m	2,300	5.7	9,043	22.3	24,511	60.4	1,871	4.6
1001 - 1500 m	3,429	3.5	24,899	25.2	70,491	71.5	1,823	1.8
1501 - 2000 m	10,936	5.5	64,606	32.5	163,722	82.2	3,334	1.7
>2000 m	2,904	2.9	27,639	27.6	85,351	85.2	5,284	5.3
>100 m	25,784	4.1	168,645	26.8	453,614	72.1	18,793	3.0

Table 7. Mean population number of villages occurring with 1.0 km of the various water bodies at various altitudinal zones within the Sepik/Ramu catchments.

	Water body type			
Altitude (m)	Large river	Medium river	Small river	Lake
<100	206.0	229.2	180.2	207.6
101 - 500	183.0	220.6	182.0	170.9
501 - 1000	152.3	157.2	159.6	143.9
1001 - 1500	186.7	323.2	377.0	218.1
1501 - 2000	1154.0	481.5	390.0	228.0
>2000	580.0	777.4	585.1	485.2

Table 8. Percentage total citizen population 10 years old and over, by econom[illegible] Provinces in the Sepik/Ramu catchments (source: 1980 National Population Cens[illegible] Summary. National Statistical Office, Port Moresby).

PROVINCE	ECONOMIC ACTIVITY			
	Working for salary/wage	Own business	Farming/fishing for money	Farming/fis[illegible] for subsist[illegible]
East Sepik	4.8	5.6	37.1	14.7
West Sepik	4.2	5.6	12.8	41.4
Madang	7.8	5.4	13.3	36.2
Enga	3.1	1.2	16.4	43.9
Western Highlands	10.5	1.6	24.6	28.6
Eastern Highlands	5.4	1.8	33.9	21.3

Table 1. Populations of the Sepik/Ramu by Province and catchment.

Province	No. villages	Total Population	Catchment			
			Sepik		Ramu	
			No. villages	Total popn.	No. villages	Total popn.
ENGA	182	120,955	182	120,955	0	0
WESTERN HIGHLANDS	199	95,136	199	95,136	0	0
EASTERN HIGHLANDS	408	137,750	0	0	408	137,750
MOROBE	7	1,022	0	0	7	1,022
MADANG	598	111,849	56	12,447	542	99,402
EAST SEPIK	936	224,890	936	224,890	0	0
WEST SEPIK	548	93,718	548	93,718	0	0
TOTAL ALL AREAS	2878	785,320	1921	547,146	957	238,174

Table 2. Water temperatures (from Coates _et al._ 1989) and population distribution data for the Sepik/Ramu basin.

Altitude range (m)	Number of people	Percentage population	Water temperature (°C) approx. range	Water temperature (°C) mean
0 - 100	155,976	19.7	34 - 26	28.5
101 - 500	190,948	24.3	32 - 22	27.0
501 - 1000	40,551	5.2	24 - 20	21.0
1001 - 1500	98,600	12.5	22 - 18	20.5
1501 - 2000	199,070	25.3	16.5 - 17.5	17.0
2001 - 2500	97,919	12.5		about 12.0 - 14.0
>2500	2,379	<1.0		<= 11.0

Table 3. Vegetation types occurring within the vicinity of villages in the Sepik/Ramu basin.

VEGETATION TYPE (VEGMAIN)	CODE	No. VILLAGES	TOTAL POPULATION	% TOTAL POPULATION
Floodplain forest	FPF	367	63,686	8.1
Nipa	NIP	0	0	0
Tree-swamp	TS	53	10,295	1.3
Swamp	SWP	16	3,325	0.4
Rainforest	RF	1211	276,482	35.3
Medium forest	MF	155	46,188	5.9
Secondary growth	SG	293	80,584	10.3
Plantation	PLT	16	6,203	0.7
Savanna	SAV	234	121,216	15.5
Grassland	GRL	522	163,856	20.9
Urban	URB	5	12,467	1.6

Table 4. Population densities in three major vegetation type areas (data combined from Coates 1989, and the present statistics).

VEGETATION TYPE	AREA (km^2)	No. PEOPLE	DENSITY (people km^{-2})
Freshwater swamps and wooded freshwater swamp	18,096	285,072	15.7
Lowland forest and montane forest to 3000m (excluding floodplain forest and tree swamp)	95,160	77,306	0.81
Savanna, grassland and gardens	18,096	403,254	14.9

Table 5. Numbers of villages and total numbers of people living within various distances of allweather roads.

DISTANCE TO NEAREST ROAD	No. VILLAGES	No. PEOPLE	% TOTAL POPULATION	MEAN POPULATION OF VILLAGES
<= 2.0 km	1108	391,348	49.8	353.2
<= 5.0 km	1318	453,278	57.7	343.9
<= 10.0 km	1522	515,176	65.6	338.5
> 10.0 km	1356	270,144	34.4	199.2

Table 6. Numbers of people living in the Sepik/Ramu catchment within either 1.0 or 2.0 km of a large, medium or small river or lake. (Percentage N refe to the percentage of the population living within that altitude range).

Distance to water body less than or equal to 1.0 km

Altitude	Large river		Medium River		Small river		Lake	
	N	%N	N	%N	N	%N	N	%N
<100 m	33,579	21.5	42,389	27.2	52,452	33.6	28,028	17.9
101 - 500 m	5,680	3.0	28,238	14.8	72,097	37.8	3,419	1.8
501 - 1000 m	1,523	3.8	6,131	15.2	19,946	49.2	1,871	4.6
1001 - 1500 m	2,614	2.6	12,928	13.1	59,621	60.5	1,527	1.5
1501 - 2000 m	8,078	4.0	44,294	22.3	140,412	70.5	1,371	0.7
>2000 m	2,904	2.9	21,767	21.7	77,822	77.7	3,396	3.4
>100 m	20,799	3.3	113,767	18.1	369,898	58.8	11,584	1.8

Distance to water body less than or equal to 2.0 km

Altitude	Large river		Medium River		Small river		Lake	
	N	%N	N	%N	N	%N	N	%N
<100 m	37,390	23.9	48,878	33.3	60,840	39.0	35,506	22.8
101 - 500 m	6,125	3.2	42,458	22.2	109,539	57.4	6,481	3.4
501 - 1000 m	2,300	5.7	9,043	22.3	24,511	60.4	1,871	4.6
1001 - 1500 m	3,429	3.5	24,899	25.2	70,491	71.5	1,823	1.8
1501 - 2000 m	10,936	5.5	64,606	32.5	163,722	82.2	3,334	1.7
>2000 m	2,904	2.9	27,639	27.6	85,351	85.2	5,284	5.3
>100 m	25,784	4.1	168,645	26.8	453,614	72.1	18,793	3.0

Table 7. Mean population number of villages occurring with 1.0 km of the various water bodies at various altitudinal zones within the Sepik/Ramu catchments.

	Water body type			
Altitude (m)	Large river	Medium river	Small river	Lake
<100	206.0	229.2	180.2	207.6
101 - 500	183.0	220.6	182.0	170.9
501 - 1000	152.3	157.2	159.6	143.9
1001 - 1500	186.7	323.2	377.0	218.1
1501 - 2000	1154.0	481.5	390.0	228.0
>2000	580.0	777.4	585.1	485.2

Table 8. Percentage total citizen population 10 years old and over, by economic activity and sector for Provinces in the Sepik/Ramu catchments (source: 1980 National Population Census. Final Figures: National Summary. National Statistical Office, Port Moresby).

PROVINCE	ECONOMIC ACTIVITY				
	Working for salary/wage	Own business	Farming/fishing for money	Farming/fishing for subsistence	Other
East Sepik	4.8	5.6	37.1	14.7	37.8
West Sepik	4.2	5.6	12.8	41.4	36.1
Madang	7.8	5.4	13.3	36.2	37.3
Enga	3.1	1.2	16.4	43.9	35.4
Western Highlands	10.5	1.6	24.6	28.6	34.7
Eastern Highlands	5.4	1.8	33.9	21.3	37.6

Table 9. Percentage of citizen households in rural village sector obtaining income from non-wage earning sectors for Provinces within the Sepik/Ramu catchment (source: 1980 National Population Census. Final Figures: National Summary. National Statistical Office, Port Moresby).

PROVINCE	SOURCE OF NON-WAGE INCOME		
	SELLING FISH	OTHER ACTIVITIES*	NO NON-WAGE INCOME
East Sepik	12.4	55.7	31.9
West Sepik	10.8	63.5	25.7
Enga	0.6	53.3	46.1
Madang	19.7	49.9	31.0
Western Highlands	0.9	65.4	33.7
Eastern Highlands	0.0	81.8	18.2

* - "other activities" includes selling artifacts, copra, food crops, running a store, PMV, canoe and other activities other than selling fish. This column was calculated by subtracting the other two columns from 100%. This, in fact, is misleading because households can undertake more than one activity. From the census figures total sources of income from the various non-wage sectors often add up to more than 100%.

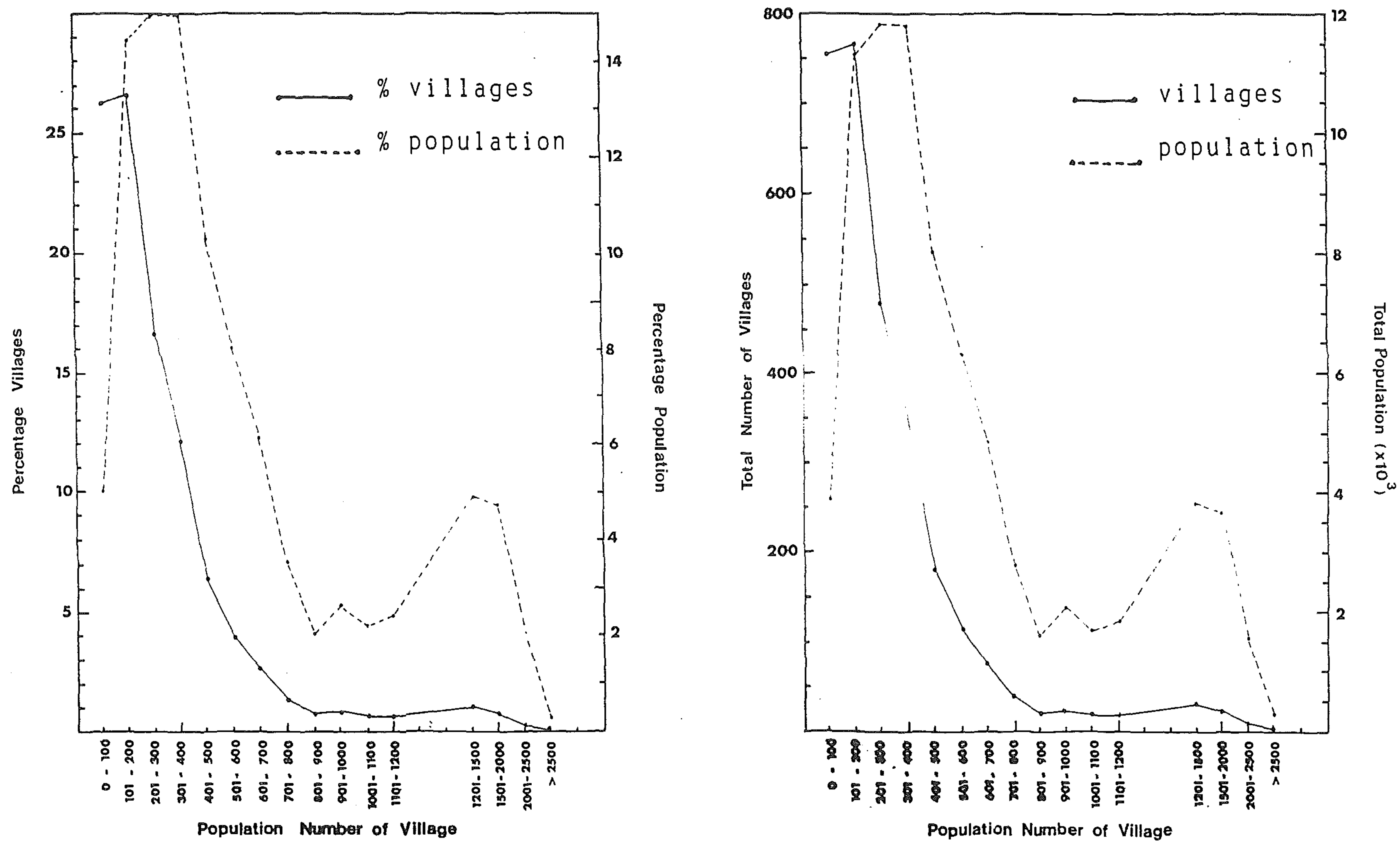


Fig. 1 Numbers of villages, percentage villages, total population and percentage population occurring in villages in various sizes (population number) within the Sepik/Ramu basin.

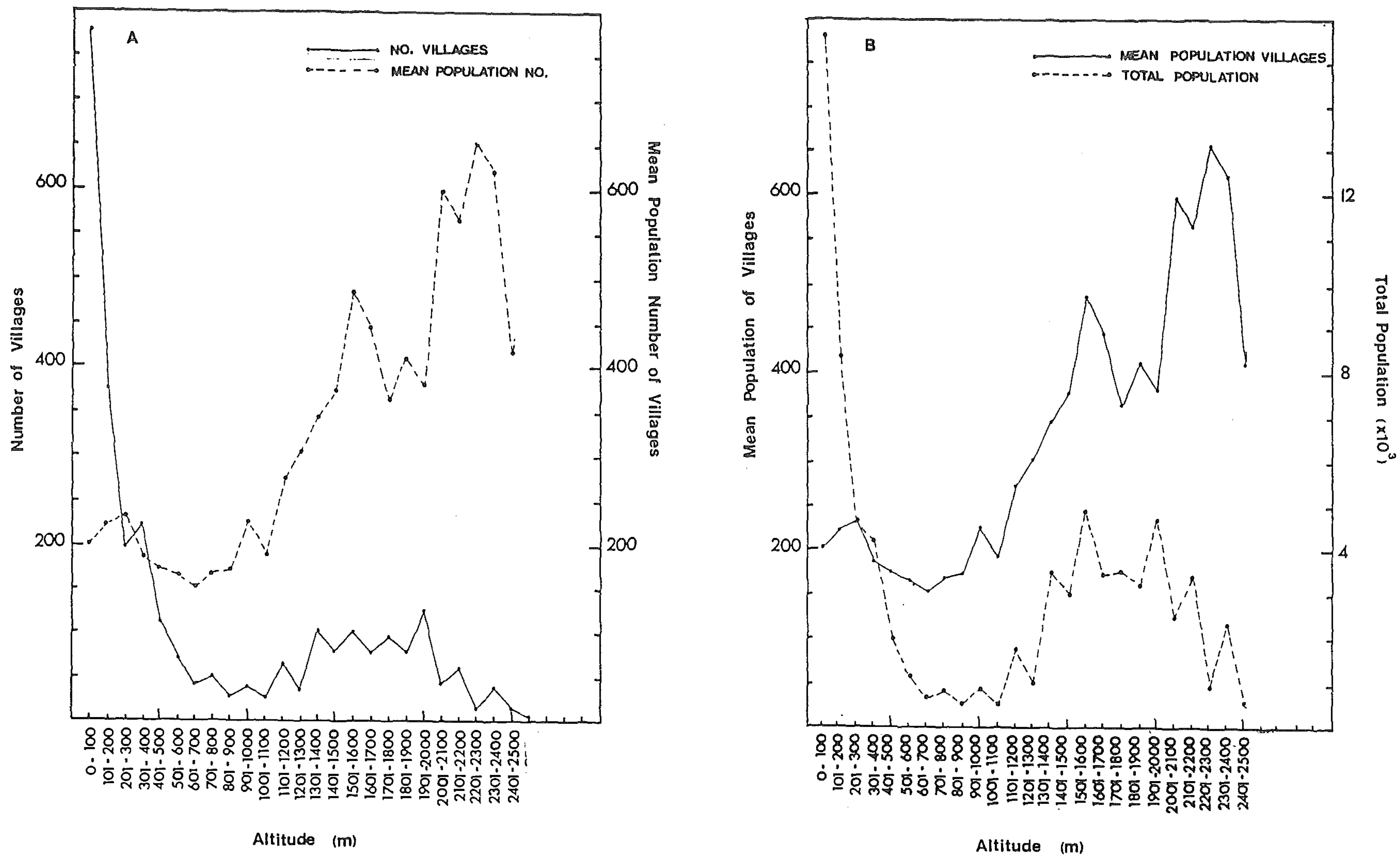


Fig. 2 (a) number of villages and mean population number of villages, (b) mean population of villages and total population, at various altitudinal zones in the Sepik/Ramu basin.

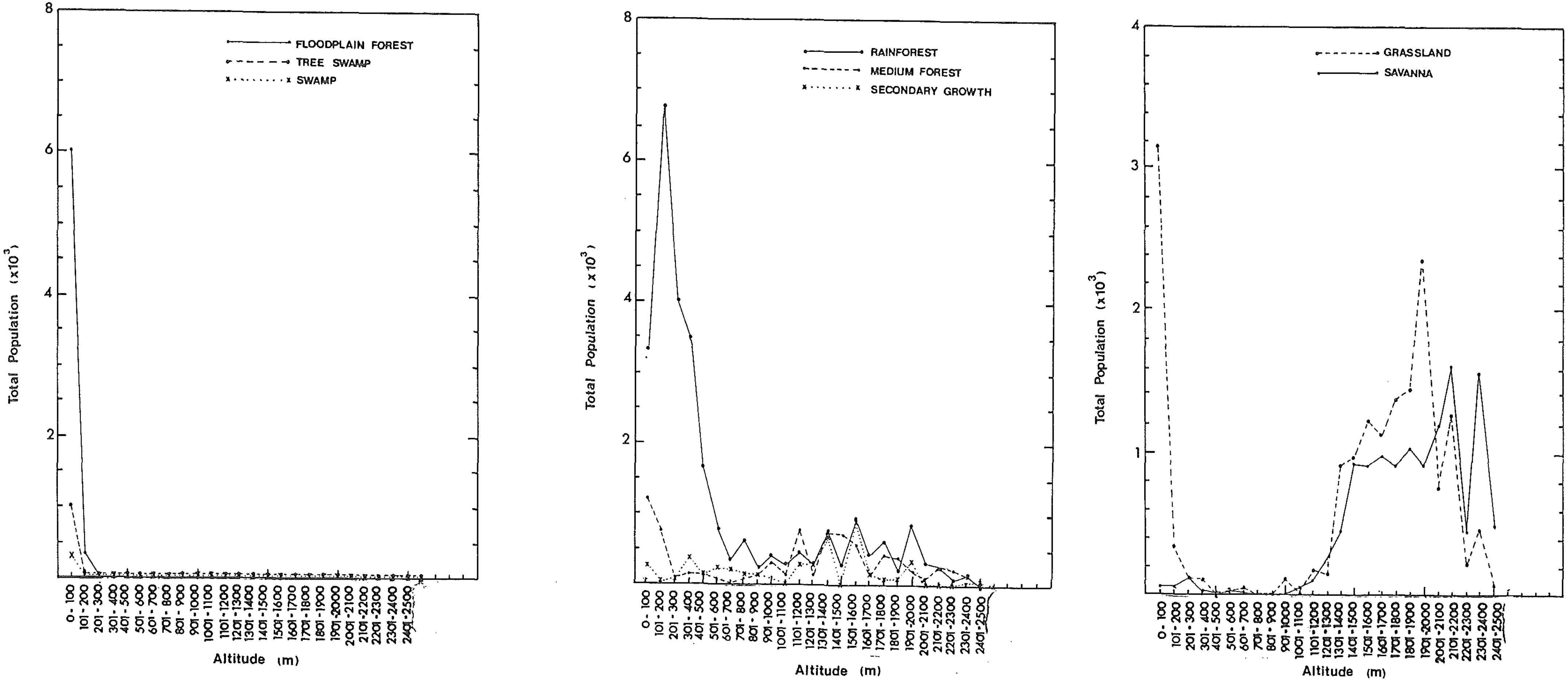


Fig. 3a. Total populations living in the vicinity of various vegetation types at various altitudinal zones within the Sepik/Ramu basin.

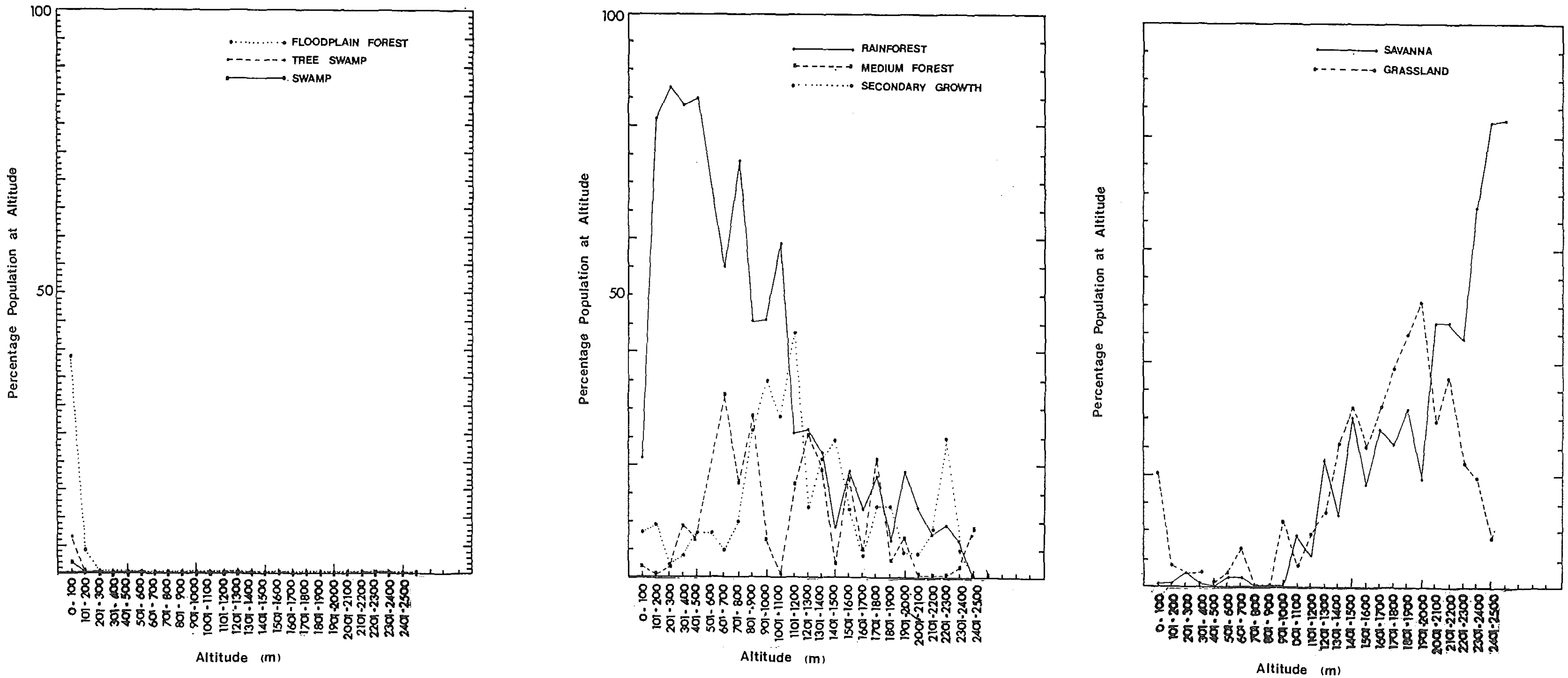


Fig. 3b. Percentage of populations at that altitude living in the vicinity of various types of vegetation at various altitudes.

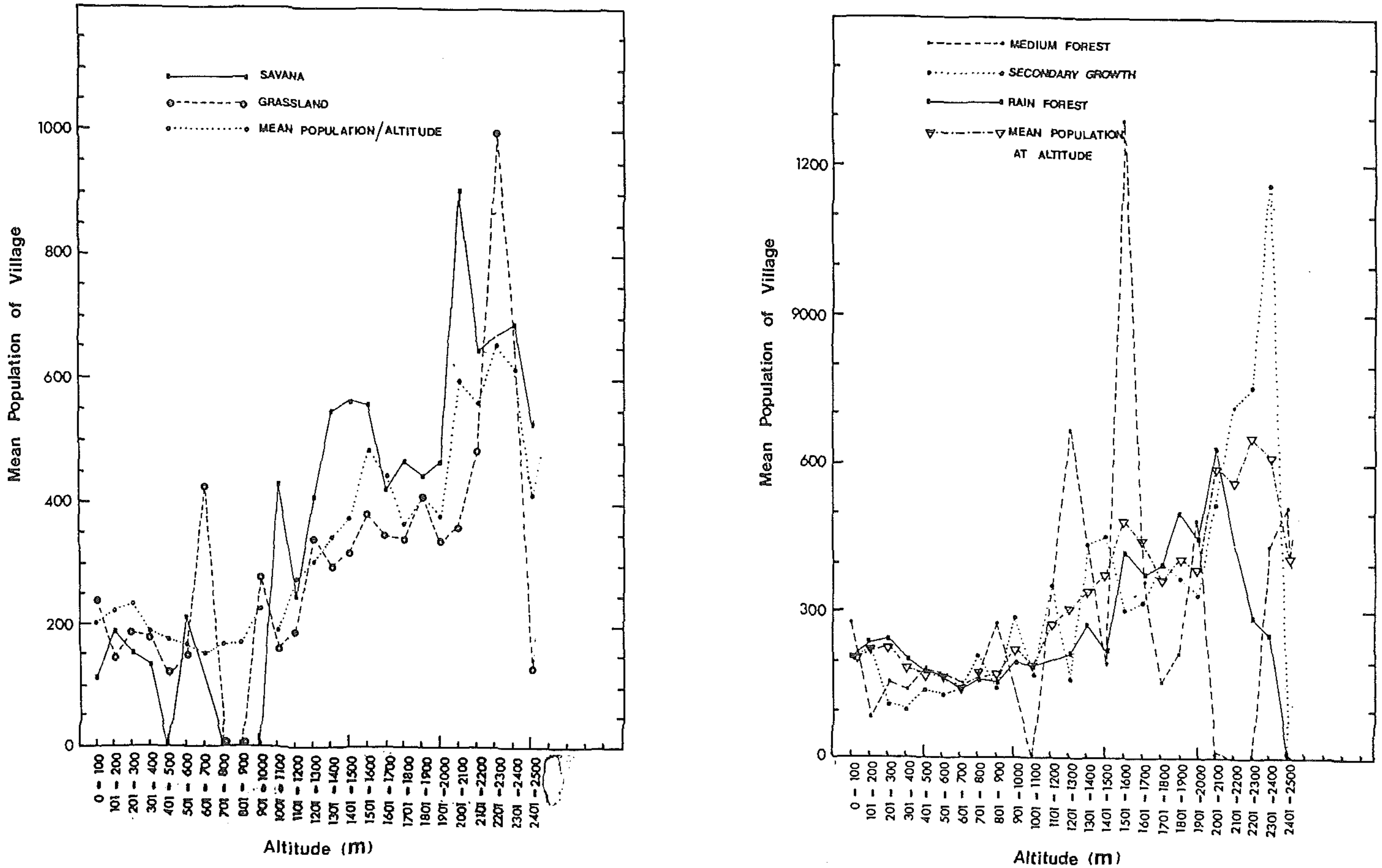


Fig. 4. Mean population numbers of villages occurring in the vicinity of various vegetation types at various altitudinal zones (and mean population number of villages related to altitude alone - included in right hand figure).

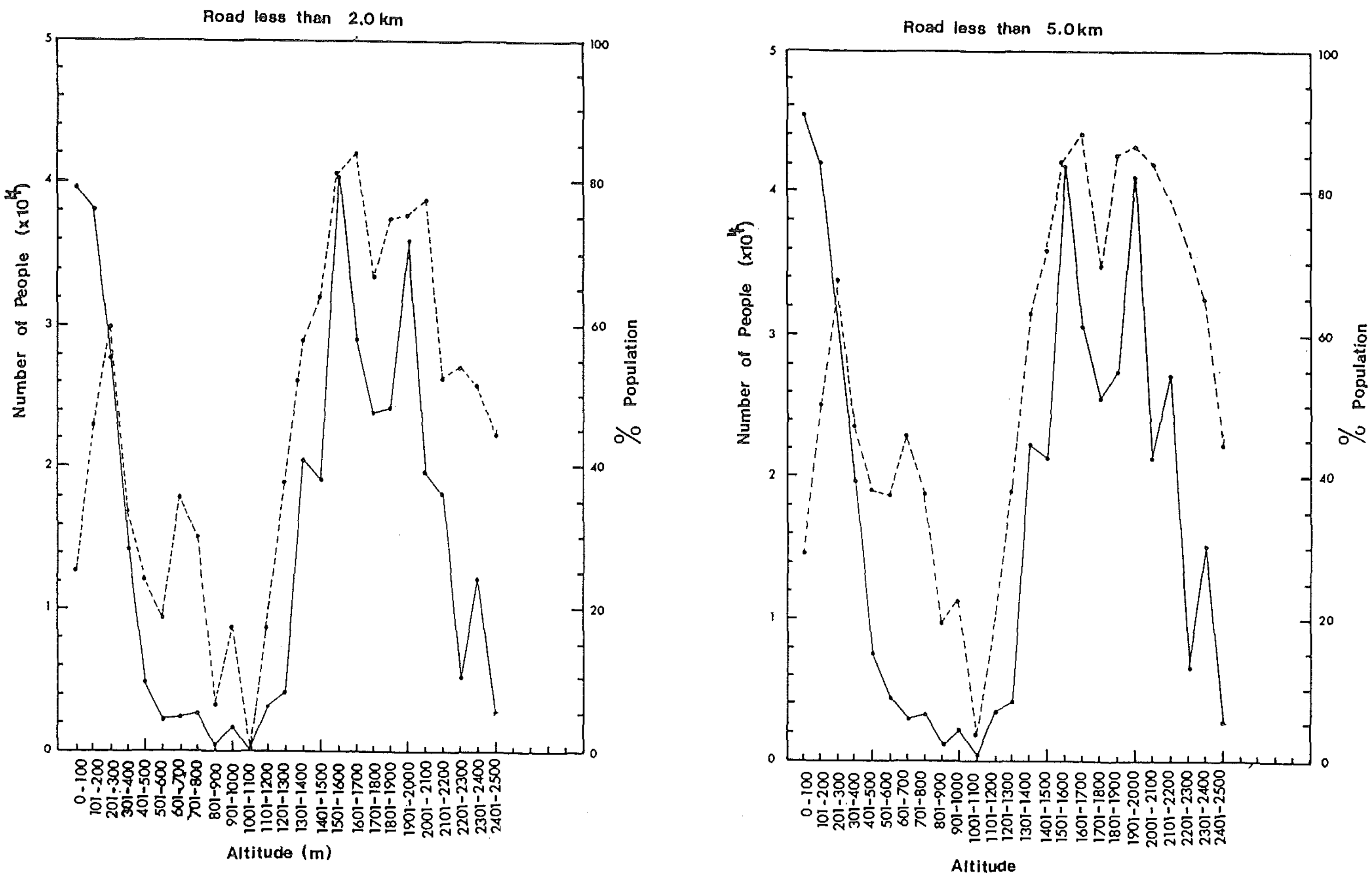


Fig. 5. Number of people and percentage population (at that altitude) living within vaious distances of an all-weather road related to altitude within the Sepik/Ramu basin (continued overleaf).

(continuous lines = number, discontinuous lines = %)

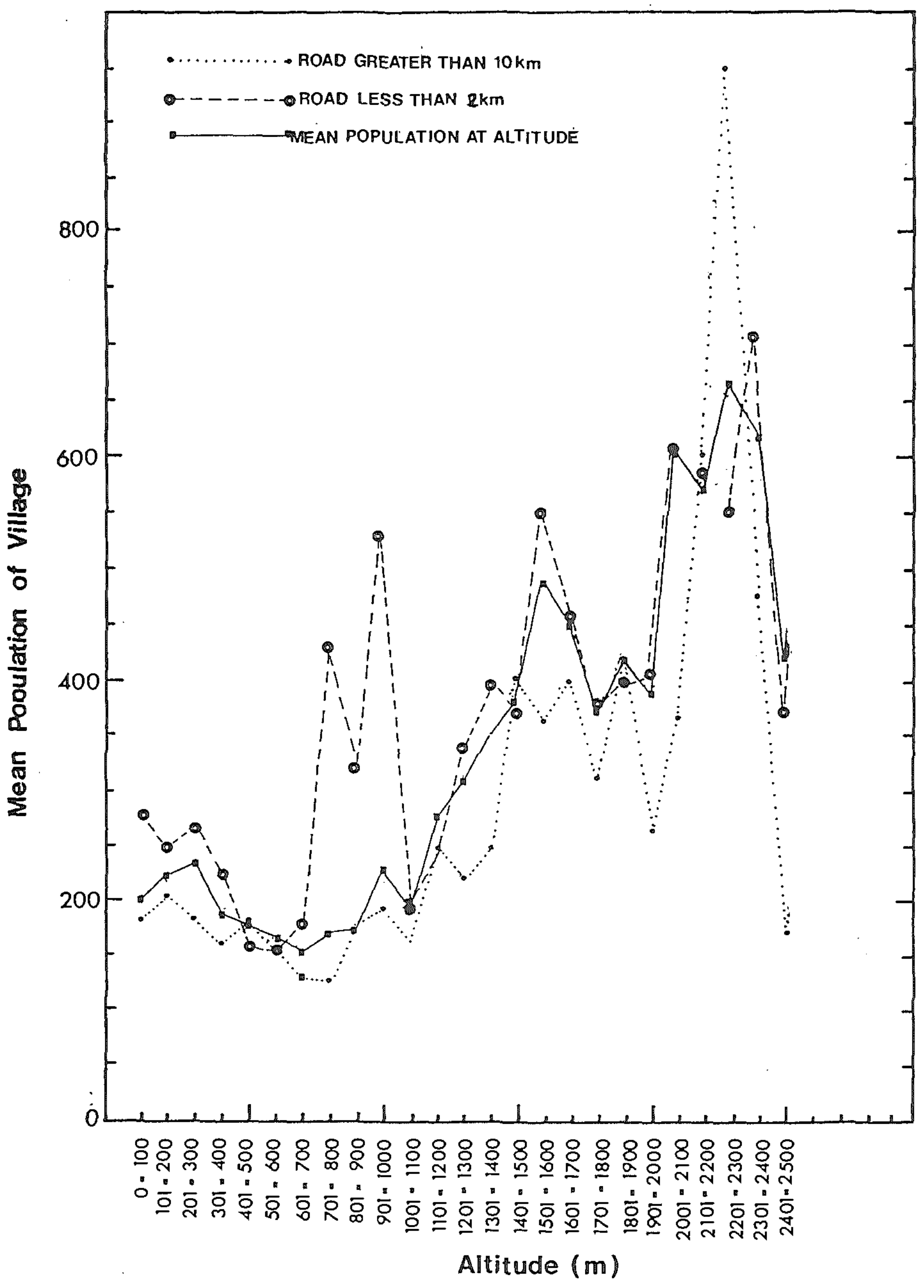
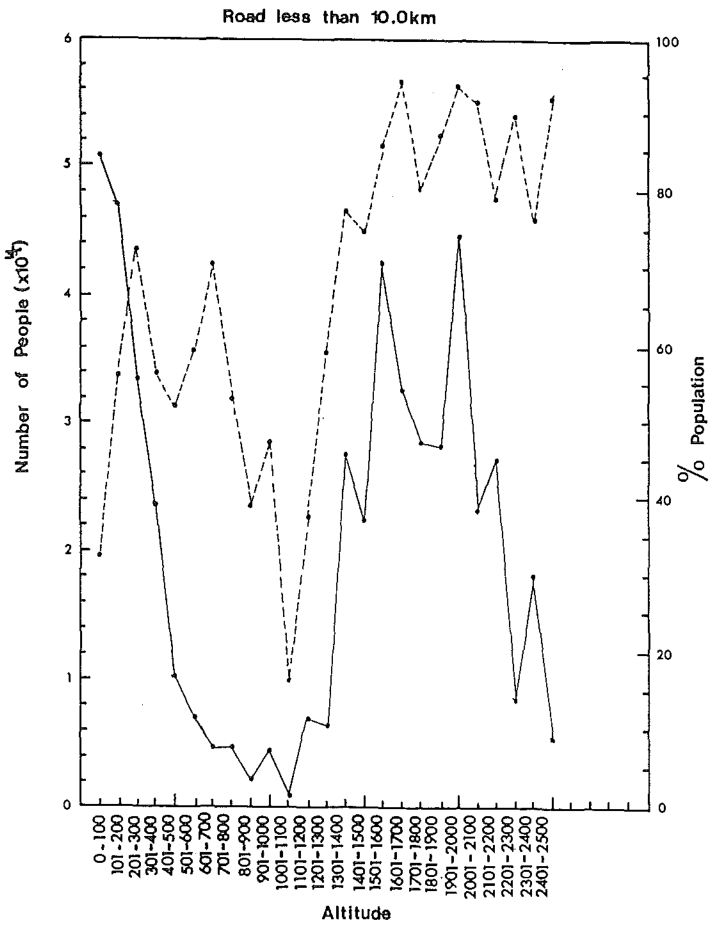


Fig. 6. Mean population number of villages at various altitudes within the Sepik/Ramu basin where roads occur within 2 km or where roads are greater than 10 km from the village compared with the mean population number of villages (at that altitude) irrespective of whether roads occur.



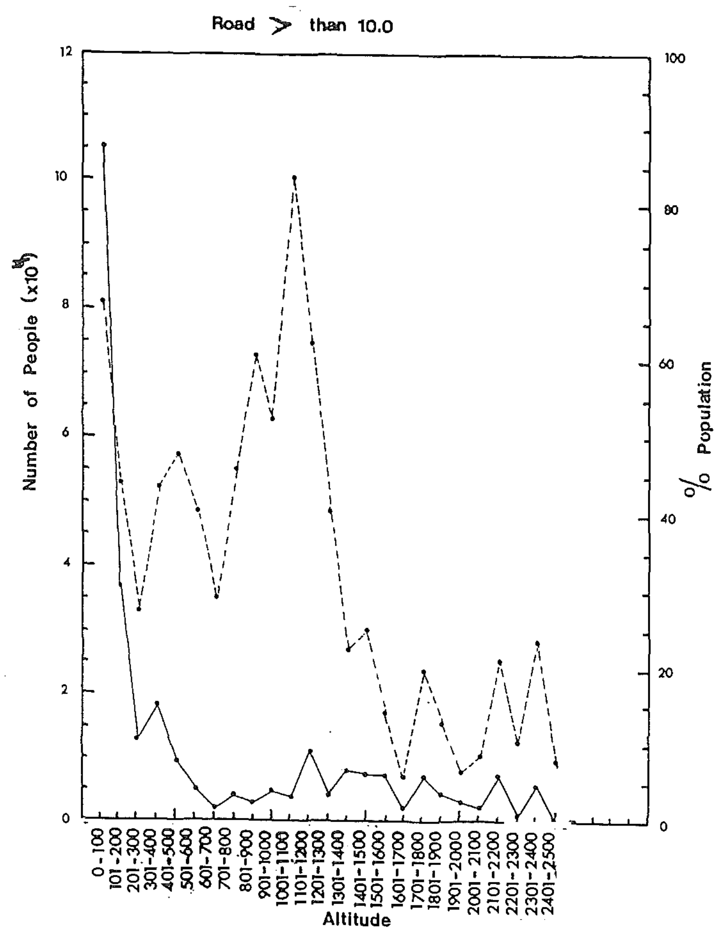


Fig. 5. .... continued