AN ASPECT OF THE GEOGRAPHY OF RECREATION

ON THE SOUTH COAST OF NEW SOUTH WALES

by

GRAHAM ARTHUR YAPP

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JULY 1975
DECLARATION

This thesis is my own composition and all sources have been acknowledged.
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AN ASPECT OF THE GEOGRAPHY OF RECREATION ON THE SOUTH COAST OF NEW SOUTH WALES

G.A. Yapp

Abstract

The problem of high peaking in recreation use of coastal resources in December and January is identified and reference made to the need for spreading this demand over a longer period. The recreation use of an area on the N.S.W. South Coast is described. The visitor population is identified and visitors' attitudes and behaviour patterns discussed. The role of climate in recreation land use and the use of indices to describe the suitability of climate for recreation are investigated. The importance of the heat balance of the human body to the comfort experienced in the course of recreation activities is identified as the most suitable method for derivation of an index of recreation climate. A model of the heat balance is proposed, and applied to daily weather data for Moruya Heads to obtain a recreation climate index.

Monthly frequencies of values of the index are derived for a number of popular recreation activities, and the most suitable time of year for a vacation in the area is identified with regard to these preferences. It is shown that the peak demand in December and January is a result of other considerations and is not justified by the area's climate. Public knowledge of the time at which the most suitable climate conditions occur in the area may assist in shifting demand to other periods of the year.
I. INTRODUCTION

Every year, in what might be called a summer holiday ritual, an untold number of Australians migrate to the beachside resorts which stud the nation's coastline.

This has led the Committee of Enquiry into the National Estate (1974) to comment on the Australian people's "long standing love affair with their coasts and beaches" in discussing the implications of recreation for coastal land use planning policies. In the same context Mercer (1972) has discussed the present and future dimensions of the use of coastal resources for recreation. These studies make it clear that heavy and increasing use of the coast is a problem for which planning solutions are urgently required. One of the most severe aspects of the problem is the intense peaking of the holiday pattern in a very short period in summer. In a nationwide study of travel behaviour, the Australian Travel Research Conference (1975) found that nearly half of all "main holiday" travel takes place in December and January, at which time schools and many industries close down. Other important reasons for the specific seaside destination and the brevity of the seasonal peak include the nature of coastal resources, the settlement pattern and climate.

This study is specifically concerned with climate and recreation in South Coastal N.S.W., an area in which the peak in recreation demand is responsible for many economic, social and environmental problems. Any mechanism which could reduce the peaking effect by spreading demand over a longer period would have considerable advantages, and better knowledge of the climate at resorts is one factor which could induce such a change in recreation behaviour.
Questionnaire studies conducted by the author indicated that people making their first visits to the area had little prior knowledge of the climate, while those making repeated annual visits have little access to climatic information which might either induce them to change their vacation destination to some other coastal place with a climate more suited to their recreation preferences, or to visit the same area at a different time of year when conditions are more favourable. This study presents a method for deriving such information.

The conventional method of presentation of climatic information is by average values of meteorological elements such as temperature and precipitation. It is difficult to determine from these data how comfortable, or how suitable for weather dependent recreation activities, a region's climate will be. Rainfall, maximum and minimum temperatures and the like are not primary concerns for human comfort and inclusion of other elements is necessary. Sunshine, wind and humidity also have some degree of direct significance to outdoor recreation. However, such additional information would not greatly assist the person planning a holiday if it were presented in conventional form. It is the heat balance of the body which is fundamental to all human responses to the environment. There is an extensive literature related to indices of human comfort based on heat balance, with particular applications to air conditioning, military and space travel clothing requirements, and medical studies. It is suggested that a similar index related to the temperature regulation of the body in the performance of nominated recreation activities under recorded weather conditions, would enable specification of the suitability for recreation throughout the year of the climate of a holiday resort.
In order to set a framework for the application of such a recreation climate classification, it is necessary first to consider the recreation resources of the study area and the attitudes and behaviour patterns of the people who use them, and these aspects are described in Parts II and III below. Part IV then describes climatic controls on recreation land use, while Parts V and VI describe the derivation and application of recreation climate indices for particular activities and activity types, with reference to the planning of vacations.
II. LOCATION AND RESOURCES OF THE STUDY AREA

The area discussed in this study is Eurobodalla Shire, which is located 285 km south of Sydney, N.S.W. (population 2.8 million) and 715 km north-east of Melbourne, Victoria (population 2.5 million). Including the population of the other towns and cities in the intervening area, the study area is therefore within reasonable driving time and distance for vacations for 6.9 million people, or more than half Australia's population (Figure 1). The great majority of the Australian population lives in cities and most of these cities are located on the coastline. Even Canberra, the largest inland city with a population of 188 000, is located within 150 km of the coast. The area has a particular attraction for the rapidly expanding population of Canberra, because it is close enough for day trips and for the full use of the daylight period at weekends. It is also becoming increasingly important due to the limited opportunities for recreation on the Victorian coastline east of Melbourne where water temperatures are lower and the morphology of the coastline less suitable for recreation, and the estuaries are generally small and dominated by areas of mudflats. The few high capability resource areas such as the Mornington Peninsula, Lakes Entrance and Mallacoota are heavily used, and all accommodation reserved at peak periods. Victorians therefore have been moving into N.S.W. in greater numbers and for greater distances in order to obtain access to coastal resorts. The growth of Albury-Wodonga also can be expected to increase the potential demand for use of the N.S.W. South Coast for recreation.

Eurobodalla Shire has an area of 3390 km$^2$ and includes the most part of the Clyde, Deua-Moruya and Tuross river catchments (Figure 2).
Figure 1. Population distribution in south-eastern Australia.
Figure 2. Boundary and settlements of the study area.
Table 1. Coastal landform types: length in Eurobodalla Shire

<table>
<thead>
<tr>
<th>Type of Shoreline</th>
<th>Landform</th>
<th>Length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky coastline</td>
<td>Plunging cliffs, cliff bluff coasts with wave</td>
<td>58.8</td>
</tr>
<tr>
<td></td>
<td>cut platforms, broken</td>
<td></td>
</tr>
<tr>
<td></td>
<td>steep and rocky coasts</td>
<td></td>
</tr>
<tr>
<td>Limited access beach</td>
<td>Cliff and bluff coasts with sandy beaches</td>
<td>13.4</td>
</tr>
<tr>
<td>Accessible beach</td>
<td>Dunes, barbeach, terrace slopes, shingle beaches</td>
<td>64.0</td>
</tr>
<tr>
<td>Mudflats</td>
<td>Tidal swamps and mud shore estuaries</td>
<td>1.1</td>
</tr>
<tr>
<td>Constructed banks</td>
<td>Retaining walls, wharves etc</td>
<td>3.0</td>
</tr>
</tbody>
</table>
sandbanks are generally more stable and exposure is less serious. Many of the headlands have very high quality scenery and, together with other parts of the coastal strip, are either subject to strict development controls, or are currently being purchased by the N.S.W. government for preservation of scenery and amenity. There are 96 public recreation reserves in the area, ranging from 0.5 to 1000 hectares, most of which are used for campgrounds, playgrounds and access to foreshores. There is also a number of flora and fauna reserves, together with one coastal National Park and large areas of mountainous forest land which are proposed for National Park reservation. The area includes the three large estuaries of the Clyde, Tuross, and Wagonga rivers, and a number of smaller estuaries of which those of the Moruya and Towamba rivers are the most important for recreation. The estuaries are important for fishing and other boating activities and provide reliable boat launching sites with open sea access. In addition there are 14 coastal lakes, ranging from 39 hectares to 826 hectares in area, which are used for boating, fishing, water-skiing and swimming and which, like the headlands, are an important element in the scenic resources of the area.

The level of development of the resources, and of facilities to supplement them, is very variable. Because of this the area provides for many types of recreation experiences between the extremes of the 'isolationist' who as far as possible seeks freedom from development and from other people, to the 'crowd-lover' seeking not only people but all the comforts of urban life in a holiday setting.

With this abundance and variety of resources, the area has become a major attraction for recreation demand. In Part III the use made of these resources and the attitudes of users are discussed.
First, however, it seems appropriate to point out the contrast between the coastal area and the inland of N.S.W. from whence come 14% of all visitors to the area (Australian Travel Research Conference 1975). The interior of the Australian continent is moderately to extremely dry, and there are few rivers and no systems of lakes such as provide a major attraction for recreation in the northern United States and Canada. Because of this scarcity of inland water resources, and since it is hotter inland than it is on the coast in summer, the major period of vacations for the Australian population clearly coincides with the least favourable inland conditions. However it is the purpose of this study to show that that is not necessarily the best time for a coastal holiday. It is the timing of the extended summer school vacation which determines the holiday peak for, at this time, many sectors of the Australian workforce also obtain their annual vacation.
III. RECREATION BEHAVIOUR AND THE ATTITUDES OF VISITORS

During the vacation period in December and January, 25 000 people descend on the resorts of Eurobodalla Shire with their cars, caravans, tents, surfboards, boats, fishing tackle and aspirations, swelling the towns and villages to capacity. At the end of January comes a major exodus and the towns return to their former routine. Periodically with the occurrence of a long weekend or at the May and September school vacations, the process is repeated on a smaller scale. An indication of the cycle of demand may be obtained from electricity consumption data. Figure 3 shows the peaking which occurs at long weekends, at Easter, and at the school vacations. The summer peak is lower because of less demand for electric power for heating. However, the high rate of transit to and from the area in summer can be seen from the volume of traffic at Nelligen, west of Batemans Bay and on the road to Canberra, also shown on Figure 3. The control exercised over other considerations by the timing of school vacations is clearly shown.

The interviews carried out during the summer peak in 1973-74 included a number of questions related to travel behaviour (see Appendix). Most visitors arrived in the area on the weekend before Christmas (39%) or between Boxing Day (Wednesday, 26 December 1973) and the weekend following Christmas (38%). The higher inflow occurred on the Saturday before Christmas when 21% of visitors arrived. This suggests a total of 5000 people entering the area on the highways from north, west and south, to which must be added those proceeding to other resorts to the north and south of the study area. Traffic congestion is increased by the high rate of departure between 0900 and 1200, so that accommodation changeover could be effected. Cars towing caravans constitute 7-10% of
Figure 3. Electricity consumption in Batemans Bay zone and traffic flow at Nelligen.

Source: Bega Valley County Council and Department of Main Roads, N.S.W.
peak traffic flow and are the main factor in traffic flow instability and delay (Byrne, Kissling and Fitzwarryne 1975). Crowding and traffic congestion are among the major sources of dissatisfaction expressed by both visitors and local residents.

The responses to a question about frequency of visits indicated that visits to the area are a well developed habit. Only 18% were making their first visit, and only 1% did not expect to make any subsequent visits. Some 34% had been visiting the area for up to 5 years, 21% from 6 to 10 years, 11% from 11 to 15 years, and 11% for more than 15 years. Obviously this pattern is conditioned by ownership of second homes in the area, but indicates a general satisfaction with the available recreation opportunities and a common tolerance of the difficulties and dissatisfactions encountered.

When respondents to the visitors survey were asked what they considered to be the best and worst things about the area, 40% indicated satisfaction with the beaches while 30% recorded dissatisfaction with the facilities and services provided. It is worthy of note, however, that while satisfaction with the landscape and resources of the area is very high, there is an element of dissatisfaction with the climate. This attitude is related either directly to the weather experienced, or indirectly to the lack of suitable recreation opportunity when the sun was not shining strongly and the weather was not suitable for beach type activities. Only 17% of respondents gave favourable climate or weather as one of the best things about the area.

The interviews included questions about leisure and recreational activities in order to determine which activities are given highest priority. Two land based and five specifically beach-and-water associated
activities dominated preferences: walking, particularly on shorelines (41%), touring and sightseeing (34%), sunbathing (24%), surfing (20%), calm water swimming (15%), fishing from boats (12%), and fishing from beaches (10%). The suitability of the climate for these general types of activities is discussed later in this study.

As a result of this part of the study I have reached the conclusion that without major, well planned investment in alternative and supporting recreation facilities both in the cities which are the major source of visitors and in the study area, the role of resource attraction is unlikely to change. Therefore the already evident conflicts and dissatisfactions and ecological damage to the coastal environment which result from the present pattern of use, are certain to continue. Eurobodalla Shire does not have a sufficiently strong economy to finance a program of conservation or to provide the necessary facilities and services at resorts. This is partly due to the brevity of the tourist season (Laut and Yapp 1974). I therefore present the hypothesis that some immediate improvement in either reduction or, more likely, spreading of the peak demand could be achieved by promotion of better public understanding of the climate of coastal resorts so that a more soundly based decision could be made both as to time and destination of vacations. The remainder of this thesis presents a description of the climate of the Shire, with a review of relevant studies of climate indices, and develops and applies a biometeorological index of recreation climate.
IV. THE IMPORTANCE OF CLIMATE TO RECREATION ON THE SOUTH COAST, N.S.W.

In summer, south-eastern Australia is subject to continental air masses from the north and west, to maritime incursions from the east and to the westerly airstream of the general circulation pattern, modified by its passage over the continent. In winter, the westerly stream of southern maritime air masses is of major importance, particularly on the west of the Snowy Mountain range. The uplift of this frequently moist and conditionally unstable air results in a winter maximum rainfall on the western slopes and crests of the range, and a strongly developed rainshadow in the lee. This effect is most prominent on the tableland but there is some influence on the coast, particularly to the south of the study area. The subtropical belt of high pressure oscillates from south to north from summer to winter. In winter the track of the centres of large anticyclones dips to the south and the coast may be under the influence of high pressure for several days at a time. This event is most pronounced in July and is the reason for lower rainfall and a relatively high number of hours of sunshine in that month. Most coastal rainfall is due to incursions of Pacific and Tasman maritime air masses. This moist air is uplifted at the coastal scarp and by wedging by fronts moving from the west, resulting in heavy rainfalls and high annual totals in the forested scarpland. Tasman sea depressions are of considerable importance to recreation in the area, as they often are intense and result in lengthy rainy periods and in high seas which are hazardous for water sports and damaging to beaches. Damage results from both the removal of sand and the dumping of seaweeds and other debris on beaches. These high seas also threaten resort developments which are often built up to the line of the main foredune.
Several tables of climatic means are included in the Appendix. Table 1 shows the monthly frequency of days with rain at 0900 and 1500 at Moruya Heads, while Tables 8 to 10 show monthly rainfall, temperature and sunshine averages, where available, for the three main towns in the study area.

**Weather Associated Controls on Recreation**

In a resource area such as the N.S.W. South Coast, weather conditions are commonly associated with restrictions on recreation. The most obvious of these are total or categorical bans on the use of fire and, in the case of forest authorities, bans on access to forest areas during periods of high or extreme fire danger.

Table 2 shows the average frequency of fire hazard ratings for forests in the Batemans Bay Forest District. September and October are clearly the months of greatest fire hazard. Forest management may be expected to seek further ability to restrict access as demand for recreation in the forests increases. There is, however, little evidence to suggest that camping and picnic fires are a major cause of serious wildfires at present because most such fires are started near roadsides and are quickly detected and more easily controlled. Table 3 shows numbers of fires and acreage involved in N.S.W. and Victoria and the relative significance of fires with a probable recreation origin.

It is difficult to relate fire hazard to the weather records available because it also depends on the fuel build-up in the forests. The figures available suggest that restrictions on some recreation activities are likely in most years.
Table 2. Average monthly frequency (%) of fire danger ratings in State Forests in Batemans Bay area (6 year period)

<table>
<thead>
<tr>
<th>Fire Danger Rating</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>87.1</td>
<td>92.9</td>
<td>91.0</td>
<td>91.7</td>
<td>97.6</td>
<td>100</td>
<td>100</td>
<td>93.5</td>
<td>81.1</td>
<td>78.1</td>
<td>89.3</td>
<td>83.9</td>
</tr>
<tr>
<td>Moderate</td>
<td>8.1</td>
<td>0.7</td>
<td>3.9</td>
<td>3.3</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>5.3</td>
<td>6.5</td>
<td>2.7</td>
<td>9.0</td>
</tr>
<tr>
<td>High</td>
<td>3.2</td>
<td>4.3</td>
<td>5.2</td>
<td>2.5</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>1.9</td>
<td>5.3</td>
<td>5.8</td>
<td>4.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Very high</td>
<td>1.3</td>
<td>1.4</td>
<td>-</td>
<td>0.8</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>3.2</td>
<td>3.3</td>
<td>7.7</td>
<td>0.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Extreme</td>
<td>0.6</td>
<td>0.7</td>
<td>-</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.3</td>
<td>1.9</td>
<td>3.3</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Source: Batemans Bay District Office, Forestry Commission of N.S.W., fire weather records.
Table 3. Forest fires attributed to recreation activity\(^{(1)}\) in Victoria, N.S.W., and N.S.W. South Coast and Southern Tablelands District

<table>
<thead>
<tr>
<th>Region</th>
<th>Period</th>
<th>Number of Outbreaks</th>
<th>% Total Outbreaks</th>
<th>Area of State Forest Burnt (ha)</th>
<th>% of State Forest Burned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria</td>
<td>1972/73</td>
<td>68</td>
<td>11.9</td>
<td>4630</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>1973/74</td>
<td>23</td>
<td>10.9</td>
<td>53</td>
<td>0.1</td>
</tr>
<tr>
<td>N.S.W.</td>
<td>1972/73</td>
<td>44</td>
<td>10.3</td>
<td>817</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>1973/74</td>
<td>15</td>
<td>11.3</td>
<td>101</td>
<td>3.4</td>
</tr>
<tr>
<td>South Coast and Southern Tablelands</td>
<td>1972/73</td>
<td>21</td>
<td>6.6</td>
<td>705</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>1973/74</td>
<td>4</td>
<td>4.0</td>
<td>75</td>
<td>2.7</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Recreation activities included under campers, tourists, sportsmen.

Source: Reports of State Forest Services
The suitability for many recreation activities is also conditioned by windspeed, e.g. exposed beaches become unpleasant at windspeeds greater than 4.2 m.s\(^{-1}\), at which speed sand grains greater than 0.1 mm in diameter are moved (Fournier 1972). Sailing, particularly on inland waters, becomes difficult for novice sailors at windspeeds greater than 8.0 m. s\(^{-1}\) and for experienced sailors at windspeeds greater than 10.8 m. s\(^{-1}\). Table 4 shows the percentage frequency of winds above these speeds at Moruya Heads. The study area is highly influenced by sea breezes which frequently have sufficient velocity to make beach recreation uncomfortable or unpleasant. An occasional phenomenon termed the 'southerly buster' brings a sharp change from calm, warm and sunny conditions to high wind, and often rainy conditions accompanied by a very sharp drop in temperature. The sea breeze and southerly buster are discussed by Berson and others (1957) and Gentilli (1969). The southerly buster has considerable implication for recreation despite its occasional nature. The sudden onset of these winds often results in extreme hazard for unwary fishermen at sea in small boats, and in the capsizing of small sailing craft. It also has sufficient velocity to move sand with considerable force. A recent death occurred when a boy was impaled by a beach umbrella blown along by such a wind.

The Role of Climate and Weather in Recreation Trip Decision-making

There have been many studies which have considered average climatic conditions in terms of their importance to the comfort of man (e.g. Maunder 1962; Murray 1972; Terjung 1966). Some studies have been specifically related to the suitability of the climate of an area for tourism and recreation (e.g. Perry 1968; Rivolier 1966). Other
Table 4. Monthly frequency (%) of days with winds exceeding critical velocities at 0900 and 1500 hrs, and frequency of strong wind and gale phenomena recorded by weather observers, Moruya Heads 1957-1972 inclusive

<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>hr</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4.2 m.s(^{-1})</td>
<td>0900</td>
<td>50.7</td>
<td>61.5</td>
<td>70.4</td>
<td>70.1</td>
<td>69.1</td>
<td>66.8</td>
<td>70.5</td>
<td>69.3</td>
<td>66.2</td>
<td>60.2</td>
<td>45.8</td>
<td>46.3</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>22.4</td>
<td>25.7</td>
<td>32.4</td>
<td>35.7</td>
<td>48.6</td>
<td>52.1</td>
<td>50.4</td>
<td>35.5</td>
<td>27.0</td>
<td>26.6</td>
<td>23.9</td>
<td>25.7</td>
</tr>
<tr>
<td>&gt;4.2 m.s(^{-1})</td>
<td>0900</td>
<td>49.3</td>
<td>38.5</td>
<td>29.6</td>
<td>29.9</td>
<td>30.9</td>
<td>33.2</td>
<td>29.5</td>
<td>30.7</td>
<td>33.8</td>
<td>39.8</td>
<td>54.2</td>
<td>53.7</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>77.6</td>
<td>74.3</td>
<td>67.6</td>
<td>64.3</td>
<td>51.4</td>
<td>47.9</td>
<td>49.6</td>
<td>64.5</td>
<td>73.0</td>
<td>73.4</td>
<td>76.1</td>
<td>74.3</td>
</tr>
<tr>
<td>&gt;8.0 m.s(^{-1})</td>
<td>0900</td>
<td>7.9</td>
<td>6.5</td>
<td>3.1</td>
<td>4.2</td>
<td>4.9</td>
<td>5.7</td>
<td>6.6</td>
<td>5.7</td>
<td>9.9</td>
<td>11.9</td>
<td>14.9</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>34.2</td>
<td>29.8</td>
<td>28.0</td>
<td>25.5</td>
<td>13.4</td>
<td>8.3</td>
<td>12.7</td>
<td>20.7</td>
<td>28.4</td>
<td>31.9</td>
<td>38.4</td>
<td>36.6</td>
</tr>
<tr>
<td>&gt;10.8m.s(^{-1})</td>
<td>0900</td>
<td>2.0</td>
<td>1.3</td>
<td>0.4</td>
<td>1.9</td>
<td>2.0</td>
<td>3.2</td>
<td>2.4</td>
<td>2.6</td>
<td>5.2</td>
<td>4.2</td>
<td>7.2</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>22.1</td>
<td>17.0</td>
<td>12.2</td>
<td>11.5</td>
<td>5.3</td>
<td>3.0</td>
<td>5.9</td>
<td>7.4</td>
<td>14.6</td>
<td>21.1</td>
<td>21.4</td>
<td>21.7</td>
</tr>
<tr>
<td>Strong wind or gale recorded (&gt;15m.s(^{-1}))</td>
<td>27.6</td>
<td>22.8</td>
<td>18.8</td>
<td>14.0</td>
<td>6.9</td>
<td>4.9</td>
<td>9.2</td>
<td>10.5</td>
<td>20.7</td>
<td>26.8</td>
<td>31.2</td>
<td>31.1</td>
<td></td>
</tr>
</tbody>
</table>
studies have attempted to explore correlations or causal relationships between weather conditions and attendance at recreation sites (Duffell 1972; Paul 1972; Perry 1972; Van Lier 1973). Perry (1972) cited studies in Canada, Britain, and Rumania which showed that, for most decisions made on a daily basis, the forecast weather in terms of temperature and rain is the most appropriate. Sunshine or cloudiness, wind, and humidity are also important to some recreations. Paul (1972) noted that a person making a day trip decision will probably consider present and forecast weather at the point of origin and at the destination. However, other studies have shown that when an unfavourable forecast is issued after a trip has been planned, that forecast often is disregarded. For example Adams (1973), in a study of New England (USA) beach trip decision-making, found that a significant proportion of those with a strong prior commitment to a trip, such as having children anticipating the trip, perceptually distorted unfavourable weather forecasts so as to justify their trip decision. Day trip recreation therefore is dependent on the individual's perception of, and reaction to, weather and weather forecasts.

The choice of destination for an annual vacation is usually made on the basis of desire for certain recreation activities at some time well in advance of available forecasts. While greater accuracy in weather forecasting, and greater public faith in that accuracy, should reduce the propensity to discount or distort the importance of forecast conditions to day trip recreation, advance planning for vacations is unlikely to be influenced by the present form of forecasting. The type of information which would permit choice between two or more destinations on the basis of expected weather is not readily available. The information
available in terms of average conditions such as number of raindays, mean hours of sunshine, and mean maximum, mean minimum, and mean daily temperatures, forms only a crude guide to expected weather conditions. The variation of these average values within the range of travel of most vacation trips (i.e. the distance from home to alternative resorts) may not be as important as the variation in other environmental considerations such as scenery or type of beach.

"From a purely outdoor recreation viewpoint, an ideal climate is one where it never rained, was always pleasantly warm but not hot, was always mildly sunny, was never too humid, had only gentle breezes, etc;" (Clawson 1966). Even if such a climate existed the keen swimmer might desire it hotter, or the sailor might wish it windier. It is suggested here that a more useful guide to holiday decision-making would be provided by frequency charts showing periodic suitability for particular types of recreation activity.

The principle stated is that conditions under which it is pleasant or comfortable for one activity, say sunbathing, may be less pleasant for some others, say bushwalking. Given activity specific information a more soundly based choice, both of the destination and time of year for a vacation, could be made.

The Use of Seasonal Indices to Describe Climatic Suitability

Indices are often used to describe how pleasant a climate is at any particular season. The summer index is the most commonly used. The weather attributes used in the derivation of these indices are, in most cases, temperature, sunshine, and rainfall. A number of seasonal indices are reviewed by Cutler (1973). The predictive value of the summer
index has been shown to be poor. Among the most simple, yet useful, indices is that of Perry (1968). Perry noted that "the general public's recollection of a particular summer is often determined by the weather that was experienced during the family's holiday". He considered that the importance attached to a few days of ideal conditions warranted investigation of the spatial and temporal variations of warm summer weather, for which he adopted a maximum daily temperature of 25°C. This statistic provided a basis for suggesting when the best chance of experiencing good recreation weather occurred at any particular resort. However, with this index, even the best of the stations considered - Kew, England - had a range from zero in all months of one year up to better than one day a week in July in another year. The uncertainty of predictions which might be made on the basis of this index is due, in part, to the fact that the relationship between the meteorological variable used and ideal, or suitable, conditions, is not clearly established. "When climatic information is used in decision-making in connection with some weather sensitive activity ..... it is essential that the information be in a form appropriate to the problem" (Maunder 1972).

Maunder (1962) had previously attempted to express all the aspects of climate which contribute to human comfort in a single index number. His assessment of the human climatic index utilized the division, into five arbitrary steps, of the range between the extremes of each element. A subjective weighting was applied to each element. The weighted scores were totalled to give the index value. This index was designed for a narrow range of climates. It has a number of inconsistencies, mainly due to the use of correlated variables such as
frequency of screen frost and of ground frost. Mander acknowledged that a major shortcoming with this approach was that several of the fourteen required elements for the index were recorded only at first order stations. The index therefore has limited spatial application and is, in addition, subjective in its evaluation of the importance of individual climatic elements.

Paul (1972) discussed the relationship between eight outdoor recreation activities and five weather variables at a number of Canadian sites. He also considered the correlation between the activities, as recorded by visits to recreation sites, and two simple climatic indices, a discomfort index and an effective temperature index. The study identified some high correlation coefficients between activities and climatic variables. Some activities were shown to be more strongly influenced by weather than were others. An hypothesis for the choice of recreational activity under different temperature conditions was presented, with the suggestion that the total weather situation should be considered in developing a complete hypothesis of activity selection.

A further study was presented by Van Lier (1973) who established that most variation in recreation attendances at observed sites was explained by the three variables temperature, sunshine or cloudiness, and wind velocity. The first two variables are correlated. The addition of humidity, wind direction, global radiation and barometric pressure added little to the variance explained, probably due to correlation with the three prime variables. These studies by Van Lier, Paul, and others appear to have more application for the manager of a recreation site estimating daily demand on the basis of forecast weather (and season and day of week) than they have for the holidaymaker in what
Clawson terms the anticipation or planning stage of recreation "when the person or family considers what to do, where to go, when, what to take, how much time and money to spend, and the like" (Clawson 1966).

It is clear that the complex pattern of weather variables is ideally treated as a single influence on recreation behaviour. There is a need for an explicit model which relates commonly recorded weather variables to suitability for recreation rather than to actual participation. It is suggested that a model of the heat balance for recreation activities therefore has considerable potential.

Application of Biometeorological Indices to Recreation

There have been many attempts to derive biometeorological indices for application to human comfort and performance. Most of these indices in some way consider the balance between the input of heat to the body from an environment, the generation of bodily heat through metabolism, and the transfer of heat from the body to its environment.

The principle of the human heat balance model is that man has a temperature regulation system which maintains a nearly constant "core" or "deep body" temperature. Maintenance of this core temperature \( T_c \) depends on control of the surface skin temperature \( T_s \) within certain comfort limits. The body makes physiological adjustment to the gradient in temperature from the core to the skin surface by means of metabolic heat production, the flow of blood, and therefore heat, to the periphery of the body, and by sweating. The value of this process to recreation studies lies in the fact that these mechanisms have definite limits. If these limits are exceeded the skin and core temperatures will rise or fall beyond the comfort value for the individual. Comfort values are linked to
safety values critical to the proper functioning and life of the body. Variations of more than about 1°C from a core temperature ($T_c$) of 37°C can be indicative of poor health, and variations of more than 2°C, particularly in heat gain, are symptomatic of serious illness (Tromp 1963). There are mechanisms by which the body regulates temperature to maintain this narrow range. Comprehensive reviews of studies of temperature regulation are given by Hammel (1968) and Cabanac (1975).

Under normal conditions the controlling mechanism is vasomotor regulation, where the body attempts to stabilize core temperature in response to the gradient between the core and the skin. Blood flow can be varied greatly by vasomotor regulation to increase the rate of transfer of heat from core to skin. If the temperature of the core is rising the blood vessels are dilated and the flow of blood, and therefore of contained heat, to the skin is increased. If the core temperature is falling the blood vessels are constricted and the flow of blood decreased. This mechanism operates in most circumstances where conditions promoting the heat gain or loss are not extreme. The importance of blood flow in heat transfer is discussed in detail by Burton and Edholm (1955), who derived a nomogram for calculation of a "thermal circulation index", the ratio between core to surface and surface to environment insulation. This study of recreation and climate is particularly concerned with the effect that weather variables have on the insulation from surface to environment, and thus in the ability of the body to maintain optimum values of $T_s$ and $T_c$.

Under the conditions where vasoregulation does not compensate for the net exchange by radiation, convection and evaporation to maintain these temperatures, the obvious response is to change the temperature,
humidity, wind or radiation environment, or some combination of these, or to change the position of the body so more or less radiation or convection occurs, or to increase or decrease the insulative layer around the skin by adjustments to the thickness and/or colour and/or wind and rain protective value of clothing. Some of the options open to the sunbather on the beach experiencing excessive heat are, for example, (1) enter the water (reduce temperature of environment, decrease area heated by solar radiation, change vapour pressure gradient), (2) move into the shade (reduce solar gain), (3) don absorbent light coloured, loose fitting clothing (reduce solar and long wave radiative gain, increase evaporative area and efficiency), or (4) leave the beach. The sunbather experiencing excessive cold may for example (1) enter the water (probably to reduce convective loss – but at hazard when leaving the water), (2) don dark, insulative clothing (increase radiative gain, decrease convective evaporative and radiative loss), (3) become active (increase bodily heat production), or (4) leave the beach.

Some attempts have been made to use the human heat balance to determine recreation climate or the importance of weather to recreation activity. Van Lier (1973) attempted to correlate daily heat balance with visits to recreation sites but the variance explained was less than that explained by the statistical weather model previously mentioned. Van Lier sought to derive daily values of the heat balance to represent a wide range of activities. It seems more appropriate to use a heat balance model for individual activities or activity sets having similar heat load characteristic under the same meteorological conditions. Applied to actual weather observations, rather than to daily or longer-term averages, such a model would permit frequency analysis of a recreation climate index to give a
more appropriate indication of the potential of an area for particular activities.

Green (1967) used the heat balance method to estimate the skin temperature condition which would result from activities having specified metabolic rates and performed under specified weather conditions. His system permits unlimited variation of clothing and metabolic rate in response to wind, air temperature, and sunshine conditions. Green used the model to predict the energy and time requirements for particular recreation activities, e.g. climbing Mt. Snowdon. Green's study has considerable relevance to trip planning and to recreation climate, but the derivation of a number of the parameters used in the equation is unclear, and the model is particularly related to English conditions.

A further important study is that by Terjung (1966) in which he provides a classification of climate, relevant to human comfort, which has potential application to tourism. However, the combination of monthly mean values of some variables with daily mean values of other variables makes the use of actual values from selected times of the day impossible. Terjung's use of effective temperatures and a wind chill-solar radiation relationship is useful for broad scale evaluation of comfort conditions but the classification is based on averages rather than actual values of weather variables. A discussion of these and several other biometeorological studies is given by Landsberg (1972).

Characteristics of an Ideal Recreation Climate Model

In view of the difficulties inherent in the indices and models discussed above, it is suggested that an ideal recreation climate model would have the following attributes:
(1) ability to use standard meteorological observations from low order stations,
(2) minimum use of average values, maximum use of real values,
(3) input of the total weather situation rather than single or limited sets of variables,
(4) application to individual activities, or sets of similar activities.

An appropriate model thus would be one which used standard observations from any first, second, or third order station in the Australian weather observation network. The external environmental variables involved are radiation, air temperature, rate of air movement, and water vapour content of the air. These can be derived from wet and dry bulb temperature, anemometer and cloud cover records.

In some areas even third order stations are sparsely located. In order to provide the fullest possible basis for trip decision-making, it would be an advantage to be able to extrapolate to a void area from a station representative of that area. Because the network of stations which record only rainfall is more closely spaced there is a potential to fill the gaps in the climate station network if one can classify rainfall into regions in which the pattern of rainfall and, by implication, the general weather pattern is similar. A regionalization study which involved the application of numerical classification techniques to rainfall records identified four rainfall regimes in the coastal zone between Wollongong and Eden (Yapp and Austin, paper in preparation). The generating mechanisms determining the rainfall climate were relatively homogeneous for each region. Moruya Heads appeared to be representative of a group of stations which included Batemans Bay and the weather
pattern identified there can reasonably be applied to the complete study area. Type stations for two groups to the north are Dapto and Nowra and for the group to the south, Merimbula.
V. DESCRIPTION OF THE RECREATION CLIMATE MODEL

Temperature Regulation Principles Used in the Model

The basic formula for temperature regulation of the human body is:

\[ M + W - E + (R + C + K) + S = 0 \]  \[ (1) \]

where \( M \) is the metabolic heat production, \( W \) is work done, \( E \) is the loss of heat by evaporation, \( R, C \) and \( K \) are radiative, convective and conductive heat exchange and \( S \) is the net storage of heat. Throughout this study these variables are expressed in SI units unless otherwise indicated.

At all times the body generates heat through the transformation of chemical energy into free energy in the process of metabolism. The basal metabolic heat production is 48 W.m\(^{-2}\), but rates up to ten times as great are common with hard exercise or heavy work. Some of the heat produced is lost in warming and humidifying inspired air but, since this is only a relatively small quantity, it may be necessary for large amounts of heat to be transferred to the surface of the skin. Heat transfer from the skin surface to the environment must then take place, often through a resistant layer of clothing. In the balanced situation, the following relationship applies:

\[ M - E - R_e = K = R + C \] \[ (2) \]

where \( M \) = net rate of heat production by the body

\( E \) = evaporative cooling at the skin surface

\( R_e \) = latent heat transfer in respiration

\( K \) = conduction of heat from skin to outer clothing surface
26.

\[ R = \text{radiative loss from outer clothing surface} \]
\[ C = \text{convective loss from outer clothing surface} \]

These processes operate in association with changing environmental conditions so that temperature regulation varies with (1) heat gained from shortwave (solar) radiation, (2) the temperature gradient between the body surface and the environment, (3) the vapour pressure gradient between the body surface and the environment and (4) the rate of air movement. If transfer by \( K \) or by \((R + C)\) is less than the amount necessary to balance the equation, the skin surface will not be able to lose heat at the rate necessary to maintain the temperature of the body \( (T_C) \) at 37°C, even with maximum dilation of blood vessels. In this situation the latent heat loss necessary for cooling exceeds the evaporative power of the environment. Similarly, if \( K \) or \((R + C)\) are so large as to exceed \((M - R_e)\), even with maximum constriction of blood vessels and with \( E = 0 \), then \( T_C \) will fall.

In the model all variables are related to unit area of body surface in order to avoid difficulties due to body shape and size (mass). Fourier's law states that the rate of loss of heat \((H)\) from a surface is directly proportional to the difference between core temperature \( (T_C) \) and the surface temperature \( (T_S) \), to the surface area \( (A) \), and to the thermal conductivity \( (k_1) \) of the body shell, and inversely proportional to its thickness \( (D) \):

\[ H = \frac{k_1 A}{D} \left( T_C - T_S \right) \]  

(3)

By using a constant unit of surface area it is possible to avoid the consideration of the heat capacity of the body, which is directly related to its mass. Since the concern in this study is with the rate of heat exchange, equation (3) can be simplified to:
where $k_2$ is the thermal conductivity per unit area. To keep $T_c$ and $T_s$ constant the value of $k_2$ can be changed by vasomotor regulation and/or by changes in surface insulation, e.g. by the addition of clothing. This study therefore explores the relationship between $H$ and $k_2$ and the environmental and metabolic conditions which control the adjustment necessary to $k_2$ in the clothed and unclothed state.

Consideration of these controls is simplified by use of the resistance ($1/k$) rather than conductance ($k$) because the insulative value of the components of the surface (skin and/or clothing) can be treated in series. Separate consideration can be given to insulation from core to skin and from skin to environment. It follows that it is possible to analyse the effect of changes in internal heat production due to metabolism, changes due to air movement and humidity, and changes in insulation at the body surface due to clothing.

The variables used in the heat balance model can be considered in two general classes (a) those related to the man and (b) those related to the environment.

**Variables Related to the Man**

**Effective Area.** Less than the complete body surface area is fully effective as a source of radiant emittance or as a receiver of radiation from the environment. The amount of reduction in effective body surface depends on the position of the body. Maximum effective area occurs in a spreadeagled position, suspended above the ground surface. Many calorimetric studies of heat exchange therefore have been carried out.
with individuals suspended in a hammock. Other studies have been carried out for standing, walking, sitting and prone positions. The effective areas per unit area of body surface for convective and longwave radiative heat transfer used in this study are $A_{\text{eff}} = 0.78 \text{ m}^2$ for standing and walking, $A_{\text{eff}} = 0.71 \text{ m}^2$ for sitting, and $A_{\text{eff}} = 0.80 \text{ m}^2$ for prone positions (Winslow and others 1940; Hardy 1949; Kerslake 1972).

The effective area for sunbathing is difficult to estimate due to the position of the body in contact with the ground and for which convective transfer would be negligible. However, the normally small component of conductive transfer is increased in this case. Its size is uncertain because of the variation in albedo and thermal conductivity of the surfaces involved, e.g. sand, coloured cotton towelling, and inflatable rubber mattresses. It is assumed that the gain in conductive transfer approximates the loss in convective transfer and the prone value indicated was adopted for sunbathing. This does not apply in the case of shortwave radiation because the area in contact with the ground will receive no direct radiation from the sun, or diffuse radiation from the sky or ground. The effective area for diffuse radiation in this case was adjusted by the half cylindrical surface area assuming average body dimensions and 85-90% effective area in the suspended prone position (Hardy 1949). The value obtained was $0.535 \text{ m}^2$. For other positions the effective area for diffuse shortwave radiation was assumed to be the same as that for longwave transfer.

The calculation of effective area for direct solar radiation is one of the largest sources of variance in human heat balance studies. It may be measured as the area of the shadow cast by the body on a surface normal to the sun's rays. A number of studies have included such
measurements, the most comprehensive being that by Ward and Underwood (1967). Estimates of irradiated area similar to those obtained by measurement have been obtained by several authors (e.g. Cena 1974; Robinson 1964) by the relationship $2 \cos \theta / \pi$ which is derived on the basis that the approximately cylindrical human body is irradiated by an area factor $D_h \cos \theta / \pi r h$, where $D$ and $r$ are the diameter and radius and $h$ the height of the cylinder and $0$ is the solar altitude. This gives a standard value of $0.63 \cos \theta$ for man in a standing position. Because this study is concerned with other positions three values were calculated for the effective area $A_{\text{dir}}$ ($\text{m}^2$):

- Standing $A_{\text{dir}} = 0.61 \cos \theta / 1.8$
- Reclining $A_{\text{dir}} = 0.61 \sin \theta / 1.8$
- Seated $A_{\text{dir}} = 0.78 \cos \theta / 1.8$

The factor 0.61 is derived from the half cylindrical area $D_h$ where $D$, the diameter of "average" man equals 0.35 m, and $h$, the height of "average" man equals 1.75 m. This is similar to the value 0.63 used by Robinson (1964) and Cena (1974) and the average 0.63 measured for nine reclining subjects by Gagge and Hardy (1967). The factor 0.78 was derived in a similar manner for the seated position, where a greater area of the body can be exposed to direct solar radiation. The calculated areas are divided by 1.8, which is a generally accepted average body surface area, in order to obtain the effective area per unit area of body surface. The value obtained is $0.34 \cos \theta$ for standing and walking positions. This closely approximates the $0.32 \cos \theta$ obtained by Lowry (1969), and others, using the relationship $\cos \theta / \pi$. 
Budyko (1974) proposed a factor \(\cot \frac{\theta}{\pi}\) which appears to be in error. At low sun angles \(\cot \theta\) overestimates the radiation area. For example, for a nude individual in clear sky conditions at Melbourne in mid-January \(\cot \frac{\theta}{\pi}\) gives a rate of direct shortwave solar gain of 554 W.m\(^{-2}\) at 0800 compared with 215 W.m\(^{-2}\) by \(D_h \cos \frac{\theta}{1.8}\) and 232 W.m\(^{-2}\) by \(\cos \frac{\theta}{\pi}\).

Albedo of the Surfaces. Averages were adopted for reflectivity of the skin and clothing. Skin reflectivity was assumed to be 30%, and that of clothing 45% for light coloured summer clothing, and 35% for darker coloured winter clothing (Fänger 1970; Lowry 1969). Albedo determines the gain from shortwave solar radiation.

Emissivity. Three values of emissivity were used, namely 0.99 for the nude individual, 0.95 for normally clothed, and the average 0.97 for partly or light weight and coloured clothing assemblies (Fanger 1970).

Clothing. The insulation of clothing is conveniently described in CLO units where 1 CLO is equal to a thermal insulation of 0.155°C.m\(^2\).W\(^{-1}\) and is expressed as the insulation which will maintain a man whose metabolism is 58 W.m\(^{-2}\) indefinitely comfortable in an environment of 21°C, relative humidity less than 50% and air movement of 0.1 m.s\(^{-1}\) (Burton and Edholm 1955). The CLO unit is equivalent for convenience to a business suit. The CLO values of average clothing assemblies were used throughout the study. The values were 0 for nude and brief swimwear, 0.1 for shorts, 0.3 for light summer casual clothing, 0.6 for average casual and bushwalking clothing; 1.0 for average winter clothing, and 1.25 for protective winter clothing. The CLO values of such assemblies have been determined by Fanger (1970), Burton and Edholm (1955) and others.
Metabolism. The metabolic heat production is determined by the rate of transformation of chemical energy into heat. It can be measured with reasonable accuracy by the rate of oxygen consumption. Part of the energy produced may be used to do work on an external system, and this would be important, for example, in calculation of the energy requirements for mountain climbing. The work done may be expressed in terms of mechanical efficiency ($\eta$) so that the net metabolic rate is equal to $M (1-\eta)$. The mechanical efficiency of recreation activities has largely been ignored in this study, firstly because most of the considered activities are assumed to have a net work value of zero, secondly because the work value is specific to the individual occurrence of an activity, and thirdly because approximations are used for the metabolic heat production of various activities and modification for thermal efficiency is not warranted. Table 5 shows the metabolic rates adopted for the general activity types discussed in this study. These values are approximations derived from calorimetric studies and other estimates by Fanger (1970), Passmore and Durnin (1967), Bazett (1949) and Edholm (1967).

Skin Temperature. A skin temperature ($T_s$) of 33°C is widely regarded as the optimum for human comfort, while the range of comfortable $T_s$ extends from 31°C to 35°C and may, under certain conditions extend as low as 29°C. In this study three skin temperatures were used to set the boundaries of the suitability of weather. It was assumed that any weather conditions under which the body heat balance could be maintained with the skin temperature of 33°C at a particular metabolic rate could be considered suitable. However, it is possible that the balance could be maintained with $T_s = 33°C$ only by maximum vasodilation and profuse sweating in hot conditions or by maximum vasoconstriction in cool conditions. In order
Table 5. Metabolic rates for activities used in analyses

<table>
<thead>
<tr>
<th>Activity</th>
<th>Metabolic Rate (W.m$^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunbathing</td>
<td>60</td>
</tr>
<tr>
<td>Fishing</td>
<td>95</td>
</tr>
<tr>
<td>Strolling - level ground at 3.2km.h$^{-1}$</td>
<td>115</td>
</tr>
<tr>
<td>Walking - level ground at 4.8km.h$^{-1}$</td>
<td>150</td>
</tr>
<tr>
<td>Light exercise - family bushwalking, light sport, golf, trout fishing</td>
<td>220</td>
</tr>
<tr>
<td>Moderate exercise - active sport, tennis</td>
<td>270</td>
</tr>
<tr>
<td>Hard exercise - hard bushwalk, vigorous sport</td>
<td>350</td>
</tr>
<tr>
<td>Very hard exercise - competition sport, squash, football</td>
<td>450</td>
</tr>
</tbody>
</table>
to define comfort more narrowly, any weather conditions suitable at both
$T_s = 31^\circ C$ and $T_s = 35^\circ C$ were considered ideal, while conditions too hot
for maintenance of balance at $T_s = 31^\circ C$, or too cold at $T_s = 35^\circ C$ were
considered suboptimum even though suitable at $33^\circ C$. Any weather
conditions too hot or too cold for maintenance of the body heat balance
at $T_s = 33^\circ C$ were deemed totally unsuitable for the relevant activity.

Variables Related to the Environment

Standard Meteorological Variables. Weather observations at most daily
return stations are recorded at 0900 and 1500. Tapes of these daily
data on Card 18 format are available from the Australian Bureau of
Meteorology. The relevant variables, as used in this study of Moruya
Heads, are 0900 and 1500 wet and dry bulb temperatures, windspeeds and
total cloud cover. Windspeeds are recorded in knots and conversion to
SI units is by the factor 0.514. Cloud is recorded in eighths of sky
covered and must be converted to the equivalent decimal for the program
used.

Because of minor gaps in the records for some months the number
of days used for the analyses of recreation climate varied. Since all
calculations were made on a monthly basis the number of days within each
suitability index is expressed as the total number of days of complete
record for that month. Table 5 in the Appendix shows the number of years
of record and number of complete days in each month.

Solar Radiation. As no direct measurements of radiation are available
from low order stations, the radiant flux must be estimated.

Radiation from the sun is attenuated by the earth's atmosphere.
The amount of direct solar radiation incident on a plane normal to the
angle of incidence of the sun's rays, and the direct, diffuse and total radiation incident on a horizontal plane, have been calculated for a number of stations by Spencer (1965, 1974). Readings for Canberra (latitude 35°S) have been used for Moruya Heads (latitude 35°55'S). The Canberra data are regarded as a reasonable approximation for Moruya Heads. The solar altitude is also obtained from these tables, for use in the calculation of effective area of the body receiving solar radiation.

The attenuation of solar radiation by cloud was calculated from cloud cover observations recorded by Bureau of Meteorology weather observers by the relation:

\[ F_r = (1 - 0.1N) \]

where \( N \) = cloud cover in eighths of sky overcast. Gates (1962) and Budyko (1974) have suggested that total overcast reduces solar radiation gain by about 80%. The assumption is made in this study that a cloud cover observation applies equally to all parts of the sky averaged over a period of one hour before and after the recording. The occurrence of stable cloud banks at sea or over mountains with sunny conditions at the coastline could not be allowed for because the records do not indicate the position or movement of cloud banks.

Reflectivity. There is an additional component of shortwave radiation due to reflection from natural and man-made surfaces. The reflectivity of a number of these surfaces has been experimentally determined (e.g. Budyko 1974; Robinson 1966). Table 6 shows the reflectivity values used in this study.
Table 6. Albedo constants used in the model

<table>
<thead>
<tr>
<th>Surface</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare human skin</td>
<td>0.30</td>
</tr>
<tr>
<td>Light coloured summer clothing (CLO 0.3)</td>
<td>0.45</td>
</tr>
<tr>
<td>Moderately light, midseason clothing (CLO 0.6)</td>
<td>0.40</td>
</tr>
<tr>
<td>Dark coloured winter clothing (CLO 1.0)</td>
<td>0.35</td>
</tr>
<tr>
<td>Sandy beaches</td>
<td>0.40</td>
</tr>
<tr>
<td>Forests and grassy parklands</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Derivation of the Parameters

Shortwave Radiation. The shortwave radiation gain by the body is equal to the sum of direct radiation from the sun plus diffuse (scattered) radiation from the sky, plus diffuse radiation reflected from the ground. Only day time conditions are considered by the model. The shortwave radiation gain (irradiance) is calculated by:

\[ R_s = \alpha_{su} \left( (A_{dir} \cdot R_{dir}) + (A_{dif} \cdot R_{dif}) + ((1-\alpha_{en}) \cdot A_{dif} \cdot R_{tot}) \right) \cdot F_r \cdot F_{acl} \text{ W.m}^{-2} \]

where
- \( \alpha_{su} \) = albedo (absorptance) of skin or clothing surface
- \( \alpha_{en} \) = net albedo of the environmental surfaces
- \( A_{dir} \) = effective area for direct solar radiation
- \( A_{dif} \) = effective area for diffuse radiation
- \( R_{dir} \) = direct solar radiation intensity on a surface normal to the solar beam
- \( R_{dif} \) = diffuse solar (sky) radiation intensity
- \( R_{tot} \) = total radiation (direct and diffuse) incident on a horizontal surface
- \( F_r \) = attenuation factor due to cloudiness
- \( F_{acl} \) = factor related to the increase of effective area, and insulation due to clothing.

The factor \( F_{acl} \) was derived from the insulative value of clothing by the relationship:

\[ F_{acl} = 1 + 0.15 I_{cl} \]

where \( I_{cl} \) is the insulation of the clothing assembly in CLO units.

Robinson (1949) has shown that clothing forms an effective barrier to radiative transfer in both directions.
The adopted values of $\alpha_{Su}$ and $\alpha_{en}$ are shown in Table 6. The values of $R_{dir}$, $R_{dif}$ and $R_{tot}$ are adopted from Spencer (1965). The derivation of $A_{dif}$ and $A_{dir}$ is described above.

**Longwave Radiation.** Where the operative or mean radiant temperature of the environment is known, longwave radiation transfer can be calculated by a single relationship involving the Stefan-Boltzmann constant and the difference in temperature between the surface of clothing and/or skin and the environment. Since the mean radiant temperature is not recorded, a satisfactory approximation for the longwave radiation component is obtained by use of the Stefan-Boltzmann constant with the difference between skin temperature and dry bulb air temperature in degrees Kelvin. The emissivity of the environment is assumed to be 1.0 which is in accord with values generally accepted in the papers referred to in this study. Observations with a Hewlett Packard radiant flux meter suggest that the environmental emissivity is lower than 1.0 especially on the sandy South Coast beaches, but insufficient satisfactory observations were completed. The difference due to lowering of the environmental emissivity of sandy beaches to its probable value of 0.98 is quite small, an average value being $0.1 \text{ W.m}^{-2}$.

The longwave radiation transfer is calculated by:

$$R_l = \varepsilon_{en} \cdot H_r (T_s - T_d) \cdot A_{eff} \cdot F_{acl} \text{ W.m}^{-2}$$

where $\varepsilon_{en}$ = emissivity of the environment

$T_s$ = skin temperature

$T_d$ = dry bulb air temperature

$A_{eff}$ = the effective radiating area of the body
36.

$H_r$ is the radiative transfer coefficient and is calculated as follows:

$$H_r = \sigma \cdot \varepsilon_s \left( \frac{T_s + T_d}{2} + 273 \right)^3 \text{W.m}^{-2} \cdot \text{°C}^{-1}$$

where $\sigma$, the Stefan-Boltzmann constant $= 5.67 \times 10^{-8}$ W.m$^{-2}$ °K$^{-4}$ and $\varepsilon_s$ is the emissivity of the skin or clothing.

**Convection.** Convection is calculated from the relation:

$$C = H_c (T_s - T_d) \cdot F_{cl} \text{W.m}^{-2}$$

where $H_c$ is the convective transfer coefficient, the value of which is adopted following Monteith (1974) as:

$$H_c = 7.6V^{0.5} \text{W.m}^{-2} \cdot \text{°C}^{-1}$$

where $V$ is the rate of air movement in m.s$^{-1}$. This expression gives values which are reasonably close to an average of values observed experimentally by partial calorimetric methods (Gagge and Hardy 1967). There appeared to be little advantage in the more complicated method of calculation by Nusselt, Reynolds and Prandtl numbers (Hardy 1949; Kerslake 1972) in view of the other approximations in this study.

$F_{cl}$ is the effect of clothing insulation on convective transfer and is determined by:

$$F_{cl} = \frac{1}{1 + 0.155 \left( \frac{H_r + H_c}{T_{cl}} \right)} \text{°C.m}^2 \cdot \text{W}^{-1}$$
as derived by Gonzales, Nishi and Gagge (1974). \( I_{cl} \) is the insulative value of clothing in CLO units (1 CLO = 0.155 \( ^\circ \text{C.m}^2.\text{W}^{-1} \)).

**Evaporation.** The evaporative transfer coefficient is related to the convective transfer coefficient by the Lewis relation (Gagge, Hardy and Rapp 1969; Kerslake and Waddell 1957):

\[
\frac{H_e}{H_c} = 2.2 \left(^\circ \text{C. mm Hg}\right) \text{ at atmospheric pressure. Converted to SI units by the factor 7.54 this expression has a value of } \frac{H_e}{H_c} = 126V^{0.5}(\text{W.m}^{-2}\text{.kPa}^{-1}) \text{ which is close to the value of } 124V^{0.5} \text{ established by Kerslake (1972).}
\]

The rate of evaporation is dependent on the difference in vapour pressure between the evaporating surface \( \left( P_s \right) \) and its surrounds \( \left( P_a \right) \). Since \( T_s \) was set in the model, the saturation vapour pressure of the skin \( \left( P_s \right) \) also was constant. For the three values of \( T_s \) used the corresponding values of \( P_s \) were:

- \( T_s = 31^\circ \text{C} \quad P_s = 4.49 \text{ kPa} \)
- \( T_s = 33^\circ \text{C} \quad P_s = 5.03 \text{ kPa} \)
- \( T_s = 35^\circ \text{C} \quad P_s = 5.62 \text{ kPa} \)

The ambient vapour pressure of air \( P_a \) was determined by the difference between the vapour pressure \( \left( P_w \right) \) at wet bulb temperature \( \left( T_w \right) \) and a constant proportion of wet bulb depression. Rather than use conventional tables, the equation below was developed to facilitate computer calculation:

\[
P_a = P_w - (0.068 (T_d - T_w)) \quad \text{ kPa}
\]

Evaporative transfer \( (E) \) can be shown to be the sum of three processes, as follows:
\[ E = E_{\text{res}} + E_{\text{diff}} + E_{\text{sw}} \]

where \( E_{\text{res}} \) is respiratory heat loss, \( E_{\text{diff}} \) is insensible perspiration by diffusion through the skin, and \( E_{\text{sw}} \) is sensible perspiration by sweating. In this model \( E_{\text{res}} \) and \( E_{\text{diff}} \) are calculated. \( E_{\text{sw}} \) is not directly calculated, but the required sweat rate (\( E_{\text{rsw}} \)) is calculated as the difference between net gains and net losses of heat by all sources of heat exchange. Since the rate of sweat production is dependent on the vapour pressure gradient between skin and air, the maximum evaporative capacity of the air (\( E_{\max} \)) is also calculated. The formulae for these calculations are as follows:

\[
E_{\text{res}} = 0.017 M (1-\eta) (P_s - P_a) \quad \text{W.m}^{-2}
\]

\[
E_{\text{diff}} = 0.06 E_{\max} \quad \text{W.m}^{-2}
\]

\[
E_{\max} = H_e (P_s - P_a) F_{\text{pcl}} \quad \text{W.m}^{-2}
\]

where 0.017 is a constant related to the latent heat of vaporization and 0.06 has been experimentally determined as the proportion of skin wetted by insensible perspiration (Gagge, Stolwijk and Nishi 1970). Apart from \( F_{\text{pcl}} \) the other variables have been defined above. \( F_{\text{pcl}} \) is a factor related to the effect of clothing on the transfer of water vapour, and the latent heat of vaporization, which has been determined by Gonzalez, Nishi and Gagge (1974) as:

\[
F_{\text{pcl}} = \frac{1}{1 + (0.143 H_c / I_{\text{cl}})} \quad \text{°C.m}^2 \cdot \text{W}^{-1}
\]
In order to determine whether the environment has the capacity to receive released latent heat at the required sweat rate \( (E_{rsw}) \), \( E_{\text{max}} \) must be reduced by the amount of heat lost by insensible perspiration \( (E_{\text{diff}}) \).

Thus:

\[
E_{\text{pos}} = 0.94 E_{\text{max}} = E_{\text{max}} - E_{\text{diff}}
\]

The final formula for calculation of the required sweat rate is:

\[
E_{rsw} = M (1-n) + R_s - E_{\text{res}} - E_{\text{diff}} - (H_r + H_c) (T_s - T_d) F_{cl} \quad \text{W.m}^{-2}
\]
VI. INDEX VALUES OF RECREATION CLIMATE

Application of the Model

The rate of sweat required under any set of environmental and activity conditions can be used to derive the recreation climate index. A negative required sweat rate \( E_{rs} \) indicates that environmental conditions are such that heat loss is occurring from the body under the metabolic rate and clothing value applying, and those conditions are therefore unsuitable for that activity. If \( E_{rs} \) is zero, the heat balance is maintained without sweating. If \( E_{rs} \) is positive but less than \( E_{pos} \), heat balance is maintained with sweating and the area of skin wet with perspiration \( W_{rs} \) can be determined:

\[
W_{rs} = (E_{rs}/E_{pos}) + 0.06
\]

The range of wet skin area therefore lies between 0.06 and unity. In this study it is assumed that maximum skin wettedness does not render the environmental conditions unsuitable because of the flexibility involved in recreation behaviour. However, if \( E_{rs} \) exceeds \( E_{pos} \) the body will gain heat, and these occasions are considered unsuitable for the nominated activity at the skin temperature used in the relevant run of the program. The required sweat rate at the three skin temperature values is used to derive five classes of the recreation climate index as follows:

\[
\begin{array}{ll}
\text{INDEX} & \\
\text{Class 1} & : E_{rs} \text{ negative at } T_s 31^\circ C, T_s 33^\circ C, T_s 35^\circ C : \text{ COLD} \\
\text{Class 2} & : E_{rs} \text{ negative at } 35^\circ C, \text{ positive and } \leq E_{pos} \\
& \text{ at } T_s 31^\circ C, T_s 33^\circ C : \text{ COOL}
\end{array}
\]
Class 3 : \( E_{rsw} \) positive and \( < E_{pos} \) at \( T_s 31^\circ C \),
\( T_s 33^\circ C, T_s 35^\circ C \) : IDEAL

Class 4 : \( E_{rsw} \) positive and \( > E_{pos} \) at \( T_s 31^\circ C \),
\( < E_{pos} \) at \( T_s 33^\circ C, T_s 35^\circ C \) : WARM

Class 5 : \( E_{rsw} \) positive and \( > E_{pos} \) at \( T_s 31^\circ C \),
\( T_s 33^\circ C, T_s 35^\circ C \) : HOT

Weather data recorded at 0900 and 1500 (Australian Eastern Standard Time) at Moruya Heads, were used in the model. Morning or afternoon indices in classes 1 or 5 were regarded as totally unsuitable periods. Indices in classes 2 and 4 were regarded as suboptimum, indicating that the nominated activity could be practised at that time but that some discomfort was probable. Indices in class 3 were regarded as optimum occasions. The frequency of each index on a monthly basis for a record of 15 years was calculated.

In order to determine the importance of individual meteorological variables the frequency with which each class of the recreation climate index occurred under four types of weather was investigated. These four types of weather were selected as having importance to the individual's perception of weather conditions as pleasant or unpleasant for outdoor recreation.

Type 1 : raining at time of observation
Type 2 : 7/8 or 8/8 overcast, not raining
Type 3 : wind greater than 10 m. s\(^{-1}\), not overcast or raining
Type 4 : fine, sunny, not excessively windy.
It was considered that, though the heat balance may be suitable under rainy conditions, rain could reduce the perceived suitability of the occasion. Similarly though e.g. the heat balance may be suitable for sunbathing with heavy overcast, the pleasure gained under these circumstances is reduced. Strong winds interfere with the enjoyment of many forms of recreation. Because of the importance of wind to some activities the wind restriction in type 3 was varied to determine the number of days in the appropriate classes with windspeeds less than 8.0 m. s$^{-1}$ and 4.2 m. s$^{-1}$.

A further variation of windspeed determination was carried out for two activities - sunbathing and bushwalking, since it was considered that the number of days suitable for the first would be greatly increased if the sunbather took shelter from the wind, and that the strength of wind recorded at the exposed weather station would be considerably reduced in the forest. For these analyses wind was held to have maximum values of 1 m. s$^{-1}$ and 2.0 m. s$^{-1}$.

Seasonal Patterns of Recreation Climates

It was shown previously that the activities for which highest preference is indicated by visitors to the N.S.W. South Coast are casual walking, touring and sightseeing, sunbathing, surfing and swimming, and fishing. Local residents indicated similar general preferences. Because environmental and metabolic conditions could not be specified it was impossible to model surfing and swimming. Only active non-water pursuits are considered hereafter. The favoured activities and some other general activity types are discussed individually below.
Casual Walking. Two metabolic rates were considered, 115 W.m$^{-2}$ for easy strolling (3.2 km. h$^{-1}$ on a level surface), and 150 W.m$^{-2}$ for walking (4.8 km. h$^{-1}$ on a level surface such as a beach). Two clothing assemblies were considered, 0.3 CLO for light summer clothing (shorts, shirt, sandals), and 1.0 CLO for average winter clothing (slacks, shirt, jumper or jacket). Figures 4 and 5 show the percentage frequency of days per month too cold (index 1) and ideal (index 3) for these activities with summer clothing. No days were too cold with the winter clothing assembly and only rare days too hot with summer clothing. It follows that suitable clothing with a CLO value between 0.3 and 1.0 could be found for all days of the year at both 0900 and 1500. The heat balance of the body therefore is not the major limiting factor for strolling and walking. Because the indicated preference was for summer clothing, January to April are the most satisfactory months. However, since the preferred place for strolling and walking is along the beaches and tidal rock platforms, the critical wind value of 4.2 m.s$^{-1}$ operates. These winds reduce the number of suitable days, particularly in the afternoons between November and February. As a result, March and April are the months with most days with a comfortable heat balance and pleasant conditions for casual walking.

This assessment was confirmed when the heat balance index and weather types were cross tabulated and five new classes identified as shown in Figure 6. The monthly distribution of these classes is shown for casual walking in Figure 7. Superimposed on the histogram are the frequency of days with rain, 7/8 and 8/8 overcast, and strong winds at the time of observation. The relationship between pleasant days and low windspeed and between cloudiness and indifferent days is clearly shown.
Figure 4. Frequency of index values for beach strolling (M = 115 W.m$^{-2}$)
Figure 5. Frequency of index values for beach walking (M = 150 W.m$^{-2}$)
<table>
<thead>
<tr>
<th>Weather type</th>
<th>Heat balance class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cold</td>
</tr>
<tr>
<td>Rain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unpleasant (cold)</td>
</tr>
<tr>
<td>Overcast</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uncomfortable</td>
</tr>
<tr>
<td>Windy and Sunny</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indifferent</td>
</tr>
<tr>
<td>Fine and Sunny</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pleasant</td>
</tr>
</tbody>
</table>

Figure 6. Method of derivation of subjective comfort classes.
Figure 7. Monthly frequency of pleasant (1), indifferent (2), uncomfortable (3) and unpleasant (4) subjective comfort classes for casual walking, and cumulative frequency of weather types.
When the sensation of comfort and pleasantness is considered, i.e. when the ASHRAE (1967) definition of thermal comfort as "that state of mind which expresses satisfaction with the thermal environment" is applied, the suitability for strolling and walking shifts further towards the winter months because of less windy and cloudy conditions in those months. However, because of lower air temperatures, especially at 0900, it is too cold for these activities with summer clothing, and the maximum suitability will be attributed to the months of April and May.

Sunbathing. In a number of studies the value of the resting metabolic rate has been determined as 56 to 58 W.m\(^{-2}\). A value of 60 W.m\(^{-2}\) is used for sunbathing as a general approximation for the resting but not motionless condition involved. Clothing was assumed to be negligible in its effect and a CLO value of zero was used. Wind is of critical importance to sunbathing and a number of analyses were completed to determine the suitability for sunbathing within specified wind limits. Figure 8 shows the frequency of days per month when the thermal balance is suitable for sunbathing, together with the frequency of days when the heat balance is suitable and the windspeed less than the critical speed for sand movement, 4.2 m. s\(^{-1}\). Because wind is regarded as of such importance the model was also applied with the assumption that the sunbather had moved into a position such that the maximum wind velocity operating on the body was 1 m. s\(^{-1}\). All wind conditions exceeding this velocity were standardized to 1 m. s\(^{-1}\). The frequency of days with a suitable thermal balance under these conditions is also shown in Figure 8. Several important attributes of the area's recreation climate are revealed by these analyses. The very great importance of the sea
Figure 8. Frequency (%) of days per month with heat balance suitable for sunbathing; and frequency of suitable conditions with windspeeds less than 4.2 m.s⁻¹, and in shelter.
breeze is highlighted in the 1500 graph. For example, 73% of all January afternoons with a suitable thermal balance and clear sky conditions had windspeeds exceeding this critical value. The Figure shows that in both morning and afternoon the frequency of pleasant sunbathing conditions is greater in February and March than in the peak season of December - January. Where the sunbather obtains shelter from the wind, yet remains in the same relationship with the other meteorological elements, all months between October and March are of similar standard, with September and April also highly attractive in the afternoons. The limiting conditions in these months are air temperatures and cloudiness. The index for summer is similar to that of autumn and spring, despite higher summer air temperatures, because of greater cloud attenuation of radiation in summer months. Figure 9 shows the relationship between the comfort sensation and wind and cloud under each set of conditions. Cloudiness of 7/8 and 8/8 coincides with the frequency of pleasant days in the three summer months, while the boundary between the uncomfortable and distinctly unpleasant classes closely follows wind and cloud throughout the year. The close parallel between frequency of cloudiness and windspeeds over 10 m. s^{-1} is of interest and may warrant further study.

**Fishing.** The most popular forms of fishing were surf fishing from the beaches, and estuary or open sea fishing from boats. Fishing from rock shelves and outcrops was also popular but considerable hazard is attached and the numbers of fishermen giving this type of fishing their first priority were smaller (Owen, in press). The heat balance for rock fishing is probably very similar to that for beach fishing and the index values obtained for the latter are assumed to apply to both. The metabolic rate
Figure 9. Monthly frequency of pleasant (1), indifferent (2), uncomfortable (3) and unpleasant (4) subjective comfort classes for sunbathing and cumulative frequency of weather types (a) critical windspeed 10 m.s$^{-1}$, (b) critical windspeed 4.2 m.s$^{-1}$.
for both beach and boat fishing is 95 W m\(^{-2}\). (This metabolic rate is also applicable to driving (touring and sightseeing), but because wind conditions are not standard and because there may be extra solar heat gain due to the glasshouse effect in cars, the effective net rate of gain of heat from the environment may be somewhat higher. It is assumed here that, because this activity has a component which involves movement away from the vehicle, the general suitability for touring with sightseeing, picnics and barbecues is close to that for boat fishing).

The number of days with a heat balance ideal for both types of fishing is very similar. The main differences occur at the other end of the scale, with more days being unpleasant for boat fishing than beach fishing. Wind hazard reduces the suitability for boat fishing to a much greater extent in afternoons than in mornings. As in the case of walking, there were no occasions when, in the course of fishing with summer clothing, the thermal balance could not be maintained because of excessive heat gain from the environment. Only on rare days in June, July and August were conditions too cold despite winter clothing. Fishing therefore is limited mainly by hazard and by the impression of cold rather than physiological inability to maintain thermal comfort. Figure 10 shows the frequency in each month of days with a heat balance suitable for fishing while wearing summer clothing. Also shown are the frequency of the "pleasant" class days, (fine, sunny days without strong winds) and of wet, overcast and windy days. The limiting effect of strong winds in the warmer months is again highlighted. At 0900 September and April are the most suitable months. The periods between August and October and between March and May are both more consistently pleasant for fishing than the high summer period November to February. Figure 10 shows that the preferred
Figure 10. Frequency (%) of days per month with summer clothing heat balance suitable for fishing.
light summer clothing is applicable on almost all suitable mornings between October and February. About 5% of suitable days in August, September, March and April and from 10-35% of winter days require heavier clothing. The outstanding feature is that the summer type of fishing weather occurs at 0900 on more than 50% of days between August and May. The months from November to February are clearly the least suitable. Only the months between April and September are suitable on more than 50% of afternoons, irrespective of the clothing worn. The increase in the number of days gained by wearing heavier clothing is small, ranging from 4% in September to 10% in July and August. For the dedicated fisherman who likes to feel warm in summer clothing, September and April are the best months. Given willingness to wear warmer clothing, more suitable days for fishing occur from June till August than occur in any other month.

Annual Variability of Suitability for Most Preferred Activities

The frequency of index values has been expressed as the percentage of the total number of days per month with a complete weather record. This method can conceal variations occurring between years. Figure 11 shows the actual number of days with suitable heat balance for sunbathing, walking and fishing in summer clothing, for the period of record for the three months with highest demand. Greatest variability occurs with sunbathing in the mornings and fishing in the afternoons.

Suitability Indices for Other Recreation Activities

A number of other activities can also be considered by means of the heat balance model. Driving for pleasure, associated with touring
Figure 11. Variation in frequency of suitable days for casual walking, fishing and sunbathing in three summer months.
and sightseeing, and picnics or barbecues, has been equated with fishing. Watching outdoor sports is similar, provided appropriate clothing is worn. The preferred heat balance may be maintained with ease but the frequency of rainy and windy conditions determines the CLO value required. The analyses showed that a CLO value greater than 1.0 would rarely be needed. The remaining activities considered here all have higher metabolic rates and the heat balance, rather than critical values of wind, assumes major importance.

Golf, Riverside Angling, and Family Bushwalking. These moderately active recreations have an average metabolic rate of about 220 W.m\(^{-2}\). Except in the three winter months, over 90% of days were suitable for a person in summer clothing (CLO = 0.3). A small percentage of days were uncomfortably warm and unpleasantly hot, and occasional days uncomfortably cool in summer. In autumn and spring a small percentage of days were cool and cold and occasional days warm or hot. In winter up to 20% of mornings and 10% of afternoons were too cool or cold, with rare days too hot. An increase in CLO value to 0.6 (mid-season clothing = slacks, shirt, light pullover) was sufficient to compensate for almost all cold days. Because golf involves periods of inactivity, CLO values higher than 0.6 may be necessary on the days indicated as too cool for summer clothing. Moruya Heads would appear to have very nearly the perfect climate for golfing, particularly for the golfer who welcomes the challenge afforded by winds.

Fishing for trout, bass and perch is a minor recreation use of the mountainous forest areas where a few of the larger streams provide some worthwhile sport. On the assumption that most of the wind effective on the more open coastal plain is blocked in the forest the above
metabolic rate was considered with a maximum wind speed of 2 m.s\(^{-1}\) and the same temperature and cloud conditions. The heat gain may be overestimated because the fisherman is very likely to be in shaded conditions. At the most extreme however it was clear that 90% or more of all mornings in all months were ideal for river angling, as were over 95% of all afternoons except between January and March. February is the least suitable month with 9% of mornings and 16% of afternoons too hot. In July 4% of mornings were too cold.

**Active Sports.** Games such as tennis, with a metabolic rate of 270 W.m\(^{-2}\) also have high year round suitability. With the light, reflective white shirts and shorts or tunic normally used for tennis, only the mornings between February and April have less than 90% suitability. Afternoons have a more favourable heat balance in these months because of greater convective heat loss due to higher wind speeds. As with golf, these high speeds may make play more difficult but it is reasonable to suggest that tennis and other similar sports could be played out of doors without major heat stress for between 90% and 95% of all days in summer and winter, with the limiting factors being rain and windspeed. With a higher CLO value of 0.6 the frequency of suitable days ranged from 49% on March mornings to 96% on June and July mornings. Cricket (and outdoor work) would obviously have some hazard attached if the level of activity of say the fast bowler were maintained for the same period as in a game of tennis.

**Bushwalking.** The suitability for most bushwalking is probably similar to the active sports index discussed above. A considerable amount of bushwalking however is worthy of being called hard sport or heavy work. The metabolic rate applied to this level of activity is 350 W.m\(^{-2}\). Figure 12
Figure 12. Frequency (%) of days per month with heat balance suitable for bushwalking, summer and midseason clothing, and with maximum effective windspeed 2 m.s$^{-1}$. 
shows the percentage frequency of days per month with a suitable heat balance for hard bushwalking with CLO values of 0.3 and 0.6. The latter value is more common because of the need for skin protection in the heavy forest common to most of the area discussed. Because the effect of wind is reduced in these forests, Figure 12 also shows the frequency of suitable days when maximum effective wind is 2 m.s$^{-1}$. The effect of clothing insulation at high metabolic rates is clearly seen from the Figure. The suitability ratings achieved are possibly applicable to other 'backwoods' sports such as climbing and advanced trailbike riding, both of which have high metabolic rates and require protective clothing, particularly in the latter case. The suitability for all these activities would appear to range from 30% to 70% of days in late summer, and from 80% to 95% of days in winter, given a judicious choice of clothing.

VII. CONCLUSION

In Eurobodalla Shire, as elsewhere, recreation demand is strongly peaked in December and January, at which time schools and many sectors of the workforce take their main vacation. The brevity of this peak period discourages investment in services and facilities and complicates the planning which is urgently needed to meet the impact of tourism and recreation on the local community and natural resources of the area.

The activities most preferred by visitors are walking, particularly on the shoreline, touring and sightseeing, sunbathing, surfing and swimming, and fishing. The Shire is well endowed with natural resources and outstanding scenery to which most of its attraction for
these seaside holidays is attributed, very little being due to its climate. There is, on the other hand, some dissatisfaction with the climate, both directly because the weather often prevents preferred recreation activities, and indirectly because there are few recreation opportunities in the area to supplement resource oriented recreation when weather conditions are unfavourable.

It has been suggested that provision of such alternative opportunities would be more likely to occur if the period of high demand were longer. Such a spreading of the main tourist season could follow from better public awareness that ideal conditions for popular recreation activities occur more frequently at other times of the year than December and January. While this may not have a decisive influence on families with school age children, it could be a convincing argument for others.

At present, information about climate is not published in a form appropriate to the decision about when or where to go for a holiday. It is of little use to know the maximum and minimum or the mean temperature, or even the average number of days with rain. The need is not for average values of the individual elements which make up weather, but for a simple index of suitability for recreation. The holiday planner needs to know what chance he has of feeling comfortable, not too hot and not too cold, while he is doing the activity of his choice. He needs some indication of how many days he can expect will be suitable for his recreation preference throughout his holiday, and if he thinks the odds are poor he needs to know where he could go for better odds, or when the odds are better at the same place.
Indices appropriate to these problems can be derived using a model of the heat balance for the human body. This model makes use of the fact that the human body and skin surface have very narrow thermal comfort ranges. Since it is possible to calculate the amount of heat gained and lost by the body in the course of a selected recreation activity, it is also possible to calculate the frequency with which imbalance between heat gained and heat lost would have resulted in a temperature outside the comfort range. Similar heat balance models have been used for other aspects of human life, but none are directly applicable to recreation. This model is not, like most others, concerned with the degree of discomfort due to weather conditions, but is related to the frequency of conditions which allow a person to feel comfortable doing what he most wants. Since climate is a summary of weather conditions, it is possible to use this frequency to determine the recreation climate of a place.

There are several other possible applications for this model. In this study the relationship between the heat balance and critical values of some weather elements has been investigated, and this could be extended for other activities and limits. For example, with reliable data for water temperatures, suitability for swimming could be modelled rather than inferred from the heat balance for its out-of-water associate sunbathing as was necessary in this study. Having modelled the heat balance for swimming, and knowing the frequency of critical surf conditions, the suitability for surfing could be determined.

The model was applied to Moruya Heads because it was found to be the most appropriate weather recording station in the area selected for study. Analyses for stations representative of other areas would permit
compilation of a map of recreation climate regions which would greatly assist the choice of holiday destination and, possibly, the route and duration of holiday travel.

While the analyses in this study were conducted on a monthly basis, they could equally well have been at shorter intervals. The model was developed and applied for an "average man" performing an activity at an "average" metabolic rate. It is possible to go from the general to the particular by changing the values of the human variables and to be more specific about the activity, e.g. to assess the frequency of conditions ideal for ascent of Pigeon House Mountain.

Predictive capability of the recreation climate index could be improved at higher order stations where weather is observed at additional times during the day, and where extra data are recorded which could reduce some of the assumptions made in the model, particularly those concerned with the gain of heat from shortwave radiation.

Figure 13 summarizes the results of this study of the recreation climate of part of South Coastal N.S.W. For the holiday in which all the most popular activities are desired, March and April are the most favourable months. For casual walking and activities with a similar metabolic rate, ideal conditions occur most often in April if preference for summer clothing is regarded. Where clothing is adjusted to maintain the heat balance, and other effects of weather considered, the most suitable periods for walking are March to May and July to September. April is the most pleasant month for fishing while wearing summer clothing, while, with adjustment to clothing, the months from February to June, and August are most agreeable. Sunbathing and, by implication, swimming and surfing conditions, are most comfortable in February and March or, if shelter from
<table>
<thead>
<tr>
<th>Class</th>
<th>Days/wk suitable</th>
<th>Class</th>
<th>Days/wk suitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3 or 4</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>5</td>
<td>5 or 6</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 13. Summary of recreation climate index values.
wind is found, between November and March, with January and February most suitable. Activities such as golf and tennis are highly suited by the climate throughout the year. With some reduction in the number of comfortable days attributed to the additional effect of rain and strong wind on a person having difficulty maintaining his thermal balance, April, May and July are marginally more suitable for active sports such as these. The activities not shown in Figure 13 are those with higher metabolic rates, all of which would be carried out in comfort with greater frequency in the months between April and November.

The peak demand for recreation in December and January is not justified by the area's climate. The results of this study permit the conclusion that optimum conditions for popular recreation activities occur most often in other months and that for some, including sunbathing, the difference is of sufficient magnitude to encourage a change in the timing of holidays. This being the case, there could be advantage in promotion of the attractiveness of the area in the autumn months. Extension of higher level demand into these months could conceivably make the economics of provision of entertainments, and supporting service and facilities, more favourable, and furthermore could generate more local employment, a matter for serious concern in the Shire at the present time.
REFERENCES


APPENDIX

This Appendix contains tables of weather data and excerpts from a questionnaire used in the study area. Table 7 shows the frequency of days with rain falling at the time of weather observations, 0900 and 1500 hr Australian Eastern Time, and the frequency of days on which cloud cover would have reduced the gain of heat from shortwave radiation to 30% or less of the expected average rate for each month at the time of observation. These data are important to the calculation of the heat balance, and to the perception of "pleasant" weather conditions. Tables 8 to 10 show other climatic averages in the more conventional form from which the person planning his holiday would need to assess the suitability of the climate of the area for his recreation preferences. Table 11 shows the number of years for which records were available on magnetic tape at the time of this study, and the number of complete days of record for each month over this period.

Table 12 is a list of questions asked in the interviews of visitors to the area. From these questions the timing and duration of holidays, recreation preferences, and attitudes to the study area were determined. Other questions are not included because they are not relevant to this study and it was technically difficult to reproduce the complete questionnaire.
Table 7. Average frequency (%) of rainfall and overcast (7/8 or 8/8 cloud, not raining) at 0900 and 1500 for 1957-1972 inclusive, Moruya Heads

<table>
<thead>
<tr>
<th>Month</th>
<th>% Rain at 0900</th>
<th>% Rain at 1500</th>
<th>% Overcast at 0900</th>
<th>% Overcast at 1500</th>
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<tbody>
<tr>
<td>J</td>
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<td>7.2</td>
<td>37.5</td>
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<tr>
<td>F</td>
<td>6.9</td>
<td>7.3</td>
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<tr>
<td>M</td>
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<td>6.1</td>
<td>32.7</td>
<td>29.4</td>
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<td>S</td>
<td>6.1</td>
<td>5.4</td>
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<td>O</td>
<td>7.9</td>
<td>8.1</td>
<td>29.0</td>
<td>28.3</td>
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<td>N</td>
<td>9.7</td>
<td>5.9</td>
<td>30.7</td>
<td>34.3</td>
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<tr>
<td>D</td>
<td>8.3</td>
<td>8.8</td>
<td>36.5</td>
<td>38.8</td>
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Source: Bureau of Meteorology records.
Table 8. Mean and median monthly rainfall (mm) at three stations, N.S.W. South Coast

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<tr>
<th>Station</th>
<th>J</th>
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<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
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<tr>
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<td>84</td>
<td>104</td>
<td>83</td>
<td>99</td>
<td>88</td>
<td>57</td>
<td>51</td>
<td>57</td>
<td>72</td>
<td>78</td>
<td>84</td>
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<tr>
<td>Median</td>
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<td>73</td>
<td>51</td>
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<td>66</td>
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<td>35</td>
<td>43</td>
<td>58</td>
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<td>61</td>
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</table>

Source: Bureau of Meteorology records.
Table 9. Mean monthly temperatures (°C) at two stations, N.S.W. South Coast

<table>
<thead>
<tr>
<th>Station</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
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<th>O</th>
<th>N</th>
<th>D</th>
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<tbody>
<tr>
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<tr>
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<td>22.7</td>
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<td>19.1</td>
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<td>11.1</td>
<td>11.7</td>
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<td>6.9</td>
<td>8.8</td>
<td>11.2</td>
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<td>Mean maximum</td>
<td>24.0</td>
<td>24.2</td>
<td>23.4</td>
<td>21.4</td>
<td>18.0</td>
<td>15.7</td>
<td>15.0</td>
<td>16.2</td>
<td>17.5</td>
<td>19.8</td>
<td>21.0</td>
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</tr>
<tr>
<td>Mean</td>
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<td>20.0</td>
<td>19.1</td>
<td>16.6</td>
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<td>12.6</td>
<td>15.3</td>
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</tr>
<tr>
<td>Mean minimum</td>
<td>14.8</td>
<td>15.8</td>
<td>14.8</td>
<td>11.7</td>
<td>8.6</td>
<td>6.5</td>
<td>5.2</td>
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<td>7.6</td>
<td>10.7</td>
<td>12.0</td>
<td>13.8</td>
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</table>

Source: Bureau of Meteorology records.
Table 10. Monthly means of hours of bright sunshine per day, four N.S.W. river valleys

<table>
<thead>
<tr>
<th>River Valley</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clyde</td>
<td>8.1</td>
<td>7.9</td>
<td>7.4</td>
<td>7.3</td>
<td>6.5</td>
<td>5.8</td>
<td>6.4</td>
<td>6.8</td>
<td>7.3</td>
<td>8.2</td>
<td>8.3</td>
<td>8.4</td>
</tr>
<tr>
<td>Moruya</td>
<td>8.1</td>
<td>7.9</td>
<td>7.4</td>
<td>7.3</td>
<td>6.5</td>
<td>6.0</td>
<td>6.5</td>
<td>6.8</td>
<td>7.5</td>
<td>8.1</td>
<td>8.3</td>
<td>8.2</td>
</tr>
<tr>
<td>Tuross</td>
<td>8.1</td>
<td>7.9</td>
<td>7.4</td>
<td>6.5</td>
<td>6.0</td>
<td>6.5</td>
<td>6.8</td>
<td>7.5</td>
<td>8.1</td>
<td>8.3</td>
<td>8.3</td>
<td>8.2</td>
</tr>
<tr>
<td>Bega</td>
<td>8.4</td>
<td>7.3</td>
<td>7.2</td>
<td>6.1</td>
<td>5.9</td>
<td>5.3</td>
<td>6.0</td>
<td>6.9</td>
<td>7.3</td>
<td>7.6</td>
<td>8.0</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Source: N.S.W. Water Conservation and Irrigation Commission, River Valley Reports (1966-1970)
Table 11. Data used in analyses, Moruya Heads

<table>
<thead>
<tr>
<th></th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of years of record</td>
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<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<td>15</td>
</tr>
<tr>
<td>No. of complete days</td>
<td>456</td>
<td>447</td>
<td>490</td>
<td>471</td>
<td>492</td>
<td>470</td>
<td>458</td>
<td>459</td>
<td>444</td>
<td>455</td>
<td>443</td>
<td>456</td>
</tr>
</tbody>
</table>
Table 12. Relevant questions from visitor questionnaire

2. When did you arrive at the place where you are staying?

<table>
<thead>
<tr>
<th>Date</th>
<th>Month</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of day</td>
<td>a.m.</td>
<td>p.m.</td>
</tr>
</tbody>
</table>

3. How long will you be staying here on this trip?

<table>
<thead>
<tr>
<th>Number of Days</th>
</tr>
</thead>
</table>

6. Which of the water-based activities listed below will you do on this holiday?

- Surfing - board
  - body
- Fishing - beach
  - boat
  - rock
  - inland
- Swimming - not surf
- Skindiving
- Boating - sail
  - power
- Water skiing
- Sunbathing

PLEASE LIST ANY OTHER WATER-BASED ACTIVITIES YOU WILL DO BELOW

* ..................................................

Of all the activities on the lists above on which will you spend most time on this holiday?

* ..................................................
Table 12. (continued)

7. Which of these other types of outdoor activities listed below will you do on this holiday?

- Touring & Sightseeing
- Picnicking & Barbeques away from home
- Walking—beach & rock
  - bush
- Trailbike Riding
- Horse riding
- Golfing
- Lawn Bowling
- Tennis

PLEASE LIST ANY OTHER NON-WATER BASED OUTDOOR ACTIVITIES YOU WILL DO BELOW

*....................................................................................................

Of all these outdoor activities on which will you spend most time on this holiday:

*....................................................................................................

11. For how many years have you been coming to the area between Durras/Batemans Bay and Bermagui for your holidays?

20. Now we would like to know what you think are the best and worst things about this area?

First the best? ...........................................................................

....................................................................................................

....................................................................................................

....................................................................................................

Now the worst? ...........................................................................

....................................................................................................

....................................................................................................