FLORISTIC AND ECOLOGICAL RECONSIDERATIONS OF THE PLEISTOCENE PLANT IMPRESSIONS FROM KASHMIR

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ABSTRACT

The Pleistocene plant impressions from the Lower Karewas in Kashmir described by Middlemiss, Stewart and Puri are considered from the floristic and ecological veiwpoints, in relation to stratigraphy and in the background of the events of the Pleistocene climatic and diastrophic changes. This attempt seeks to straighten out the facts and remove the confusion created by a similar consideration of this fossil flora by the earlier workers.

From the stratigraphical considerations it is discovered that this flora came off from an upper part of the Lower Karewas (Lithozone 4) and is in no way representative of the vegetation of the entire Lower Karewas. Furthermore the fossil flora is suggestive of temperate climate rather than tropical or subtropical as deduced by earlier workers.

Comments are also made towards the application of this flora in determining the Plio-Pleistocene boundary in the Lower Karewas.

INTRODUCTION

THE Pleistocene flora from the valley of Kashmir has so far been described from the terraced lake deposits called the Karewas exposed on the Kashmir flank of the Pir Panjal. A well-defined unconformity divides the several thousand feet thick Karewa deposits into the Upper and the Lower Karewas. Our knowledge of the Pleistocene flora from Kashmir is largely derived from the Lower Karewas. Despite the evidence of the occurrence of plant remains, viz. lacerated stems of rushes and grasses (DE TERRA & PATERSON 1939, p. 85) and some pollen grains of *Abies*, *Picea*, *Pinus*, *Corylus* and *Ephedra* (WODEHOUSE & DE TERRA, 1935), in the Upper Karewas, the recognizable plant species so far known from them are extremely rare.

From the Lower Karewas the plant remains comprising *Cinnamomum* ? *tamala*, *Jasminum* sp. and *Buxus sempervirens* were first reported by Middlemiss in 1910. Later in 1935 pollen grains of *Picea*, *Abies*, *Ephedra*, *Carpinus*, *Alnus*, *Juglans*, *Persicaria*, *Artemisia*, Chenopodiaceae and Gramineae, were reported from the Lower Karewas by Wodehouse and De Terra (*loc. cit.*). Stewart (DE TERRA & PATERSON, 1939) identified a host of woody plants, aquatics and ferns from the remains of seeds, fruits and leaves collected by De Terra and Paterson from the Lower Karewas. This comprehensive collection, though preliminarily determined, comprised 57 species and 36 genera distributed over 22 orders of higher plants and ferns.

Later Puri (1945-60), in a series of papers, has described the plant remains from the Lower Karewas and has added several species to the list of the Pleistocene flora of India. The climatic and the orogenic implications together with the phytogeographical aspects of the Karewa flora were first discussed by De Terra and Paterson (*loc. cit.*) and later dilated upon by Puri (*loc. cit.*).

The age of the Lower Karewa deposits is very much disputed: some assign these deposits to the First Interglacial, while the others believe that a part of them might belong to the Pliocene. Wadia (1951) has recently employed the palaeobotanical evidence together with the palaeontological and geological evidences in determining the age of the Lower Karewas.

As a result of the studies of the Karewa Flora by various workers the following conclusions have been arrived at regarding the climatic changes, the orogenic movements, the immigration of the plant species and the age of the Lower Karewas —

Sequence of Fossil Flora — (1) Puri believes that the Karewa Flora described by him presents a fairly complete sequence of fossil floras from the Pir Panjal (Puri 1945, 1948).

Probable Age — (2) The Lower Karewas belong to the First Interglacial (DE TERRA & PATERTON *loc. cit.*; PILGRIM, 1944). (2a) A large part of the Lower Karewas except the upper one-third belong to the Preglacial or Pliocene (WADIA 1951, MIDDLEMISS 1910).

Palaeoecology — (3) The climate during the First Interglacial in the Kashmir valley was more moist and slightly warmer than today (De TERRA & PATERSON, 1939).

(4) The Pir Panjal during the Karewa time was of lesser height than now, and the change in climate took place by the uplift of the Pir Panjal which was also responsible for the vertical shifting of vegetational zones as well as the southward migration of the monsoon forest.

(5) Conforming to the First Interglacial age of the Lower Karewas, Puri has concluded subtropical or tropical climate from his studies of the Karewa Flora. Further he believes that the climate throughout the First Interglacial remained the same. On the basis of exclusively temperate climate inferred from the plant remains at Ningle Nullah, Puri holds that the plant-bearing beds at Ningle Nullah, owing to a different climate, could not possibly belong to the First Interglacial and consequently he places the Ningle Nullah beds in the Second Interglacial. It must be stated here that the Ningle Nullah plant-bearing beds are placed by De Terra and Paterson (*loc. cit.*) in the First Interglacial.

(6) The climate of the valley has remained unchanged since the deposition of the Ningle Nullah beds (PURI, 1945).

Palaeophytogeography — (7) *Cedrus* and *Pinus* were more in the valley during the Pleistocene than *Abies*. *Picea* was unrepresented.

(8) In one of his latest papers, Puri (1957) recognizes in the Karewa flora three stages in the phytogeographical evolution of the valley.

(a) *Stage* 1. *Prior to glaciation.* (i) The vegetation comprised the oak-laural woods with little or no conifers.

(ii) The first glaciation being weak or mild, much of this preglacial vegetation survived and flourished in the valley during the First Interglacial.

(iii) The immigration of the conifers in the valley took place probably after an intense glaciation and subsequent to the uplift of the Himalayas.

(iv) During this early Pleistocene period (his Preglacial) the valley was accessible to summer monsoons from the south.

(*b*) *Stage* 2. *The close of the First Interglacial period.* The vegetation was of Pine-oak woods. The valley became inaccessible to the summer monsoons due to uplift and the climate changed from tropical to subtropical or even somewhat temperate.

(*c*) *Stage* 3. *The close of the Second Interglacial.* The mountains were uplifted to the present elevation. The vegetationcomprised the conifer woods mainly *Abies* and *Pinus*.

(*d*) *Stage* 4. *The present period.* The modern vegetation of the Kashmir valley and of the Northern slopes of the Pir Panjal is very much similar to the vegetation towards the close of Second Interglacial.

A critical appraisal of the previous work done on the Lower Karewas in the light of the recent palynological and stratigraphical studies of the Lower Karewas (VISHNU-MITTRE, SINGH & SAXENA 1962) reveals that several of the conclusions arrived at by previous workers cannot be upheld now.

The necessity towards the reconsideration of the Pleistocene Flora, hitherto known largely from the megafossils, from Kashmir arose out of the attempt to assemble the record of the Pleistocene plant remains from this region with a view to correlate it with the data from the pollen-analytical investigations undertaken by us (VISHNU-MITTRE, SINGH & SAXENA, 1962) and to aquaint ourselves with the present position of the various palaeoecological and palaeophytogeographical problems in this region. A mere glance at the literature assured us of plenty of valuable information which has accumulated but a critical approach to it soon revealed that this wealth of information had not been rightly adjudged in the background of the climatic sequence of glacial epochs and especially in relation to stratigraphy. Further the climate had been inferred from the individual plant constituents without regard to their status in the floristic composition. Furthermore the fossil flora together with the climatic inferences had also been employed in determining that critical horizon — the Plio-Pleistocene boundary without ascertaining if the fossil flora had really come off from this critical horizon.

An undoubted geological evidence has been found of the uplift of the Pir Panjal, which has been of the intermittent nature. The evidence from the fossil flora has also been advanced in support of this disatrophism. The arguments which have pleaded the uplift on the floristic evidence when applied to the fossil flora from different localities equally bring out the evidence of subsidence besides that of the uplift.

In the light of the above critical appraisal of the palaeobotanical investigations from the Lower Karewas it was considered necessary to straighten out the facts of vegetational history discovered by other workers. Prior to their interpretation due consideration is given to the stratigraphical position of the plant-bearing beds — a feature which has largely been overlooked by the earlier workers who have made important remarks regarding the forest history, the climatic changes and the age of the deposits, etc. After a careful execution of the vegetational and stratigraphical correlation, a possible approach is made towards inferring the climatic conditions, the nature of vegetation and the effect of the orogenic movements in inducing both the climatic and vegetational changes in the valley. Finally the comments are made regarding the age of the deposits.

MATERIAL AND METHODS

An attempt towards the reconsideration of the plant remains known from Kashmir is chiefly made from the ecological point of view. This largely comprises the reconstruction of the vegetation from the relative frequencies of the plant remains. The plant remains considered here are largely the megafossils, viz., the leaves, the seeds and the fruits etc., and from their relative abundance or scarcity (from the published data) the respective frequency of each species is determined. Realizing the limitations of the application of this method to the megafossils for the reconstruction of past vegetation, the determination of the percentage frequencies of the individual species has been altogether avoided.

The resort to this method was essential since the assemblage of the plant fossils consists of species of variable ecological requirements and the inference regarding the precise climatic conditions could hardly be had, unless the frequencies of the individual species were considered.

In the reconstruction of the past vegetation and the climatic inferences therefrom, the ecology of the modern vegetation types of the eastern and the western Himalayas constituted by the species identified has largely been borne in mind. Despite the poverty of records of plant fossils and their insufficiently-determined frequencies from each site, an attempt has also been made to reconstruct the plant associations at or around each site. The nature of the plant remains preserved, however, is not suggestive of their transport from a pretty long distance, otherwise the plant remains would have been mutilated, lacerated and fragmentated defying all efforts towards their identification.

It may also be pointed out that the frequencies of the plant fossils have been very inadequately recorded by the previous workers but, nevertheless, their overall evaluation provides dependable data for the reconstruction of vegetation.

The species identified from the plant remains by previous workers are retained as such and their lists with records of their frequencies are compiled from the published data.

RECONSIDERATION OF THE PLEISTOCENE FLORA

A. STRATIGRAPHICAL POSITION OF THE PLANT-BEARING DEPOSITS

The stratigraphy of the Lower Karewas has been worked out by De Terra and Paterson (*loc. cit.*). They divide the Lower Karewa deposits, about over 2160 ft. in thickness, comprising clays, sands, lignites and conglomerate beds into five Lithozones viz., (1) the basal clay series (about 600 ft.), (2) the lower lignite zone (about 440 ft.), (3) the upper lignite zone (about 670 ft.), (4) the upper clay zone (about 450 ft.) and (5) the upper sand and gravel zone (about over 100 ft.).

The plant beds, from which our knowledge of the Pleistocene flora has been built up, according to De Terra and Paterson belong to the Lithozone 4, the upper clay zone. During their stratigraphical work De Terra and Paterson did not discover plant beds in the other Lithozones and in their account of Lithozone 4 they have described the plant-bearing beds at Liddarmarg, Ningle valley etc. the localities from which the plant fossils have been described subsequently. Furthermore incorporating the list of plant remains identified by Stewart in their memoire they have explicitely stated that these plant remains have been discovered from the Lithozone 4 (DE TERRA & PATERSON *loc. cit.*, p. 118). It is, therefore, obvious that our present knowledge of the Karewa plant remains, through the investigations of Middlemiss (*loc. cit.*), Stewart (*loc. cit.*) and Puri (*loc. cit.*), comes from the Lithozone 4 which constitutes an upper part of the entire Lower Karewas and consequently all floristic and climatic inferences deduced from it pertain to the Lithozone 4 and not to the entire Lower Karewas.

Quite unmindful of the stratigraphical position of the deposits, one of the workers (PURI *loc. cit.*) dealing with the phytogeographical considerations of the flora discusses the vegetational history from the Preglacial to the First Interglacial leading to the Second Interglacial and, thereafter, according to him neither the vegetation nor the climate has changed in this region. This is not only due to the utter disregard of the stratigraphy but also to the unacquaintance of the sequence of events in the Pleistocene.

B. THE PLEISTOCENE FLORA

The substantial contributions to the Pleistocene Flora have been made by Stewart (*loc. cit.*) and Puri (*loc. cit.*) and the account that follows of this flora is largely based upon their work, though it also includes a few plant remains identified by Burkill and reported by Middlemiss (1910).

Stewart's List of Karewa Plants

Since this list has been compiled from the plant remains discovered from various sites, the assemblage of plant remains, therefore, ought to be suggestive of plant formatioin the valley. The list also includes quite a few such plant species of which the identification is tentative as indicated by a question mark against the generic or the specific name (TABLE 1). Furthermore the list is far from complete since it does not include several other species found later by Dr. Stewart (DE TERRA & PATERSON *loc. cit.* p. 122). The number of species added to the list later by Puri probably constitutes the large bulk of the species not included by Stewart in this list and these will be added to the reconstructed vegetation later in course of consideration of Puri's list of Karewa plants.

TABLE 1 — STEWART'S LIST OF KAREWA PLANT SPECIES

SPECIES	NATURE OF SPECIMENS			NO. OF SPECIMENS	OTHER REMARKS
	Leaf	Fruit	Seed		
Ranunculaceae					
Clematis montana Buch-Ham.		Fr		1	
Berberidaceae					
Berberis ceratophylla G. Don	lvs			Many	
Aceraceae					
Acer caesium Wall. ex Brandis	lf	fr		2	
A. pentapomicum Stewart	lf			1	?
A. sp. cf. *acuminatum* Wall.	lf			1	?
Hippocastanaceae					
Aesculus indica Colebr.	lvsf			Many	
Sabiaceae					
Meliosma pungens Walp.	lvsf			,,	??
Papilionaceae					
Indigofera hebepetata Benth.	lls			,,	?
Rhamnaceae					
Rhamnus purpurea Edgew.	lvsf			,,	?
Rosaceae					
Prunus jacquemontii Hook vel. aff.	lvs			,,	
P. cornuta Wall.	lvsf			,,	
P. cerasifera Ehr. vel. aff.	lvs			,,	
Spiraea canescens D. Don	lvs			,,	?

TABLE 1 — STEWART'S LIST OF KAREWA PLANT SPECIES *(contd)*

Species	Nature of specimens: Leaf	Fruit	Seed	No. of specimens	Other Remarks
Rosa webbiana Wall.	lvs			Many	Specimens very small appr. *R. beggeriana* Sch-rank.
R. macrophylla Lindl.	lvs			,,	
Pyrus communis L. vel. aff.	leaf			1	
P. foliolosa wall vel aff.	lls			Many	
P. aucuparia Gaertn. vel aff.	lls			,,	
P. pashia Buch-Ham	lvs			,,	
Cotoneaster microphylla Wall.	lvs			,,	
C. nummularia Fisch. et Meyer	lvs			,,	
C. bacillaris Wall.					
Araliaceae					
Hedera nepalensis K. Koch (*helix* L.)		fr		1	
Cornaceae					
Cornus macrophylla Wall.	lf			—	?
Caprifoliaceae					
Viburnum stellulatum Wall. vel aff.				1	
Oleaceae					
Fraxinus excelsior L.		frs		Many	
Cupuliferae					
Alnus nitida Endl.	lvs	fr		,,	
A. sp.		frs		,,	
Carpinus sp.	lvs			,,	?
Betula utilis D. Don	lvs	fr		,,	
Betula sp.	lvs			Many	
Quercus incana Roxb.	lvs			abundant	
Q. semecarpifolia Smith	lvs			,,	
Q. ilex L.	lvs			,,	
Q. glauca Thunb	lvs			frequent	
Castanopsis sp.	lfs			1	
Juglandaceae					
Juglans regia L.	lls			2	?
Ulmaceae					
Ulmus wallichiana Planch.	lvs			Many	
U. parviflora Jacq.	lvs			,,	
Salicaceae					
Salix wallichiana Anders.	lvs			,,	
S. denticulata Anders.	lvs			,,	
S. sp.	lvs				2 or 3 spp.
Populus alba L.	lf			1	?
P. nigra L. vel aff.	lvs			Many	
P. ciliata Wall.	lf			1	?
Coniferae					
Pinus excelsa Wall.	nf			Many	
Abies webbiana Lindl.			S	,,	
Picea smithiana Boiss.			S	1	
Juniperus sp.	l	fr		2	?
Taxus ?	l				?
Nymphaeacae					
Nelumbo nucifer Gaertn.	lf			1	
Hydrocaryaceae					
Trapa natans L.		frs		Many	
Typhaceae					
Typha ?	lvs			,,	?
Adiantum sp.	pinnule				
Dryopteris cf. *filix mas* (L.) Schott.	pinnules				?
Selaginella ?					

lvs — Leaves; lf — leaf fragment; S — Seed
fr — fruit; nf — fragment of needle.; lls — Leaflets

Reconstruction of vegetation — The Karewa lake was a quiet sheet of water inhabited largely by the free floating plants of *Trapa natans*, along the shores of which the reed swamps were largely made up of *Typha* ?. *Nelumbo nucifer* was extremely rare.

The forests comprised largely by the oak woods in which *Q. semecarpifolia* and *Q. incana* dominated. *Q. ilex* formed consocies in the drier situations. The other fairly common constituents of the woods comprised the ash (*Fraxinus excelsior*), *Betula utilis*, Alders, elms (*Ulmus wallichiana* and *parviflora*), *Salix wallichiana* and *denticulata*, Poplars (*Populus nigra*), the horse chestunt (*Aesculus indica*), *Rhamnus purpurea* and the species of *Prunus* and *Pyrus*.

The conifer constituent of the oak woods consisted of the commonly distributed *Pinus excelsa* and *Abies webbiana*. *Picea smithiana* and a *Juniperus* sp. were extremely rare. *Taxus baccata* was probably of occasional occurrence.

Acer eaesium, *A. pentapomicum*, *Juglans regia* and probably also a species of *Castanopsis* were also present in the woods, though of extremely rare occurrence.

The shrubby vegetation consisted largely of *Prunus jacquemontii*, *Berberis ceratophylla*, *Indigofera* probably *I. hebepetala*, *Spiraea*, *Rosa macrophylla* and a small-leaver *Rosa webbiana* cf. *R. beggeriana*. *Viburnum stellulatum* constituted a rare member of the vegetation. The genus *Cotoneaster* was also well represented, of which two species (*nummularia* and *microphilla*) were present.

Hedera nepalensis and *Clematis montana*, rare and insignificant members of the forest vegetation, clothed the branches and the boles of trees.

Amongst the ferns, *Adiantum* sp. and *Dryopteris filixmas* were present though not very common. Very likely *Selaginella* also occurred.

The presence of conifers especially of *Pinus excelsa* in large frequency suggests that the forests were not pure oak-woods rather Pine-oak or oak-pine woods. The conifers constituted the upper canopy while the second storey was largely constituted by the evergreen and the deciduous broad-leaved spp. In this montane region, though the altitude was not the same as today, the vegetation must have been disposed in altitudinal zones. Besides, the southern and the northern aspects must have been inhabited by different plant communities.

The plant assemblage here includes species of diverse ecological habitants such as *Q. ilex* and *Acer pentapomicum* which are typical of drier habitats while several other species are of the moist habitats. The varying topography in this montane region must have provided varying habitats under similar climatic conditions as is seen in the Western Himalayas today. It, therefore, appears that in such physiographical situations the influence of the edaphic factor was very much varied.

Puri's contribution to Karewa Flora

Stewart's list of Karewa plants gives an idea of the overall vegetational picture and in the absence of the list of floras from the individual sites, it is hardly possible to build up a picture of the various plant communities around. The segregation of the plant species of diverse ecological habitat from the general list of Karewa plants can, of course, help us to know the various plant associations, but this attempt cannot be free from pitfalls. Luckily Puri has published this required information in a series of papers. From his studies of the Karewa Fossil Flora, Puri has added several plant species to Stewart's list (TABLE 2).

Puri adds as many as 49 species to the already known 56 spp. of the Karewa flora. Besides describing additional species of the already known genera such as *Berberis*, *Acer*, *Betula*, *Alnus*, *Cornus*, *Ulmus*, *Salix*, *Populus*, *Trapa*, *Nelumbium*, *Clematis* and *Indigofera*, Puri adds to the list the following important hitherto undiscovered genera from the Lower Karewa deposits —

Litsaea (*lanuginosa*, *elongata*)
Machilus (*odoratissima*, *duthie*)
Phoebe (*lanceolata*)
Buxus (*wallichiana*, *papillosa*)
Marlea (*begoniaefolia*)
Parrotia (*jacquemontiana*)
Rhus (*cotinus*, *punjabensis*, *succidenia*)
Odina (*wodier*)
Englehardtia (*colebrookiana*)
Mallotus (*philipensis*)
Woodfordia (*fruticosa*)
Myrsine (*africana*, *semiserrata*)
Berchemia (*floribunda*)

TABLE 2 — PURI'S ADDITION TO THE KAREWA FOSSIL FLORA

SPECIES	NATURE OF SPECIMENS	NO. OF SPECIMENS	REMARKS
Berberidaceae			
Berberis lycium Royle	lvs	9	
B. sp.			
Aceraceae			
Acer oblongum Wall.	lvs	10	
A. villosum Wall.	lvs	6	
A. pictum Thunb.	lvs	6	
A. sp.	lvs	4	
Lauraceae			
Litsaea lanuginosa Nees	lvs	10	
L. elongata Wall.	lvs	4	
L. sp.	l		
Cinnamomum tamala		3	
Machilus duthie King			
M. odoratissima Nees	lvs	25	
Phoebe lanceo'ata Nees	lvs	2	
Buxaceae			
Buxus wallichiana Baillon	lvs	2	
B. papillopsa Schn.	lvs	2	
Betulaceae			
Betula alnoides Buch-Ham.	l	1	
B. sp.	l	2	
Alnus nepalensis D. Don.	lvs	10	
A. sp.	l		
Conaceae			
? *Cornus capitata* Wall.	fr	1	
C. macrophylla Wall.	fr	1	
Cornus sp.	fr	1	
Marlea begoniaefolia Roxb.	lvs	2	
Parrotia jacquemontiana Dcne	l		
Ulmaceae			
Ulmus campestris L.	lvs		
Anacardiaceae			
Rhus cotinus L.	lf	1	
R. punjabensis Stewart.	l	1	
? *R. succedania* L.	lt	1	
Odina wodier Roxb.	lt	1	
Juglandaceae			
Englehardtia colebrookiana Lindl.	l	1	
Myrsinaceae			
Myrsine africana L.			
M. semiserrata Wall.			
Pittosporaceae			
Pittosporum eriocarpum Royle			
Rosaceae			
Pyrus communis L.			
Cotoneaster sp.			
Spiraea sp.			
Euphorbiaceae			
Mallotus philippensis Muel.	lvs	10	
Rhamnaceae			
Rhamnus virgata Roxb.			
R. triquetra Laws.			
Berchemia floribunda Wall.			
Rutaceae			
Skimmia laureola Hook. f.			
Toddalia sp.			
Salicaceae			
Salix elegans Wall.	l	1	
Populus nigra var. *fastigiata* Desf.	lvs	10	
P. sp.	l	1	
Lythraceae			
Woodfordia fruticosa Linn.	lvs	2	

TABLE 2 — PURI'S ADDITION TO THE KAREWA FOSSIL FLORA (*contd*)

SPECIES	NATURE OF SPECIMENS	NO. OF SPECIMENS	REMARKS
Urticaceae			
Ficus cunia Ham.	lvs	4	
Papilionaceae			
Desmodium tiliaefolium G. Don.	l	1	
D. podocarpum D.C.	l	1	
? *D. nutans* Wall.	l	1	
D. laxiflorum D.C.	l	2	
D. latifolium D.C.	l	1	
D. gangeticum D.C.	l	1	
D. sp.	l	1	
Indigofera sp.	l	1	
Ranunculaceae			
Banunculus sp.	fr	1	
Clematis sp.	fr	1	
Ceratophyllaceae			
Ceratophyllum sp.	lf	10	
Haloragaceae			
? *Myriophyllum* sp.	shoots		
Hydrocaryaceae			
Trapa bispinosa Roxb.	fr	Many	
Nymphaeaceae			
Nelumbo (*Nelumbium*) *nucifer* Gartn.	lf	4	
Typhaceae			
Typha sp.			
Sparganium sp.			
Cyperaceae			
Cyperus sp.			
Scirpus sp.			
Acorus sp.			

Ficus (*cunia*)
Toddalia (sp.)
Ceratophyllum (sp.)
Myriophyllum (sp.)
Sparganium (sp.)
Acorus (sp.)
Scirpus (sp.)
Cyperus (sp.)
Ranunculus (sp.)
Desmodium (*tiliaefolium*, *podocarpum*, *nutans*, *laxiflorum*, *latifolium*, *gangeticum* and a sp.)

Many of the plant species added to the list of Karewa Flora by Puri are found in the modern oak woods in the Himalayas either as the constituents of the tree vegetation or of the undergrowth and Puri's contribution helps to complete our knowledge of the Early Pleistocene vegetation in Kashmir. Further his contribution to the aquatic and reedswamp communities is also considerable, of which our knowledge derived from Stewart's list was very poor.

Middlemiss's (*loc. cit.*) report of the doubtful occurrence of *Cinnamomum tamala* in the Karewa deposits has been ascertained by Puri who has further advanced our knowledge of the Pleistocene Lauraceae by three more genera and five species.

The reported occurrence of *Jasminum* by Middlemiss has not been confirmed either by Stewart or by Puri.

After Puri, no fresh attempts have been made towards the reinvestigation of the Pleistocene flora from Kashmir and the combined list though very exhaustive, about 80 plant species of trees, herbs and shrubs excluding the aquatics and reedswamp flora, should in fact be considered far from complete because several other species might have grown in situations, where the conditions for their preservation might have been unfavourable.

THE LOWER KAREWA VEGETATION

With the inclusion of Puri's list of additional plant species, the overall picture of Karewa vegetation would be as follows:

The submerged plant community in the Karewa Lake comprised largely by the spp. of *Ceratophyllum* and *Myriophyllum*;

Trapa and *Nelumbo* constituted the floating plant community and reedswamps were populated by *Typha*, *Sparganium*, spp. of *Cyperus*, *Scirpus* and *Acorus*.

Conifers occurred in the woods. *Pinus excelsa* and *Abies webbiana* were very common and the other conifers present were *Picea smithiana*, *Juniperus* sp. and *Taxus baccata*. Very likely the conifers comprised the upper canopy as they do today.

Amongst the broadleaved trees, the oaks dominated. The temperate decidous genera such as *Acer*, *Carpinus*, *Aesculus*, *Prunus*, *Ulmus* and *Betula* were of fair distribution and formed local consociations together with the oaks according to the aspects and the altitudinal ranges obtained in the region. The Lauraceae represented by *Litsaea*, *Machilus* and *Cinnamomum* was generally present. The other common evergreen genera were *Euonymus* and *Ilex*. The other constituents included *Rhamnus*, *Meliosma*, *Fraxinus*, birches and alders, the latter especially in wetter regions and fringing the banks of the river and tributaries and along the shores of the lake.

The shrubby undergrowth formed a distinct and recognizable storey comprising *Rosa macrophylla*, species of *Rubus*, *Spiraea*, *Viburnum*, *Berberis aristata*, *Salix elegans*, various species of *Desmodium* and *Indigofera*.

Some species of *Rosa*, *Hedera* and *Clematis* comprised the climbers in this region. Not much is known about the ground vegetation but the ferns such as *Adiantum* and *Dryopteris* sp. were present.

The plant formation on the whole was of the mixed type — pine-oak woods or oak-pine woods. It consisted of plant associations or consociations in some of which the oaks dominated and in others the pines. The local climatic and edaphic conditions varied very much in this montane region.

COMMENTS ON THE FOSSIL FLORA OF THE INDIVIDUAL SITES

The fossil flora has so far been described from Ningle Nullah, Liddarmarg, Laredura, Dangarpur, Gogajipathri and Botapathri. Stratigraphically speaking all these plant-bearing deposits belong to Lithozone 4, as investigated by De Terra and Paterson (*loc. cit.*), but their precise position in chronological order within Lithozone 4 has never been worked out. The plant bearing beds are exposed at various places at varying altitudes and from their account by De Terra and Paterson, it appears that there are three major exposures one near Baramula, the other in the Ningle valley, and the third around Nilnag. In each of those regions, the plant beds are further exposed at more than one spot for instance at Laredura alone the plant beds are seen at more than seven spots and as many as at five spots at Dangarpur. These local exposures at Baramula, Ningle Nullah and around Nilnag may or may not belong to the same horizon. A detailed stratigraphical work together with the palaeobotanical correlations might be able to provide the necessary information.

Laredura, Dangarpur, Ningle Nullah and Botapathri are more or less closely situated. The plant beds at Laredura and Dangarpur are exposed at more or less the same altitude (6-6500 ft. a.s.l.) while at Botapathri and Ningle Nullah they are exposed at 9500 ft. a.s.l. Gogajipathri and Liddarmarg are both closely located and the beds exposed at 8800 and 10,600 respectively. How far this close association of the exposed beds is suggestive of their belonging to the same horizon within the Lithozone 4 is not possible to tell at the moment? The floristic comparison and the detailed stratigraphical work may be able to bring about this correlation. Based on floristic evidence Puri correlates the beds of Gogajipathri, Nagpal and Dangarpur with Laredura and considers Ningle Nullah flora and the Liddarmarg flora as distinctly different from the Laredura flora (Puri 1960, pp. 75-76). From the geographical distribution of the sites it appears that the beds of more or less same horizon might have been exposed at —

(i) Laredura, Dangarpur, (altitude ± the same).

(ii) Ningle Nullah and Botapathri (about 9500 ft. each).

(iii) Gogajipathri and Liddarmarg.

For the purpose of reconstruction of vegetation at each site from the identified plant remains, the lists of plant spp. together with the nature of the plant remains and their frequencies wherever known are tabulated. The necessary data have been assembled from Puri's published papers on the Karewa plant remains.

Ningle Nullah (TABLE 3) — This site is situated at a height of about 9000 ft. a.s.l.

The plant remains representative of the lake vegetation comprise the free floating *Nelumbo* (*Nelumbium*) *nucifer* and the members of the reedswamp communities such as *Typha* and *Sparganium*.

The woods around were largely composed of conifers viz., spruce, *Abies*, pine and cedar together with the deciduous poplars, *Salix*, *Acer*, birches and elms. The shrubby vegetation comprised *Desmodium gangeticum* and *Cornus macrophylla*.

From this assemblage of the fossil flora, Puri believes that the climate was temperate and essentially similar to that obtained in the valley today. The temperate nature of the climate is undoubted but whether the climate was as temperate as in the valley today does not seem to be established.

The present altitude of the site may not have been the same when this flora flourished in the vicinity. This is borne out not only by the orogenic changes during the period when the Lower Karewas were laid but also by the heterogenous nature of the flora. Of all the plant remains identified, *Betula utilis* finds its lowermost limit at 10,000 ft. above sea level, *Cornus macrophylla* does not grow above 8000 ft. a.s.l. And *Marlea begoniaefolia* never above 6303 ft. a.s.l. *Desmodium gangeticum* finds its upper limit at 5000 ft. a.s.l. All the aquatics identified, according to Puri (1946, p. 176), do not grow in the Kashmir Himalayas above 5200 ft. a.s.l. The climate obviously must have been different, to allow the plant species of this heterogenous assemblage to grow together, from that obtained in the valley today.

Further both from the altitudinal limitations and the distribution in warmer parts of Asia, *Nelumbo nucifer* Gartn. (*Nelumbium speciosum* Wild.) would seem to be a misfit in this 'exclusively temperate vegetation'. More or less similar conclusion

TABLE 3 – FOSSIL FLORA FROM NINGLE NULLAH*

(About 9000 ft. a.s.l.)

SPECIES	NATURE OF SPECIMENS	NO. OF SPECIMENS	REMARKS
Ulmaceae			
Ulmus laevigata Royle	1		
Salicaceae			
Salix wallichiana Anders	lvs	10	
S. elegans Wallich.	1	1	
S. sp.	lvs	6	
Populus ciliata Wall.	lvs	10	
P. nigra L. var. *fastigiata* Desf.	lvs	10	
P. sp.	lvs	3	
Betulaceae			
Betula utilis D. Don.	1		
Alnus nepalensis D. Don.	lvs	5	
Al. sp.	lvs	4	
Aceraceae			
Acer pentapomicum Stewart	lvs	4	
A. villosum Wallich.	lvs	6	
A. pictum Thunb.	lvs	6	
A. sp.	lvs	1	
Cornaceae			
Cornus macrophylla Wall.	1	1	
Marlea begoniaefolia Roxb.	lvs	2	
Papilionaceae			
Desmodium gangeticum D.C.	1	1	
Nymphaeaceae			
Nelumbo (*Nelumbium*) *nucifer* Gaertn	lvs	4	
Typhaceae			
Typha sp.			
Sparganium sp.			

*An abundance of Spruce, *Abies*, Pine, Cedar — from pollen evidence. (Cf. Puri 1960 p. 76, Indian Forest Ecology).

may be deduced from the presence of *Marlea begoniaefolia* and *Desmodium gangeticum*. Does this anomalous situation suggest the immediate need of the redetermination of this fossil flora?

Botapathri (TABLE 4) — This site is close to Ningle Nullah, and the beds here are exposed at more or less the same altitude (9500′) as at Ningle Nullah.

The plant fossils descovered from this site are not many: obviously they present an incomplete picture of the plant association in the vicinity.

But for *Trapa natans* nothing is known of the other aquatics.

The arboreal elements suggest oak woods.

The plant fossils from this site are clearly suggestive of much lower altitude of the deposits when this flora flourished in the vicinity.

Laredura (TABLE 5) — The Laredura fossil flora shows that the lake was inhabited by *Ceratophyllum* and *Myriophyllum* as members of the submerged plant communities and both the spp. of *Trapa*.

The forest vegetation was made up largely of the oak woods with conifers and deciduous elements such as elms, *Salix*, *Acer*, birches, etc. The undergrowth was largely formed by several spp. of *Desmodium*, *Indigofera* and *Berberis lycium*. *Hedera nepalensis* clothed the boles of the trees.

In this account of the forest vegetation no mention is made of *Woodfordia fruticosa*, *Mallotus philippensis*, *Odina wodier* and *Olea* and some other plant species and their exclusion is justified below.

The fossil flora at Laredura consists of plant species of heterogeneous assemblage: certain spp. which find their lowest limit at 6000, or 7 to 8000 ft. a.s.l. while the plant beds are only exposed at 6000 and there are plant species of incompatible ecological requirements.

While the occurrence of *Woodfordia fruticosa*, *Mallotus philipensis* and *Odina wodier* which find their maximum altitudinal limit up to 5000 or 4500 in the fossil flora might be cited in favour of the uplift of the beds exposed at 6000 a.s.l., the occurrence of *Betula utilis* (lowest limit 10,000), *Quercus semecarpifolia* (lowest limit 8000′) and several other plant species such as *Ulmus campestris*, *Quercus dilatata*, *Acer villosum* and *A. caesium* each with the lowest limit at 7000 remains unexplained. If the extent of uplift of the Pir Panjal is also taken into account, then the occurrence of the high altitude elements at low altitude is almost mysterious. Amongst the ecologically incompatible elements, the occurrence of *Quercus ilex* with those of *dilatata* and *semecarpifolia* is an anamoly. Further-more the occurrence of the last two species together (of which the leaf impressions are equally abundant) and in the same vicinity is again anamolous since both these species are distributed today in altitudinal belts and in the region of overlap of their maximum and minimum limits both the species are never found equally abundant.

Without entering into any explanation of these anamolies and the climatic indications it seems feasible to point out that the redetermination of the fossil flora is likely to solve many of the above anamolies.

From the fossil flora at Laredura, Puri deduces tropical climate. This needs a justification in the occurrence of abundance of temperate oaks comprising *Q. semecarpifolia*, *Q. dilatata* and *Q. ilex* on the one hand and the abundance of *Trapa* (both *natans* and *bispinosa*) on the other.

TABLE 4 – FOSSIL FLORA FROM BOTAPATHRI

(Alt. 9500 a.s.l.)

SPECIES	NATURE OF SPECIMENS	NO. OF SPECIMENS	REMARKS
Fagaceae			
Quercus incana Roxb.			
Q. glauca Thunb.			
Hydrocaryaceae			
Trapa natans Linn.			

TABLE 5 — FOSSIL FLORA FROM LAREDURA

(Alt. 6000 a.s.l.)

SPECIES	NATURE OF SPECIMENS	NO. OF SPECIMENS	REMARKS
Lythraceaə			
Woodfordia fruticosa Linn.	l	1	
Euphorbiaceae			
Mallotus philippensis Muell.	lvs	10	
Juglandaceae			
Englehardtia colebrookiana Lindl.	l	1	
Hippocastanaceae			
Aesculus indica Colebr.	lvs	5	
Myrsinaceae			
Myrsine sp.			
Oleaceae			
Olea sp.			
Ulmaceae			
U. wallichiana Planch.	l		
U. campestris L.	l		
U. laevigata Royle	l		
U. sp.	l		
Salicaceae			
Salix elegans Wall.	l	1	
S. sp.	l	1	
Fagaceae			
Quercus semecarpifolia Smith	lvs	many	
Q dilatata Lindl.	lvs	many	
Q. ilex L.	lvs	many	
Betulaceae			
Betula utilis D. Don	l Bark		
B. alnoides Buch-Ham.	l	1	
B. sp.	l	4	
Alnus nitida Endl.	lvs	2	
Aceraceae			
Acer villosum Wall.	lvs		
A. caesium Wall.	l fr	1	
A. sp.	leaves	4	
Berberidaceae			
Berberis lycium Royle	lvs	3	
Araliaceae			
Hedera nepalensis K. Koch.			
Papilionaceae			
Desmodium latifolium D.C.	l	1	
D. tiliaceum D.C.	l	1	
Indigofera hebepetala Benth	l		
Indigofera sp.	l	1	
Anacardiaceae			
Rhus punjabensis Stewart	l	1	
R. succedania Linn.	l	1	
Odina wodier Roxb.	l	1	
Ranunculaceae			
Ranunculus sp.	l		
Clematis sp.	l		
Hydrocaryaceae			
Trapa natans Linn.	fr	many	
T. bispinosa Roxb.	fr		
Ceratophyllaceae			
Ceratophyllum sp.	l		
Haloragaceae			
Myriophyllum sp.	l		

**Pinus, Cedrus, Abies* vide Puri 1960.

Dangarpur (TABLE 6) — Geographically speaking the locality Dangarpur is closely situated to Laredura.

Both the aquatic and the forest vegetation on the whole is not very different from that at Laredura except that many plant remains

TABLE 6 – FOSSIL FLORA FROM DANGARPUR

(Alt. 6500 a.s.l.)

Species	Nature of specimens	No. of specimens	Remarks
Fagaceae			
Quercus semecarpifolia Smith	lvs		
Q. dilatata Lindl.	lvs		
Q. ilex Linn.	lvs		
Araliaceae			
Hedera nepalensis K. Koch.	fr	1	
Lauraceae			
Litsaea elongata Wall.	lvs		
L. sp.	l		
Hydrocaryaceae			
Trapa bispinosa Roxb.			
Typhaceae			
Typha sp.			
Sparganium sp.			
Ceratophyllaceae			
Ceratophyllum sp.			
Haloragaceae			
Myriophyllum sp.			

have not been discovered from this site. The characteristic elements are the laurels (*Litsaea elongata* and *L.* sp.) which are new elements here.

The genus *Litsaea* along with *Machilus* does form a constituent, though of rare or occasional frequency, of the oak woods in the NW Himalayas, but none of them occurs in the oak woods constituted exclusively by *Q. semecarpifolia*.

Litsaea elongata is of subtropical to temperate distribution, and its occurrence together with the oaks of decidely temperate climate would obviously suggest temperate climate for the Dangarpur flora and not tropical.

The comments made for Laredura flora are equally applicable to the flora of Dangarpur.

Liddarmarg (TABLE 7) — This site occurs at an altitude of 10,200-10,600 ft. and the bulk of the fossil flora is of comparatively low altitude. The thesis of the palaeobotanical evidence supporting the uplift of Pir Panjal (PURI, 1946) is largely based on this material. It is certainly true that the fossil flora from this site has been rightly adjudged from this point of view.

To the so-far-known flora of the lake, *Acorus* sp., *Scirpus* sp. and *Cyperus* sp. are added from this site.

The forest vegetation consisted largely of the oak woods constituted mainly by *Q. incana* and *Q. glauca* (their leaf impressions are 70% of the total impressions), Lauraceae, boxes and birches. The alders formed recognizable but less frequent constituents of the oak woods. The undergrowth consisted of spp. of *Desmodium, Cornus*, *Berberis, Cotoneaster, Spiraea*, etc.

Besides the fact that this flora illustrates the uplift very effectively, some of the anamolies reported earlier especially cases of heterogenous and ecologically incomatible plant species are equally present in this flora such as *Betula utilis* and the two spp. of *Acer* (*oblongum* and *pentapomicum*).

The general remarks made earlier in connection with the Laredura flora are also applicable to the fossil flora of this site.

Gogajipathri (TABLE 8) — This locality is close to Liddarmarg though the plant beds are exposed at a lesser altitude (8800′ a.s.l.).

The forest vegetation comprised oak woods with deciduous elements such as elms and *Rhus*.

The general remarks made in connection with the fossil flora of the other sites are applicable to the flora of this site also.

This critical appraisal of the fossil flora from the individual sites of the Lower Karewas brings out certain difficulties in the reconstruction of the vegetation at or around each site namely the heterogeneous assemblage of the plant species of which

TABLE 7 — FOSSIL FLORA FROM LIDDARMARG

(Alt. 10,200-10,600 ft. a.s.l.)

SPECIES	NATURE OF SPECIMENS	NO. OF SPECIMENS	REMARKS
Fagaceae			
Quercus incana Roxb.	lvs	abundant	70 % of total
Q. glauca Thunb.	lvs	,,	
Euphorbiaceae			
Mallotus philippensis Muell.	l		
Urticaceae			
Ficus cunia Buch-Ham.	lf	4	
Aceraceae			
Acer oblongum Wall.	l		
A. pentapomicum Stewart	lvs	4	
A. sp.	fr	1	
Lauraceae			
Litsaea lanuginosa Nees.	lvs	10	
Cinnamonum tamala Nees.	lvs		
Machilus odoratissima Nees	lvs		
M. duthie King	lvs		
Phoebe lanceolata Nees.	lvs	2	
Buxaceae			
Buxus wallichiana Baillon	lvs	2	
B. papillosa Schn.	lvs	2	
Ulmaceae			
Ulmus sp.	lvs	not abundant	
Rutaceae			
Sikimmia laureola Hook. f.			
Toddalia sp.			
Pittosporaceae			
Pittosporum eriocarpum Royle.			
Rhamnaceae			
Rhamnus virgata Roxb.			
R. triquetra Wall.			
Berchemia floribunda Wall.			
Myrsinaceae			
Myrsine africana Linn.			
M. semiserrata Wall.			
Oleaceae			
Syringa emodi Wall.			
Rubiaceae			
Wendlandia exserta D.C.			
Rosaceae			
Pyrus communis L.			
Cotoneaster sp.			
Spiraea sp.			
Betulaceae			
Betula utilis D. Don	lvs	10	
Alnus nepalensis D. Don	lvs	5	
Berberidaceae			
Berberis lycium Royle	lvs	6	
Berberis sp.	lvs	3	
Cornaceae			
Cornus capitata Wall.			
Hamamelidaceae			
Parrotia jacquimontiana Dcne.	l		
Papilionaceae			
Desmodium podocarpum D.C.	lvs	2	
D. laxiflorum D.C.	lvs	2	
D. sp.	l	1	
Compositae			
Inula cappa D.C.			
Araceae			
Acorus sp.			
Cyperaceae			
Scirpus sp.			
Cyperus sp.			

TABLE 7 — FOSSIL FLORA FROM LIDDARMARG (*contd*)

(Alt. 10,300-10,600 ft. a.s.l.)

Species	Nature of specimens	No. of specimens	Remarks
Hydrocaryaceae			
Trapa bispinosa Roxb.			
T. natans Linn.			
Typhaceae			
Typha sp.			
Sparganium sp.			

TABLE 8 – FOSSIL FLORA FROM GOGAJIPATHRI

(Alt. 8800 a.s.l.)

Species	Nature of specimens	No. of specimens	Remarks
Ulmaceae			
Ulmus campestris Linn.			
Fagaceae			
Quercus semecarpifolia Smith			
Q. ilex Linn.			
Anacardiaceae			
Rhus cotinus Linn.			
Typhaceae			
Sparganium sp.			

quite a few are of widely different climatic requirements. Consequently it is not possible to infer any precise climatic conditions from the local floras. A fact of great importance that emerges from this study suggests the immediate revision of the entire fossil flora so as not only to determine the present spp. but also the extinct ones.

DISCUSSION AND CONCLUSIONS

The Interglacial Sequence of Climate — At the outset it seems our duty to correct the confusion created by the previous work regarding the climatic sequence during an interglacial. Both the works of De Terra and Paterson (*loc. cit.*) and Puri (*loc. cit.*) impress upon the readers the occurrence of a single type of climate during an interglacial, which is not founded on facts. An interglacial is a period between two glaciations with a climate very much warmer than during the periods of glaciation. But the climate during an interglacial shows a succession from the gradually warming climate after deglaciation approaching the optimal conditions (warmth maximum) from where it tends to change into the gradually cooling climate approaching climax in the onset of the next glaciation. The climatic sequence, therefore, throughout a complete interglacial should be cool-warm-cool. Besides, there may be some oscillation in warm phase. This broad climatic sequence during an interglacial period may further be subdivided into dry and wet subphases of the cool and or the warm periods.

The application of this concept of the climate of the Interglacial to the Lower Karewas, of which the age for the moment is believed to be First Interglacial, would show a similar sequence of climate — cool-warm-cool, if the Lower Karewa sediments represent the entire interglacial period.

Ecological considerations of the Karewa Flora — That the Lower Karewa Fossil Flora contains plant species ranging in their climatic requirements from the subtropical to cold temperate and that some of them are today restricted to distinct altitudes in the Himalayas has already been pointed out by Puri and Stewart. The occurrence of plant species of diverse habitat and of varying ecological requirements is analysed in detail before deducing any climatic conditions under which this flora flourished.

Status of the Tropical elements — Amongst the tropical and subtropical elements, Puri lists the following:

Ficus cunia, *Mallotus philipensis*, *Pittosporum eriocarpum*, *Wendlandia exserta*, *Berchemia*, *Myrsine*, *Odina wodier*, *Acer oblongum*, *Litsaea lanuginosa*, *Woodfordia fruticosa*, *Buxus* spp., *Machilus* sp.

These include a large number of the plant species of tropical and subtropical climates. Their true status as members of the plant communities can be best understood by taking into consideration their relative frequencies in the finds and their present range in altitude in the Western Himalayas. In the light of these two facts, their role as determiners of climate in the entire vegetation will be assessable to the fullest degree.

From the tables constructed here of the frequency of their records, one would find that in this area of dominant oak-pine or pine-oak woods with a large majority of the temperate elements, the frequency of these tropical-subtropical elements is fairly negligible, which when expressed in terms of ecology would refer to their occurrence as very rare or rare. Furthermore many of these elements find their maximum altitudinal limit up to 5000 or 6000 ft. while a few up to 4000 ft. above sea level. It must be stated that their maximum altitudinal limit does bring them, if not in the temperate zone, at least to the threshold of the temperate zone in the Western Himalayas. Together with the preponderance of the temperate elements, it would be feasible to infer that they constituted the rare members of the temperate vegetation. In view of the montane topography of this region, they probably occurred at the foot of the hills. If they were any abundant or formed the dominant or subdominant members of the plant communities, their records must have been profuse amongst the plant remains while the facts are just the opposite. It would thus bring out that the inference of tropical and subtropical climate as inferred by Puri from the occurrence of these plant remains in the Lower Karewa, when judged from their ecological perspective, is not borne out at all. The ecological analysis of the flora from the L. Karewas suggests the prevalence of temperate climate which was also moist.

Altitude of Pir Panjal during the Lower Karewas — Of all the plant remains, the identified species of oaks are of special significance. The relative frequencies of the various spp. are far from known but on the whole the oak leaves dominate the plant remains. The three species of *Quercus*, viz., *semecarpifolia*, *dilatata* and *incana* (and also *glauca*) are of chief interest. They occupy today distinct altitudinal zones with *incana* at the bottom and *semecarpifolia* towards the top of the range. Both *incana* and *dilatata* occur between 6-8000 ft. a.s.l. *Dilatata* occurs above 7000 ft. while *semecarpifolia* occurs above 8000 ft. (8-12000 ft.). Both *incana* and *dilatata* may occur together in oak woods or mixed oakwoods since a good deal of overlap in their respective altitudes is seen, but the oakwoods of *semecarpifolia* are invariably found to be either pure or mixed with *dilatata*. *Incana* is rarely found mixed with them as in the *Spruce*-deodar belt in the Sutlej Valley. Occasionally *semecarpifolia* may descend to 6000 ft. but it is seldom found in abundance below 8000 ft. From the equally abundant remains of *semecarpifolia* and from its altitudinal considerations one would safely conclude that the altitude of the Pir Panjal was in any case not less than 8000 ft., it might have been higher than this.

The above view is also corroborated by the high level birch, *Betula utilis*, which normally occurs between 10-14000 ft. in the Western Himalayas, though sporadically it is found as far below as 6000 ft. a.s.l.

It may be pointed out that the prevailing climate in the montane region is the chief determiner of the altitudinal zonation of vegetation. An extremely cold (arctic) climate would shift the altitudinal zones towards the foot of the mountains and consequently the high level forms would tend to occur at low levels while during the warmer climate the vegetation belts would ascend higher. The approximate climatic conditions inferred from the Karewa fossil flora approach those of a temperate climate and not that of the arctic, the approximate estimate of the altitude of Pir Panjal, therefore, seems to have been a little higher than 8000 ft. and the highest peaks may have borne the open vegetation chiefly the steppe type and must have been snowbound during a large part of the year as will follow from the account below. From this it would appear that from the base to the top of the Pir Panjal range, the vegetation was disposed in altitudinal zones as can be seen today. In the valley as well as along the slopes of the Pir Panjal distinct plant associations and consociations depending upon local topography and local edaphic conditions existed as they do today.

Climate — The climate of this region has been deduced to be temperate and not subtropical. The montane topography and peculiar physiographical conditions warrant the acceptance of one type of climate in this region. A corresponding example could be taken from any ranges of the Western Himalayas. Though there is a marked difference in the climatic conditions obtained above 8000 ft. a.s.l. these ranges do present climatic conditions showing a great range from subtropical or warm temperate to cool temperate. Above 10,000 ft. arctic-alpine conditions prevail. This is chiefly conditioned by the decrease in temperature with the rising altitude which is estimated to be 1° for 1000 ft. rise in altitude but at the same time comparatively more reduction in temperature is noted by a rise of 1000 ft. at higher elevation.

Furthermore within this altitudinal range the rainfall is not equally distributed and the available water content also varies considerably. There will be sheltered sites, sites fairly dry and sites ranging from moist to wet. Besides the climate, the local edaphic conditions exercise their own influence. The accumulating effect of all these factors will express itself so strongly that not only the vegetation will be disposed in recognizable belts, but within each belt the plant communities will differ qualitatively and quantitatively from one another and one would be left wondering if such widely diverse climatic and ecological plant communities could exist under the same climate. A very much similar situation is obtained in both the outer, the middle and the inner Himalayas.

More or less similar climatic conditions must have prevailed when the lower Karewa flora flourished in this region. The recognition of the plant species of diverse ecological habitats, attention to which has already been drawn in the succeeding pages, suffices to bear out this fact.

The reconsideration of the Fossil Flora from the Lower Karewas affects the conclusions arrived at by earlier workers. The present position of these conclusions in the light of the reconsideration of the flora is discussed below.

1. Age of the Lower Karewas

The plant-bearing beds belong to the Lithozone 4 of the long profile of the Lower Karewas and represent the top region of the Lower Karewas. On account of their stratigraphical position, these plant-bearing beds belong to the First Interglacial, whether their age is considered from the viewpoint of De Terra and Paterson (*loc. cit.*) or of Wadia (*loc. cit.*).

2. Uplift and Altitude of Pir Panjal

The Pir Panjal was decidedly of a lesser height than now and its subsequent uplift was responsible for the change of the climate. The uplift together with the changing climate must have excercised its influence in the shifting of vegetational belts and in the southward migration of the monsoon forest.

3. Climate

(i) The contention of De Terra and Paterson that the climate was moister and warmer than today seems to be borne out by the reconsideration of the flora.

(ii) The climate was temperate and not tropical or subtropical. Since we know the Fossil Flora only from the Lithozone 4, the climatic deductions pertain to this part of the Lower Karewas. We are still unaware of the climatic conditions during the remaining Lithozones 1-3 and 5.

(iii) Stratigraphically the Ningle Nullah beds also belong to Lithozone 4 and to the First Interglacial. The climate was equally temperate here too.

(iv) The present climate of the Valley did not evolve from that of the First Interglacial. Between the present and the First Interglacial, the long gap of time, the Kashmir Valley has witnessed three more major glaciations besides minor advances and retreats. Between these glaciations there have been two more Interglacial periods followed by the third Interglacial — the present one which started after the last glaciation. Thus there have been numerous successive and alternate changes of climate from cold to warm, dry to wet and vice versa. Consequently the climate of the First Interglacial must have changed many times during these glacial epochs and there must have been successive immigrations of the plant communities in this region ultimately struggling and stabilizing into the present flora and climate of the valley.

It is, therefore, incorrect to say that the climate of the Valley has remained unchanged since the deposition of the Ningle Nullah beds.

4. Palaeophytogeography

(i) The fossil flora from these beds (all belonging to Lithozone 4) does not represent a complete sequence of fossil floras from the Pir Panjal. It constitutes a fraction of that infact (cf. 5 above).

(ii) It is not possible to say with any definiteness which of the elements of the conifers were better represented than the others. Nevertheless *Pinus* does appear to have been dominant over the other conifers. *Picea* was not unrepresented as the abundance of pollengrains of Spruce have been recorded (Puri 1960, p. 76).

(iii) The three stages of the phytogeographical evolution of the valley are not founded on facts.

The Lithozone 4 is a part of the First Interglacial and we have no knowledge of the flora from the deposits before and after the Lithozone 4. Thus the discussion of the preglacial flora is completely fallacious or imaginary.

Puri's stages of vegetational evolution — the preglacial vegetation, the First Interglacial vegetation, the vegetation during the close of the First Interglacial and that during the close of the second Interglacial are largely based upon the fossil flora from the beds which are included by De Terra and Paterson in Lithozone 4 — a part of the First Interglacial. This illustrates a case of usual pitfall in palaeobotany when the fossil floras are dealt with without any regard to their stratigraphical position.

APPENDIX

Record of Pleistocene Flora from Kashmir

ANGIOSPERMS	
Ranunculaceae	
Ranunculus sp.	Laredura
Clematis montana Buch-Ham.	...
Clematis sp.	Laredura
Berberidaceae	
Berberis ceratophylla G. Don.	...
Berberis lycium Royle	Liddarmarg, Laredura.
Berberis sp.	,,
Pittosporaceae	
Pittosporum eriocarpum Rayle	Liddarmarg
Rhamnaceae	
Rhamnus purpurea Edgew.	...
R. virgata Roxb.	Liddarmarg
R. triquetra Wall.	,,
Berchemia floribunda Wall.	,,
Aceraceae	
Acer caesium Wall ex Brandis	...
**A. pentapomicum* Stewart	Liddarmarg

*Now known as *A. pentaponticum*

A. villosum Wallich	Laredura
A. pictum Thunb.	
A. oblongum Wall.	Liddarmarg
A. sp. cf. *acuminatum* Wall.	...
A. spp.	Liddarmarg, Laredura
Hippocastanaceae	
Aesculus indica Colebr.	Laredura
Rutaceae	
Skimmia laureola Hook. f.	Liddarmarg
Toddalia sp.	Liddarmarg
Sabiaceae	
Meliosma pungens Wall.	...
Anacardiaceae	
Rhus punjabensis Stewart	Laredura
R. succedania Linn.	,,
R. cotinus Linn.	Gogajipathri
**Odina wodier* Roxb.	Laredura
Leguminosae	
Indigofera hebepetala Benth.	Laredura
Indigofera sp.	,,
Desmodium podocarpum D.C.	Liddarmarg
D. laxiflorum D.C.	,,
D. gangeticum D.C.	Ningle Nullah

*Now known as *Lannea grandis* Engler.

D. latifolium D.C.	Laredura
D. tiliaceum D.C.	,,
D. nutans Wall. (*D. tiliaefolium* ?)	,,
D. sp.	Liddarmarg
Rosaceae	
Prunus jacquemontii Hook. vel aff.	...
P. cornuta Wall.	...
P. cerasifolia Ehr. vel aff.	...
Spiraea canescens D. Don	...
S. sp.	Liddarmarg
Rosa webbiana Wall. appr. *R. beggariana* Schrank.	...
R. macrophylla Lindl.	
Pyrus communis Linn. vel aff.	Liddarmarg
* *P. foliosa* Wall. vel. aff.	
P. aucuparia Gaertn. vel aff.	...
P. pashia Buch-Ham	...
Cotoneaster microphylla Wall.	...
C. nummularia Fisch et Meyer	...
C. bacillaris Wall.	...
C. sp.	Liddarmarg
Hamamelidaceae	
Parrotia jacquemontiana Dcne.	Liddarmarg
Lythraceae	
Woodfordia fruticosa Linn.	Laredura
Araliaceae	
Hedera nepalensis K. Koch.	Laredura, Dangarpur.
Cornaceae	
Cornus macrophylla Wall.	Ningle Nullah
+ *C. capitata* Wall.	Liddarmarg
Marlea begoniaefolia Roxb.	Ningle Nullah
Caprifoliaceae	
Viburnum stellulatum Wall. vel aff.	...
Rubiaceae	
Wendlandia exserta D.C.	Liddarmarg
Compositae	
Inula cappa D.C.	Liddarmarg
Artemisia sp.	
Myrsinaceae	
Myrsine africana Linn.	Liddarmarg
Myrsine semiserrata Wall.	,,
Myrsine sp.	Laredura
Oleaceae	
Jasminum sp.	...
Olea sp.	Laredura
Fraxinus excelsior Linn.	...
Syringa emodi Wall.	Liddarmarg
Lauraceae	
Cinnamomum tamala Nees.	Liddarmarg
Machilus odoratissima Nees.	,,
M. duthiei King	,,

Phoebe lanceolata Nees	Ningle Nullah
Litsaea lanuginosa Nees	,,
L. elongata	Dangarpur
L. sp.	,,
Buxaceae	
Buxus wallichiana Baillon	Liddarmarg
B. papillosa Schn.	,,
Euphorbiaceae	
Mallotus philippensis Muell. Arg.	Liddarmarg, Laredura
Ulmaceae	
Ulmus *wallichiana* Planch.	Laredura
U. parviflora Jacq.	
U. laevigata Royle	Ningle Nullah, Laredura
U. campestris Linn.	Laredura, Gogajipathri
U. sp.	Laredura, Liddarmarg.
Urticaceae	
Ficus cunia Buch-Ham.	Liddarmarg
Juglandaceae	
Juglans regia Linn.	...
Englehardtia colebrookiana Lindl.	Laredura
Betulaceae	
Betula utilis Don.	Laredura, Liddarmarg, Ningle nullah.
B. alnoides Huch-Ham.	Laredura
B. sp.	...
B. sp.	Laredura
Alnus nitida Endl.	Laredura
A. nepalensis D. Don.	Ningle Nullah, Liddarmarg
A. sp.	...
A. sp.	Ningle Nullah.
Carpinus sp.	
Fagaceae	
Quercus semecarpifolia Smith	Gogajipathri, Dangarpur, Laredura.
Q. incana Roxb.	Liddarmarg, Botapathri
* *Q. dilatata* Lindl.	Laredura, Dangarpur.
Q. glauca Thunb.	Liddarmarg, Botapathri
Q. ilex Linn.	Laredura, Dangarpur, Gogajipathri.
Castanopsis sp.	...
Salicaceae	
Salix wallichiana Anders.	Ningle Nullah
S. denticulata Anders	...
S. spp.	...
S. elegans Wallich.	Ningle Nullah
S. sp.	,,
Populus alba L. vel. aff.	...
P. ciliata Wall.	Ningle Nullah
P. nigra var. *fastigiata* Desf.	,,
P. sp.	...
Gramineae	

*Now known as *Sorbus foliolosa* (Wall.) Spach.

+Now known as *Dendrobenthamia capitata* (Wall.) Hutch.

*The correct name of this species is *Q. floribunda* Wall. cf. A. Rehder, *Journ. Arn. Arboretum* (1941), pp. 572-3).

Chenopodiaceae	
Persicaria sp.	
Araceae	
Acorus sp.	Liddarmarg.
Cyperaceae	
Cyperus sp.	Liddarmarg
Scirpus sp.	,,
Typhaceae	
Typha sp.	Dangarpur, Ningle Nullah, Liddarmarg.
Sparganium sp.	Ningle Nullah, Liddarmarg, Dangarpur, Gogajipathri.
Hydrocaryaceae	
Trapa natans L.	Botapathri, Liddarmarg, Laredura.
Trapa bispinosa Roxb.	Liddarmarg, Laredura, Dangarpur.
Haloragaceae	
Myriophyllum sp.	Laredura, Dangarpur.
Ceratophyllaceae	
Ceratophyllum sp.	Laredura, Dangarpur.
Nymphaeaceae	
Nelumbo (*Nelumbium*) *nucifer* Gaertn.	Ningle Nullah.

GYMNOSPERMS

Coniferales	
Pinus excelsa Wall.	...
Abies webbiana Lindl.	...
Picea smithiana Boiss.	...
Juniperus sp.	...
Taxus sp. (*baccata*)	...
Cedrus (*deodara*)	...
Ephedrales	
Ephedra	

PTERIDOPHYTA

Selaginellaceae	
Selaginella ?	
Filicales	
Adiantum sp.	
Dryopteris cf. *filix-mass* (L.) Schott.	

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