LOKTA (Daphne Spp.)

&

CRAFT PAPER-MAKING IN NEPAL

A RESEARCH REPORT

BASED ON

A LITERATURE REVIEW

AND

PRELIMINARY FIELD OBSERVATIONS

(May 1984 - October 1984)

by

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NOVEMBER 1984

Published by:

FOREST RESEARCH AND INFORMATION CENTRE
FOREST SURVEY AND RESEARCH OFFICE
DEPARTMENT OF FOREST
KATHMANDU, NEPAL

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A report on the current status, based on a literature review and preliminary field observations (MAY 1984 - OCTOBER 1984)

by

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18th November 1984

SUMMARY

The inner fibrous bark of Lokta shrubs (*Daphne bholua* and *Daphne papyracea*) provide the chief raw material for cottage industry paper-making in Nepal. The recent increase in demand for this high quality paper has resulted in the over-exploitation of the resource in many hill areas.

This report reviews the current status of the resource, focussing mainly on its natural distribution, ecology, silviculture and management. Traditional and improved manufacturing techniques are described and a comparison made of their specific fuelwood requirements.

Other fibre - producing species are listed and their potential as alternative sources of raw material for the industry is discussed.

Past research is reviewed and future research priorities, relevant to management of natural stands of *Daphne* for conservation and sustained yield, are outlined.

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ACKNOWLEDGEMENTS

I wish to thank the following organisations and individuals for the assistance provided to the Fibre Research Programme: Voluntary Service Overseas (V.S.O.) for the job placement; The Silvicultural Research Project (O.D.A.) for technical assistance and nursery facilities; Dr. Christian Haberli (S.A.T.A.) for logistical support and the provision of a trial site at Kalinchok forest; Ms. Kathy Peterson (UNICEF); Devendra Amatya (Forestry Services); the staff at the Department of Forest (HMG/N); and in particular Mr. Ian Thompson for his assistance with the design of the Biomass studies.

ACRONYMS USED IN THE TEXT

ADB	=	Agricultural Development Bank (Nepal)
CFI	=	Commonwealth Forestry Institute, Oxford, U.K.
DCVI	=	Department of Cottage and Village Industries (Nepal)
DFC	=	District Forest Controller
FSRO	=	Forest Survey and Research Office (Nepal)
HMG/N	=	His Majesty's Government of Nepal
SATA/IHDP	=	Swiss Aid for Technical Assistance/Integrated Hill Development Project
SECID/RCUP	=	South East Consortium for International Development/ Resource Conservation and Utilization Project
UNICEF	=	United Nations' Childrens' Fund

PRELIMINARY REPORT ON LOKTA (DAPHNE Spp.) AND CRAFT PAPER-MAKING IN NEPAL

SECTION 1: INTRODUCTION

1.1 The Importance of Lokta in Nepal

From the distant past up to the present day, the paper - makers in Nepal have almost exclusively used the inner bark, or bast, of several closely related species of shrubs of the family Thymelaeaceae, as fibre - materials for the manufacture of paper. Throughout the middle hills from the East to the Far-West of Nepal two species of the genus Daphne; D. bholua Buch. - Ham. ex D. Don and D. papyracea Wall. ex Steud. emend. W.W. Smith and Cave, and one species of the genus Edgeworthia *Edgeworthia gardneri (Wall.) Meisn. are commonly used for the manufacture of Nepalese hand-made paper known in the vernacular as 'Nepali kagaj'.

The history of paper-making as a rural based cottage industry in Nepal can be traced back to at least the 12th century A.D. (Trier, 1972), when locally produced paper was used extensively for the publication of Mantras, tracts and books of a religious and secular nature (Bajracharya, 1983). The art of its manufacture came to South-West China (Szechwan) sometime around the first century A.D. probably coinciding with the introduction of Buddhism and the consequent increase in demand for writing materials. Then with the expansion of the Tibetan empire up to the 10th century waves of migrants moved westwards and southwards over the Himalayan passes into Bhutan and Nepal. According to Trier (1972) the Nepalese living in the northern areas of the middle hills range Tamang, Gurung, and Magar are largely the descendants of these migrations. Paper-makers seem to have been among the latest arrivals of these people around the turn of the millennium (Trier, 1972) (Vending, pers. comm, 1984).

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* usually be mixing it with D. bholua or D. papyracea in a ratio of 1:3, it is rarely used alone.

In twentieth century Nepal, despite increasing imports of paper from abroad, the hand-made paper industry remains one of the chief traditional cottage industries in the country (Suvedi and Raymajhi, 1976).* It partly meets the demand for legal documents, horoscopes, fortune - telling cards, paintings, masks, incense wrappings, wound dressings, calendars, lampshades and a host of other products, including stationery, for both the domestic and overseas market (see Trier, 1972; pp. 129-160). Although in recent years the industry had been experiencing a gradual decline, the establishment of a UNICEF assisted Card manufacturing and paper processing factory at Bhaktapur in 1981 led to renewed interest in, and increased demand for Lokta paper. This has resulted in inevitable pressure on the resource and growing concern for its conservation and management on a sustainable basis.

1.2 Objectives of the Fibre Research Programme

The Fibre Research Programme was proposed by the Ministry of Forests and Soil Conservation and is a logical extension of the preliminary broad - based 'Lokta survey' carried out by the Forest Survey and Research Office (FSRO), HMG/N Department of Forests (1984).** Moreover, it reflects concerned official interest in the future conservation and sustained use of the resource.

In accordance with these objectives of conservation and sustained use, the research programme, which started in March 1984 will run for an initial two year period and will focus primarily on the following priorities:

i) A regional survey to determine the ecological conditions and factors which optimize the growth of natural stands of Daphne species.

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* Industrial Services Centre, Balaju, Kathmandu.

** See map No. 1.

ii) To observe and record current management practices and where appropriate to make recommendations for improved management aimed at maximizing sustained bark yield and stand conservation.

iii) In conjunction with ii), to establish permanent growth and management trial plots in order to quantify regrowth, bark yield and optimum rotation length, under a veriety of management regimes at different elevations.

iv) To develop methods appropriate to the propagation of the two main Daphne species by investigating the viability of a range of techniques e.g.; vegetative propagation of different cutting types, aerial and ground layering, seedling production seed viability, storage and handling.

v) In conjunction with iv), to assess the potential for planned cultivation of Daphne species and to conduct a programme of research to evaluate the optimal methods for their establishment based on sound ecological principles.

vi) To conduct a regional survey aimed at quantifying fuelwood requirements for the manufacture of hand-made paper by both the traditional and improved (Caustic Soda) methods and where possible to recommend improvements in the way fuelwood is currently used in the industry.

vii) To explore the possibilities of using other fibre-producing species in the event of projected Lokta supplies being insufficient to meet estimated future demand.

The requirement for further research will be reviewed at the end of the initial two year period.

SECTION 2: SOURCES OF INFORMATION

2.1 Introduction

The first 4 months in project were chiefly devoted to:

i) Collecting references and reviewing relevant literature from a variety of sources; The Forest Research and Information Centre, Dept. of Forests; UNICEF; Forestry Services (Pvt); HMG/N Dept. of Cottage and Village Industries; Industrial Services Centre; Resource Conservation and Utilization Project (RCUP); The Swiss Association for Technical Assistance (SATA); The Commonwealth Forestry Institute (CFI) Library, Oxford; and a number of other libraries in Kathmandu; The Royal Botanical Gardens, Godavari.

ii) Visiting government and non-government organisations and individuals involved in research and development work associated with Lokta production and the craft paper-making industry.

iii) Conducting field studies within and outside the valley at Nagarkot, Kalinchok Phulchoki, Simbhanjyang, Kaulithana, Syabru and Ghore Tabela (Langtang National Park)* with the aims of a) becoming familiar with the genus and its ecology, b) assessing the feasibility of areas with good road access as trial sites, c) collecting cutting materials, specimens and seed, d) studying natural regeneration.

iv) Setting up replicated propagation screening trials (soft-wood, semi-hardwood, hardwood and root cuttings) at two monthly intervals at Hetauda, Chalnakel, and Kaulithana nurseries.*

2.2 Literature Sources

The most complete collection of literature on the subject in Nepal is housed in the Forest Research and Information Centre, Department

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* See map No. 2.

of Forests, Babar Mahal. Godavari Botanic Gardens library has a selection of the most important taxonomic literature, and the Dept. of Cottage and Village Industries, Kalimati has a collection related to manufacturing processes. An exhaustive list of the literature consulted is provided in the attached bibliography; the most relevant are marked with an asterisk.

2.3 Herbarium Collections

Herbarium specimens of Thymelaeaceae from Nepal are available at Kew and Edinburgh botanic gardens. Godavari Herbarium has a representative collection of the following related species: Daphne bholua (syn. D. cannabina), Daphne papyracea (syn. D. cannabina), Daphne retusa, Daphne sureil, Daphne gracilis (probably D. bholua var. glacialis misnamed), Edgeworthia gardneri, Stellera chamaejasme, Wikstroemia canescens (a list of specimen numbers is given in Appendix 1).

There are live speciments at Kew, Edinburgh and Copenhagen Botanical gardens and a single specimen of Daphne bholua at Godavari.

2.4 Past Research and Development

A review of the available literature reveals a paucity of well - documented, scientific research on the subject. Most of the recent research into Lokta management and propagation has been undertaken in Nepal by FSRO (1984); D.B. Amatya, Forestry Services for UNICEF, SECID/RCUP, AND SATA/IHDP (1983/84); Industrial Services Centre, Balaju (1976/77); Malcolm W. Campbell, Nepal/Australia Forestry Project (1983).

Research into manufacturing techniques is being conducted with Japanese technical assistance by HMG/N Dept. of Cottage and Village Industries, Kathmandu. The same department has initiated a series of three month training programmes in improved manufacturing methods for paper-makers from all over Nepal.

Daphne bud chromosome studies have been conducted by S. Bhattarai a botanist at Godavari Botanic gardens.

In Japan microscopic structural examinations have been carried out on three Daphne species by J. Ohtani and S. Ishida (1978) and in India the compositional and pulping characteristics of Daphne bholua were evaluated by C.N. Saikia et.al. (1972).

'Ethno - technological' research and field work were carried out by J. Trier (1962-70) and his findings are published in his very valuable book 'Ancient Paper of Nepal' (1972).

SECTION 3: DESCRIPTION OF THE SPECIES, THEIR NATURAL DISTRIBUTION AND ECOLOGY

3.1 Introduction, the Family Thymelaeaceae

Domke, 1934, divides the family into 4 sub-families, including Thymelaeoideae, which again is subdivided into 4 tribes including Daphneae (see Table 1). According to the author this comprises 13 genera and C. 150 species which have spread to nearly all parts of the globe.

Daphneae is further divided into 5 subtribes, two of which are relevant to this current study: Wikstroemiinae (including the species Wikstroemia canescens and Wikstroemia chamaejasme) and Daphninae.

Daphneae is divided into two subseries of which the first comprises Daphne and Erisolena (with its single species Daphne involucrata) and the second Edgeworthia (comprising the two species Edgeworthia gardneri and Edgeworthia chrysantha).

The genus Daphne comprises C. 70 species and is divided into 3 sections, viz. Daphnantes, Laureola and Mezereum (including Daphne mezereum).

Daphnantes is again subdivided into 6 subsections, 4 of which are Daphnanthoides and include: Daphne bholua, Daphne papyracea, Daphne sureil, Daphne retusa and Daphne tangutica.

Table 1: The Family Thymelaeaceae (adapted from Trier, 1972)

SUBFAMILY	TRIBE	SUBTRIBE	SUBSERIES RAMUS	SECTION	SUBSECTION
CONYSTYLOIDEAE					
AQUILARIOIDEAE	DICRANOLEPIDEAE				
GILGIODAPHNOIDEAE		WIKSTROEMIINAEA			DAPHNANTHOIDES
	PHALERIEAE				ALPINAE
THYMELAEOIDEAE		DENDROSTELLERINAE			
	DAPHNEAE	DAPHNOPSINAE	DAPHNE	DAPHNANTES	PSEUDOMEZEREUM
		DAPHNINAE	ERISOLENA	LAUREOLA	OLEOIDES
	GNIDIEAE				
		RHAMNONEURINAE	EDGEWORTHIA	MEZEREUM	COLLINAE
					CNEORUM

It should be noted that with regard to D. bholua and D. papyracea, the two most important paper - fibre plants, botanical classification remains controversial, and there has been considerable taxonomic confusion between these two and other closely related species such as Daphne sureil W.W. Smith and Cave.

3.2 Nomenclature

FAMILY : Thymelaeaceae Meiss. (1857)

GENUS : Daphne Linn.;

LATIN NAMES : a) Daphne bholua Buch. - Ham. ex. D. Don (syn. D. cannabina Wall.)

b) Daphne papyracea Wall. ex Steud. (syn. D. cannabina Lour. ex Wall.)

CHROMOSOME No.: n = 9

VERNACULAR: There are many local names often used interchangeably and generally little distinction is made between species. Trier lists 49 different names for the two species (P. 59). The most commonly used names in the Himalayan region are:

i) NEPAL. Kagat pat (e), Kagate, Kaghuti, Dunkotah, Gande, Argayle, Arbadi, Sikre, Shunsu, Baruwa (1), Balwa, Bholuswa (Newari), Bhullu. A distinction is sometimes made between 'Seto balua (baruwa)' and 'Kalo baluwa (baruwa)' i.e., White and black which probably refers to the White flowers of D. papyracea and the black fruit of D. bholua or, as Trier (1972) suggests the difference in colour of the paper produced from these two plants, that of D. papyracea being whiter than that of D. bholua which often has a greyish hue. Both plants are often referred to as 'Lokta' or 'Lokoda' as is the paper manufactured from the bast of these two species.

ii) INDIA. Satpura, Setburwa, Setburosa, Niggi, Jeku, Supkaseng, Chamma, Dhak Chamboi, and Mahadeo ka phul (God's flower) alluding to its use for temple offerings.

iii) SIKKIM and BHUTAN. Dhenok, Dayshing.

iv) BURMA. Hsele.

3.3 General Botanical Description*

Daphne bholua is an erect or spreading evergreen or deciduous (var. glacialis) shrub on average 1 to 3 m high with branches 2 to 3 cm thick. The leaves are entire, dull green, leathery, hairless, alternate 5 to 10 cm or more with a very short petiole, elliptic to oblanceolate, (average leaf - 7.6 cm x 2 cm).

The flowers are sweet - scented, white, flushed externally pink or purplish with slender silky-haired perianth tube 6 to 12 mm long each with 4 broad or narrow ovate acute spreading lobes C. 6 to 8 mm long, and are borne in terminal rounded stalkless clusters of about 6 to 12. Flowering is usually from December - May (incl.) depending

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* adapted from the taxonomic literature, but chiefly from Polunin and Stainton (1985) and Trier (1972).

on altitude etc. The fruit is an ellipsoid berry, purple or almost black when ripe. The fruits ripen from March - June.

Daphne bholua var. glacialis (W.W. Smith and Cave) Burtt., is a deciduous shrub with pink to purple very sweet - scented flowers, appearing in stalkless clusters on bare branches in spring and occasionally in winter; from West Nepal to Sikkim reported to replace D. bholua above 3,000 - 3,500 m. It is usually a small shrub.

Daphne papyracea is a much-branched erect evergreen shrub 1 to 3 m high with branches up to 3 cm thick, having smooth grey bark. The leaves are entire, very dark green (darker than D. bholua), smooth and thinly leathery, when dry they become a dark bluish-grey. They are alternate, narrow-lanceolate to oblanceolate, rather corrugated 5 - 15 cm hairless, with veins impressed above, short petioled and grooved, (average leaf - 9 cm x 2.25 cm).

The flowers have either a faint scent or none, are white or greenish-white with a slender perianth tube* 10 to 13 mm long, very downy outside each with 4 acute spreading lobes C. 8 mm long. They are borne in sessile, bracteate terminal clusters of 10 to 16 with persistent hairy bracts. Flowering time is generally given as from November to February (incl.). However, during recent field studies in the Langtang national park several plants were discovered in flower by the second week of October (10/10/84), along the Langtang Khola in subtropical forest at altitudes of between 1,600 - 2,000 m.

The fruit is a fleshy berry C. 1 cm, orange at first and then a deep red when fully ripe. The fruits ripen from April to May.

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* longer than in D. bholua

3.4 Review of the Taxonomic Literature*

Daphne bholua and Daphne papyracea have been known to western science as raw materials for paper - making since the first botanical descriptions of them made at the beginning of the 19th century A.D. As they are often found growing side by side and because they are fairly similar in appearance, many writers have had difficulty distinguishing between them or have described them as one species, often Daphne cannabina. Hence, they are frequently treated together in the literature.

The earliest collections from the Himalaya which record the genus are those of Buchanan-Hamilton who travelled in Nepal and Kumaon from 1802-3. His material was taken to England, and D. Don's descriptions of two species, D. bholua and D. odora (syn. D. cannabina) in his book Prodromus Florae Nepalensis (1825), were based upon it and accompanying notes, with some additions collected by Wallich (1820). Thus the taxonomic confusion between the two species seems to have started with Don who was the first to describe D. bholua along with D. odora which, 'fide Burtt' in the British museum enumeration is D. papyracea. Henceforth, some taxonomists have listed D. bholua as variously synonymous with both D. odora and D. cannabina whereas others have chosen to ignore D. bholua altogether and describe D. papyracea and D. cannabina as the same species.

To the present day, there has always been doubt as to whether the D. cannabina Wall. of the Flora of British India (Hooker, 1885 - 90) contained one or more species (Smith and Cave, 1913). Hooker's material was inadequate to settle the dispute although he expressed his feeling that it probably consisted of at least two distinct species.

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* For a detailed enumeration of the major Nepalese species see: Hara (1982) P. 188 in 'An Enumeration of The Flowering Plants of Nepal'. Trustees of British Museum (Nat. History) London, 1982.

However, from a review of the available taxonomic literature, supported by detailed field studies, and after having compiled a summary of the various authors' descriptions, it seems reasonable to conclude that there are indeed at least two distinct species viz. Daphne bholua (syn. D. cannabina) and Daphne papyracea (syn. D. odora and D. cannabina), at present widely used in Nepal for the manufacture of paper. Their major distinguishing features are summarized in Table 2 below (further details are given in Appendix 2).

Table 2: Distinguishing Features of Daphre Bholua and Daphne Papyracea

	DAPHNE BHOLUA	DAPHNE PAPYRACEA
DISTRIBUTION	UTTAR PRADESH-S.W. CHINA	PAKISTAN-CENTRAL NEPAL
ALTITUDE RANGE	1800-3600 M (4000 M)	1600-2500 M (3000 M)
HABIT	EVERGREEN OR DECIDUOUS	EVERGREEN
FLOWERS	HEAVILY SCENTED WHITE, EXTERNALLY PINK OR LILAC.	VIRTUALLY SCENTLESS WHITE OR GREENISH-WHITE
COROLLA	USUALLY OVATE	USUALLY ACUTE
FRUIT	BLACK OR PURPLE WHEN RIPE	ORANGE THEN DEEP RED WHEN RIPE
LEAVES	USUALLY OBLANCEOLATE, 5-10 CM	USUALLY LANCEOLATE OBLANCEOLATE, 5-15 CM

3.5 Natural Distribution

Where the two species are distinguished in the literature, there is general consensus that Daphne bholua extends from Uttar Pradesh through Nepal, Southern Tibet, Northern Assam and Bengal, Sikkim and Bhutan to South West China. It is found from C.1,800 m up to 3,600 m and occasionally D. bholua var. glacialis extends up to C.4,000 m in East Nepal. However, in West Nepal, where annual precipitation is less and the upper timber line corresponsingly lower, it rarely exceeds heights of 3,000 m.

Daphne papyracea occurs from Pakistan eastwards as far as Central Nepal and is found between 1,600 m and 2,500 m occasionally extending up to 3,000 m. It is less frequent than D. bholua both horizontally and vertically and appears to be generally less gregarious in habit.

3.6 Ecology

It is well known that the ecology and vegetation of Nepal is one of the richest and most varied in the world, mainly because altitude, precipitation and radiation are so diverse. The Himalayan range constitutes a corridor for the dispersion of temperate plant and tree species from East and West Asia, bordered by tropical India to the south and the cold, dry climate of Central Asia to the north.

It has been suggested that most species of plants and trees spread from Western China into the Himalaya, geologically the younger of the two regions, which has been rising ever since the Cretaceous period (Nakao, cf. KIHARA, 1955).

According to Trier (1972), Stainton (1972) and other authors, four major vegetation zones* can be distinguished: i) tropical, moist and evergreen in the Terai and lower parts of the Churia range (where much of the undergrowth consists of Sabai grass (Eulaliopsis binata), which is sold to India for paper-making; ii) subtropical and moist, comprising parts of the Churia, Inner Terai, Mahabharat Lekh and the southern part of the Middle Range. Pine (P. roxburghii) is the predominant species from 1,000 - 2,000 m and underwood is often sparse. Higher on the Mahabharat Lekh a more species rich forest type occurs, consisting chiefly of Conifers, Oak, Rhododendron, Poplar, Walnut, Alder and Magnolia. It is here that the first natural stands of Daphne as an understorey can occasionally be found. iii) In the higher parts of the Middle Range the vegetation becomes

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* See table 3.

temperate and moist from the border with the highlands at about 2,000 m. This horizontal band extending up to C. 3,500 m is represented by various species of Rhododondron, Bamboo, Oak, Maple, Pine (P. wallichiana), Spruce, Fir and Hemlock with Larch and Birch at the higher elevations. This zone is characterised by the variety of species and a dense jungle-like undergrowth. At altitudes of about 3,500 m (usually slightly less) in the East and 3,000 m in the West, where annual precipitation is lower, we find the upper limit for most shrubs of the family Thymelaeaceae. iv) The alpine zone from about 3,500 - 5,500 m. The vegetation here is usually scrubby and stunted with extensive areas of grassy vegetation frequently used as high pasture for yaks, cows and sheep.

Both D. bholua and D. papyracea occur widely as understorey shrubs, the former often growing gregariously in the moist conifer and broadleaf forests of the temperate Himalaya. They are generally sparse or non-existent in more open forest and pasture land, although exceptions, such as a dense stand of open grown Daphne at about 7,000' (2.100 m) on the Omje Khola near Yamphodin, Taplejung district, have been recorded (Carson, pers. comm. 1984).

The density of Daphne stands is dependant on several ecological and biotic factors; highest densities occurring between 7,000 and 9,000 ft (2,100 - 2,800 m) above mean sea level on north facing slopes (FSRO 1984); (Amatya, Forestry Services, 1983). On east and west facing slopes, the tendency is towards stands of medium density whereas the drier south facing slopes usually display a scattered population pattern. The species which are associated with a range of forest types (see Appendix 3), generally favour sites with tree crops of Quercus and Rhododendron, Hemlock, (Tsuga dumosa) or Fir (Abies sp.) and are also found to a lesser extent in upper-mixed-hardwood forest. They are almost completely absent in Blue Pine (P. wallichiana), Deodar (Cedrus deodara) and Spruce (Picea smithiana), prefering medium to light crown-cover and usually avoiding sites with dense crown-cover or large open areas. Numbers also decrease in areas of intense or haphazard exploitation of the forest resource, and where there are frequent fires associated with heavy grazing.

Table 3: Showing Distribution of Thymelaeaceae by Vertical and Horizontal Vegetation Zones (Adapted from Dobremez, 1976, Shrestha, 1982)

THYMELAEACEAE PRESENT	Altitude m.	Bio-climatic zone	Characteristic vegetation		
			Western Nepal	Central Nepal	Eastern Nepal
	0-100	Tropical	Shorea robusta	S. robusta	S. robusta
D.P. (W/C) D.S. (E) D.I. (E) E.G. (N) W.C. (N)	1000-2100	Sub-tropical	Pinus roxburghii*	Schima wallichii - Castanopsis indica	S. wallichii - C. indica
D.P. (W/C) D.B. (N) E.G. (N) W.C. (N) S.C. (W/C)	2100-3000	Temperate	(i) Coniferous forests - Pinus wallichiana, Picea smithiana, Abies pindrow (ii) Evergreen oaks Quercus incana	(i) Coniferous forests Tsuga dumosa, Picea smithiana (ii) Evergreen oaks Q. lamellosa Q. lanata Q. glauca	(i) Oak Rhododendrons Rhododendron spp. Q. semecarpifolia Lithocarpus spicata Q. lamellosa Daphnephyllum himalayense
D.B. (N) D.P. (W/C) S.C. (W/C) D.R. (N)	3000-3700	Subalpine (inferior)	Abies spectabilis Q. semecarpifolia Betula utilis	Abies spectabilis Betula utilis	Abies spectabilis Rhododendron spp.
D.B.g. (N) D.R. (N) S.C. (W/C	3700-4000	Subalpine (superior)	Betula utilis Rh. campanulatum	Betula utilis Rh. campanulatum	Betula utilis Rh. campanulatum
S.C. (W/C)	4000-5000	Alpine	Grasses & herbs Juniper, Salix scrubs	Grasses & herbs Rhododendron scrubs	Grasses & herbs Rhododendron scrubs

* Pinus roxburghii avoids wetter sites in Centre and East.

KEY	SPECIES	DISTRIBUTION +
D.B.	= Daphne bholua	E = East only
D.P.	= Daphne papyracea	W/C = West and centre only
D.S.	= Daphne sureil	N = Throughout Nepal
D.R.	= Daphne retusa	
D.I.	= Daphne involucrata	
D.B.g.	= Daphne bholua var. glacialis	
E.G.	= Edgeworthia gardneri	+ For further details of distribution see Appendix 3 and Section 8.2.
W.C.	= Wikstroemia canescens	
S.C.	= Stellera chamaejasme	

They appear to thrive on a wide range of soil types but generally favour moist sites with a rich organic humus layer overlying well-drained Sandy Loams or Brown Earth. As a cultivated plant it does well in both acid and alkaline conditions even growing on very chalky soils (Brickell and Mathew, 1976). Soil samples collected at Simbhanjyang on the Daman ridge (2,400 m) in forest dominated by Quercus semecarpifolia gave a pH reading of 5.5. Schilling (pers. comm. 1984) cites the following cultural requirements: Acidic soil, warm to cool temperate monsoon - influenced forest, shade or partial shade as the norm; commonest associated trees are Rhododendron arboreum and Quercus semecarpifolia.

SECTION 4: SILVICULTURE

4.1 Introduction

To date very little work has been undertaken on the silviculture of Daphne in Nepal and consequently general prescriptions for the propagation and management of the genus are usually based on 'educated guesswork' unsubstantiated by scientific research, and as such, are only tentative and should be treated with caution.

4.2 Propagation, Natural and Artificial

A preliminary study of natural regeneration at four different sites in Central Nepal (Simbhanjyang, 2,400 m; Nagarkot Bal Ban, 2,100 m and Gore Tabola 3,000 m)* conducted from June to October 1984 revealed that regeneration takes place both through seed and root-suckers (a shoot which arises from an adventitious bud on a root (Hartmann and Kester, 1976)). Excavation and examination of a number of roots indicated that suckers are readily produced from lateral roots radiating out from a single parent plant over quite considerable distances. Up to 5 metres distance and 8 shoots so far recorded for a single lateral root at Nagarkot Bal Ban (Jeanmaud, 1984).

The literature suggests several methods for the artificial propagation of Daphne species; however, not all these methods may be appropriate to the two species under consideration in this report.

4.3 Seed

Much of the information on the availability and viability of Daphne seed is of a contradictory nature.

Brickell and Mathew (1976) state that in the wild seed is freely produced and natural regeneration is at a relatively high level; and Berrisford (1975) says of the genus that it is easily increased from seed, giving the species D. mezereum as an example. In contrast, Campbell (1980) first claims good viability for seed

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* See map No. 2.

(10,000 dried fruit/kg), with germinated seedlings making slow growth compared to that of cuttings, but then in a later publication (NEFTIB, March 1983) he cites the RHS Dictionary of gardening (1974, P. 635) which suggests that the genus is difficult to germinate from seed and he goes on to say that in Nepal heavy weevil damage is common so little viable seed is set.

Schilling (pers. comm. 1984) states that the fruit of Daphne bholua is very attractive to birds and hence prompt harvesting is essential if seed is to be procured in any quantity. He also advises that seed should be sown as soon after collection as possible as it has an extremely short viability. He suggests the following method: the soft fleshy outer covering should be removed and the seeds sown in a neutral to acid seed compost. The seeds should germinate within three weeks to a month if kept at a temperature of about 22°C (70°F), if they have not germinated within three months they will not appear. Dr. Herklots (Cf. Brickell and Mathew, 1976) also found that fresh seed germinates rapidly whereas older, stored seed loses its viability quickly.

Field observations at Simbhanjyang, Nagarkot, Pulchoki and Gore Tabela, revealed a marked difference in the amount of regeneration by seed. At the first two sites, seedling regeneration was sparse and propagation through root-suckers predominated. However, at the second two sites seedlings were fairly prolifie (C. 4 -5/30 cm^2). This variation between the sites is probably due to human factors. Both Nagarkot and Simbhanjyang are subject to biotic interference in the form of pre-monsoon burning of ground vegetation to stimulate the production of grasses palatable to ungulates. This practice combined with subsequent heavy grazing is presumably destructive to seedlings.+ On the other hand, both Pulchoki and Gore Tabela are protected forest areas from which domestic animals are largely excluded. Where juvenile material is required for nursery experiments

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+ Recent field study revealed that goats will browse the leaves and young shoots of Daphne.

or planting out, it may be more practical to collect seedlings from the forests 2 - 3 weeks after germination, rather than seed.

4.4 Cuttings

Various cutting types are recommended for artificial propagation of Daphne species (Campbell, 1980; Campbell, 1983; Chandler, 1969; Wells, 1955; Hartmann and Kester, 1976; May and Baker, 1983; Brickell and Mathew, 1976).

i) Soft-tip or softwood cuttings: These should be taken in the growing season (Monsoon) and brought to the nursery to be lined out in beds or propagators under shade. This type of material is available from late May or early June.

ii)* Semi-hardwood cuttings: These can be taken from the end of June and lined out in a bed or propagator under shade. Campbell (1980) recommends the bed surface be heavily mulched with straw and the rooted cuttings be potted up in winter to be planted out after 12 months in the nursery. The cuttings should be inserted/lined out in a mixture of 2 parts sharp sand and 1 part peat, moss or loam. Alternatively a sterile sand medium can be used. Cuttings placed in a closed propagating frame with a diurnal temperature range of 26°-31°C (79°-85°F) (Campbell, 1983) or 10°-15°C (50°-60°F) (Chandler, 1969) should be shaded fairly heavily and thoroughly watered in. However, over watering must be avoided until rooting takes place although, at the same time, cuttings must never be allowed to dry out. Cuttings should have rooted within 6 - 12 weeks, but may take as long as 6 months.

iii) Hardwood cuttings: These are probably best prepared during winter dormancy and either stored in some suitable medium, such as sand or peat, until required for lining out in early spring or lined out in beds directly at the time of preparation.

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* Semi-lignified material of current season's growth, supple and pliable, will not snap on bending like hardwood cuttings.

iv) Root cuttings: The best results are likely if material is taken during winter dormancy or early spring when roots are well supplied with stored food but before new growth starts. Securing cutting material in quantity can be labourious so it is advisable to build up nursery stocks from which cuttings 5 to 15 cm (2" - 6") long are made by trimming roots as plants are lifted. As with hardwood cuttings, it is important to maintain the correct polarity when planting; and thus to avoid planting up side down the proximal end may be made with a straight cut and the distal end with an angled cut (Hartmann and Kester, 1976). However, this is not so important if lateral roots are used to provide cutting material as these may be lined out horizontally 1 or 2 inches deep.

4.5 Preparation of Stem Cutting Material

For softwood or semi-hardwood cuttings, material 10 to 30 cm long and 3 to 10 mm in diameter, with or without a heel should be selected. Campbell (1980 and 1983) recommends either that the cutting should have an axillary bud and the leaves removed, or include the growing tip and have a reduced leaf area to minimize transpiration.

For hardwood cuttings, material 10 to 15 cm long and 10 to 20 mm in diameter is used; this should be angled at the base to prevent planting up side down and include at least 2 or 3 nodes.

4.6 Layering

The genus can also be propagated in situ using a simple ground layering technique. Long side branches can be bent over and anchored to the ground by placing stones over them. Once rooting has been initiated the new plants can either be detached and replanted or left to grow on (Berrisford, 1975). Root initiation can be encouraged by wounding or ring - barking at the point of stem contact with the soil (Wells, 1955).

Aerial layering is another potential propagation technique. This involves wounding or ring-barking a side branch, then binding the

wound with damp moss and covering this with polythene to retain moisture. Once again when root initiation has occurred the branch can be detached and replanted. However, this is probably not a viable method for large-scale propagation in the field as it is both laborious and time-consuming. Layering should be carried out in June or July with rooted layers removed in September or October when cool, mild days will help to accelerate growth until winter dormancy (Campbell, 1983).

4.7 Grafting

This has proved very successful with Daphne bholua in a horticultural context but would probably be of little use for large-scale propagation. Root stocks known to have been used include; D. mezereum, D. longilobata, D. giraldii, D. laureola, (Brickell and Mathew, 1976).

4.8 Management

Lokta harvesting generally begins during the agricultural slack season after the festival of Dasain, i.e. from the end of September or mid-October and often continues into late spring to mid-May (Kartik - Jeth), usually with two months break during the coldest months of Push and Magh (mid-December to mid-February) (Messerschmidt and Pandey, 1983). Harvesting of the bark is not usually done by the paper-makers themselves (Acharya, IHDP, 1975) (Trier, 1972).

4.9 Traditional Harvesting and Improved Techniques

A review of the literature suggests that current management practices, generally undertaken on an ad hoc basis, tend to militate against resource conservation and sustained bark yield. In Baglung and Myagdi districts traditional harvesting consists of partially cutting through the stem of the plant at a height of one metre or more above the ground and then peeling the bark down to the root-collar. According to Amatya (Forestry Services, 1983/84) this effectively destroys the meristematic tissue from which coppice shoots arise. He therefore recommends that in future plants (at least 1.5 m high)

should be cut off completely 15 cm (6") above the ground and the bark then peeled from the cut stem. However, when this technique was proposed to local harvesters at the SECID/FCUP Lokta workshop in Baglung (Oct. 1983) they argued against it on the grounds that the traditional method did not affect regeneration and that the new technique would result in less bast fibre production. This was refuted and the harvesters eventually agreed to adopt the 'improved' practice (Pandey, pers. comm. 1984).

Recent field studies suggest that Daphne propagates readily from root-suckers and moreover, it was noted that where plants had been cut at ground level or just above (Simbhanjyang), basal stem and root-collar shoots had developed (Jeanrenaud, 1984). These findings lend a measure of support to the harvesters' contention and emphasise the importance of carefully considering local knowledge and methods before management prescriptions are rigidly defined.

4.10 The Potential for Planned Cultivation of Thymelaeaceae

There are no extant records of Daphne cultivation for bast production in Nepal, and it is unlikely that past exploitation of the resource would have warranted planned cultivation. However, given present demands for Lokta paper it is an option which deserves investigation. The genus being shade-tolerant may lend itself to cultivation as an understorey crop in already established timber or fuelwood plantations. There is some evidence to support this hypothesis as Daphne has been found growing under pine on a site at Tistung, Narayani, cleared for provenance trials about 4 years ago.

Of the other main bast producing genus Edgeworthia, Wallich (1820) says that Edgeworthia gardneri "... grows to be a large shrub and is cultivated extensively about Kathmandu, both on account of its beauty and perfume, and also on account of the utility of its bark ...". This observation is impossible to verify and to my knowledge E. gardneri is not found in any large numbers either in Kathmandu or the valley. Trier (1972) suggests from his own observations of harvesting procedures, that Wallich may have been

misled by the fact that bark collectors harvested the branches in a way that permitted the plant to regenerate after 1 or 2 years. This involved a level of care of the bushes that could have been interpreted as cultivation. Cultivation of Edgeworthia is certainly possible and Shionome (1971) says that in Japan Edgeworthia gardneri seeds are collected in June and buried in soil to prevent dessication. In April the following year, they are planted out under shade. He states that 2 litres of seed will produce about 1,200 seedlings which are pricked out in February or March of the second year and replanted at a rate of 1 to 2 seedlings per 30 cm^2. Harvesting starts from around the third year with an acre yielding about 12 kg of bleached bark and peaks from year 10 to 12 with yields of about 14 to 16 kg per acre (i.e. C. 25 - 30 kg/ha). Although it is not stated, these crops are presumably managed on a coppice - rotation system with old stools being replaced every 7 or 8 years.

Shionome also mentions that six species of the genus Wikstroemia are harvested for fibre in Japan but cultivation is not practised and the bast is collected from natural stands.

4.11 Discussion - Propagation and Management

Given the present lack of scientifically established data it is reasonable to recommend that research into Daphne propagation should concentrate on seedling, semi-hardwood and root-cutting production in the nursery and that methods of field propagation by layering, and root severing, to encourage suckering, should be examined.

Proposals for management of the resource under a coppice regime should be scientifically examined to determine:

i) Optimal cutting height (ground level to 15 cm) commensurate with shoot production, stool life and bark yield.

ii) Optimum rotation length based on growth studies and local knowledge. At present a 3 to 4 year cycle is recommended but this

is based on 'educated guesswork' as no hard data is currently available.

iii) Optimum number of shoots per stool to maximize bark yield for a particular rotation length.

An interim management compromise might be that of coppicing plants at or near ground level, thus permitting maximum bark yield without destruction of the meristematic tissue. In addition, further research is necessary to determine:

iv) Optimal harvesting technique - traditional (e.g. Baglung method) or coppicing.

SECTION 5: UTILIZATION - TRADITIONAL AND IMPROVED PAPER MANUFACTURE AND OTHER PRODUCTS

5.1 Introduction

The superior quality of hand-made Daphne paper was noted in Europe as early as 1837 when Lord Auckland undertook an enquiry into its manufacture as a result of examining official Nepalese records, more than a century old, written on this type of paper. Dr. B. Royle (1855) reported that at the Great International Exhibition held in the Crystal Palace, London in 1851, a sample of Nepalese paper was exhibited of "such size and quality" as to create "universal surprise". He said, "This paper is remarkable for its toughness, as well as its smoothness. It is so pliable, elastic, and durable, that it does not wear at the folds during twenty years, whereas English-made or Chinese-made paper, when eight or ten sheets are folded up into one packet, do not stand keeping in this state uninjured for more than four or five years". A copy of a Sanskrit Work dated 1687 was found to be very well preserved and free from the ravages of wear and tear and insect attack (many species of Daphne contain an acrid poison and are emetic and purgative) (Bajracharya, 1983). Moreover, because it is as strong and durable as leather it was found to be suitable for making cartridges (Dastur, 1964).

5.2 Ethnic Groups Traditionally Involved in Producing and Trading in Paper

i) TAMANGS: Until fairly recently, this group was found mainly in North-Eastern Nepal; however, these days they are distributed throughout the country, many having settled south of Kathmandu in the Mahabharat Lekh and the Terai. The Tamang language belongs to the Tibeto - Burman language group and is closely related to Tibetan. Most Tamangs are nominally Buddhist like the Sherpas and Bhotias. Although they have embraced the lamaist tradition they still practice old Shamanistic rites and in the isolated northern areas the magician continues to have an important role. In the lower - lying areas the original Tamang religion has mixed with or

been replaced by Hinduism. They are chiefly farmers, possessing a high level of skill in many crafts. Where they live among other groups their "caste" has a low status and hence they often perform the service of porters. This is in keeping with the fact that they produce paper and transport it down to the bazaars and towns but do not usually deal in it. They are the chief practitioners of the craft of paper-making often still using the early, primitive methods largely unchanged since their introduction in the 9th or 10th century (Trier, 1972).

ii) MAGARS: The main area traditionally inhabited by this group is the western and southern spurs of the Dhaulagiri - massif but nowadays groups are found throughout most of the country. Their language is Tibeto - Burman in origin and the majority believe in Hinduism although there are smaller groups who are Buddhist. They are the main paper producers in the Baglung and Myagdi region of Western Nepal.

iii) GURUNGS: According to Hagen (1960) their traditional area is the southern flanks of the Annapurna massif but they have also spread widely through the Middle Range and are found as far away as the eastern border of Nepal. Their language has many dialects and appears to be related to Tamang and Thakali (Kawakita Cf. KIHARA, 1957). He also distinguishes between 'Lama - Gurung', who are Lamaists and whose culture is Tibetan, and 'Cho - Gurung' who dwell in the lower areas, many of whom worship Hindu deities. According to Trier (1972) they have a tradition of paper-making but the extent of their past involvement is unknown.

iv) SHERPAS: They dwell traditionally in three adjoining valleys of the Everest-massif and are also found in smaller groups along the great Himalaya but not much further west than the meridian of Kathmandu. They live primarily at altitudes above 2,500 m, and have long-distance trade links with both Tibet and India. Their language is Tibetan and they are usually exclusively Lamaist. Trier (1972) says that in the past they have occasionally made paper but that in their main areas it was often considered beneath them to

participate personally in the manufacturing process; and that in general, they ordered the paper from Tamangs or lent them the money to start production. However, more recently several Sherpas have been trained in improved manufacturing methods at the Dept. of Cottage and Village Industries, Kathmandu and have since established production units in their home areas.

v) RAIS AND LIMBUS: Both groups are called 'Kiranti' and both speak Tibeto - Burman languages. The Rais are found mainly in East Nepal, west of the Arun river around Sun Kosi whereas the Limbus live further to the east between the Arun and the border of Sikkim generally at lower altitudes than the Rais. It is asserted that both groups have been involved in paper-making and certainly several have recently been trained in improved methods in Kathmandu. This fact suggests previous involvement, as it has been a policy of the Dept. of Cottage and Village Industries only to train paper-makers with a previous family background in the craft.

vi) BHOTIAS: This group actually consists of several different peoples, lives in the northernmost parts of Nepal and differs only a little from the Tibetans on the other side of the border in both appearance and culture. They speak Tibetan and are Lamaist. As the group generally lives above the upper limit of growth of the bast producing species they rarely make paper, except perhaps in the easternmost region of Nepal (Trier, 1972). According to Corneille Jest, Musee de l'Homme, they once made paper in the Dolpa area of West Nepal. They were however, traditionally middlemen in the paper trade between Nepal and Tibet and they also make considerable use of it themselves for both religious and secular purposes.

vii) THAKALIS: A small group concentrated in the Kali Gandaki region North-West of Pokhara. Their language is related to Tibetan and their culture expresses both southern and northern influences. They are traditionally inn-keepers and traders and as a result have become wealthier and more influential than the surrounding ethnic groups. Their involvement with paper has been mainly related with trade to the north.

viii) NEWARS: This group lives mainly in the Kathmandu valley, although they are also dispersed widely throughout the rest of Nepal. Newari appears to belong to the Tibeto - Burman group of languages and it is the only language of the country that possesses a considerable literature (Trier, 1972). They are divided into two subgroups, those who believe in the Hindu deities and those who are Buddhists. However, the distinction is slight and many of their beliefs and practices are intertwined. The Newars who are farmers, craftsmen and traders, became the only large-scale purchasers of paper in Nepal, for the production of books, south of the Great Himalaya.

From the literature it appears that until recently the majority of people directly involved in paper-making were Buddhist, or perhaps more importantly, non-Hindu. This might suggest that paper-making, as a manual occupation, was considered by the caste-Hindu as a lowly profession (see Trier, P. 20) whereas for the Buddhist no such prohibitions existed. Today however, there appear to be few if any restrictions or prejudices against the craft, and the list of recent trainees who have attended courses at the Dept. of Cottage and Village Industries includes, Brahmins, Chhetris and representatives of most other ethnic groups.

5.3 Traditional Nepali Paper-Making

NOTE: The general process as described below may vary in detail in different areas.

The white, fibrous inner bark or bast of the Daphne plant (Lokta) is the principal raw material for the manufacture of Nepali paper.

Approximately 30 to 70 gm wet weight of bark is yielded from a mature plant 1.5 to 2 m high (Amatya, 1984). This is sun dried for about a week to minimize bacterial and fungal attack and results in a 50% weight reduction.*

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* It is assumed that the moisture content in wet bark is 50% of air dry weight and 64% of oven dry weight (Amatya, 1983).

The craft is traditionally associated with villagers of the hills and mountains where the plants are relatively abundant and there are small paper production units scattered throughout the hilly regions of Nepal. At present, the bulk of paper finding its way onto the Kathmandu market has its origins in Baglung, Dolakha and Solu Khumbu. As all stages in the manufacturing are carried out by hand, it is an extrerely labour intensive and time-consuming process. Some production units are temporary huts within the forest areas where Daphne plants are abundant and a supply of fuelwood and clear running water is available. Others are larger units located in or near a bazaar town to which supplies of raw material are brought.

The process can be divided into three major stages:

i) PULPING: Wood ash (preferably from Quercus spp.) is placed in a finely woven wickerwork basket, water is then poured over it and allowed to percolate through into a container. This process is repeated until the lye is deemed to be sufficiently strong (i.e. pH 12.5 to 13.5, Trier, 1972). The alkali obtained is then filtered through a clean cloth to remove dirt particles and other insoluble material. The alkali liquor is then heated to boiling point in a metal cauldron over a wood fire or stove. As soon as it begins to boil, a quantity of the previously soaked and cleaned bast (approximately equivalent to the quantity of liquid) is placed in the cauldron and boiled continuously for at least an hour. After boiling the alkaline liquor will be nearly all absorbed or have evaporated and the bark sufficiently softened for the next step.

The bark is transferred to a stone or wooden mortar and is beaten with a mallet or stone pestle until reduced to a homogenous dough-like pulp. It is then placed in another vessel or vat containing pure water and stirred or agitated until it loses all 'stringiness' and will spread out quite easily when shaken under water. If the fibres have not completely separated and 'stringiness' persists the whole process is repeated until the pulp is considered ready for the frame.

ii) SHEET FORMATION: The moulding-frame is made of stout wooden or bamboo sides, so that it readily floats, with the bottom being made of finely woven cotton cloth-mesh. It should be porous enough to allow the free passage of water whilst retaining all the pulp. Sufficient prepared pulp to cover the frame is placed in a sieve* having the same dimensions as the frame. Next, both sieve and frame (one on top of the other) are floated in a cistern of water and agitated so the pulp spreads over the sieve; the knotty and impure parts of the pulp will remain in the sieve and the rest will ooze through onto the frame. When sufficient pulp has passed through to cover the frame with a layer of the desired thickness, the sieve is removed. The frame is held with one hand, slightly below the surface of the water, while the water and pulp are agitated with the other hand to obtain a uniform distribution of the pulp over the surface of the mesh. The frame is then carefully raised from the water to allow draining without disturbing the film of pulp. The pulp is then dried on the frame by being exposed at an angle to a big fire or the sun.

iii) FINISHING: After drying, the sheet is removed from the frame by slowly and carefully peeling it off usually starting at one corner. Irregular edges can be trimmed with a sharp knife; and polishing accomplished by placing the sheet on a flat board and rubbing it vigorously with a smooth stone, conch shell, glass paper-weight or similar object. Polishing is usually adequate to produce a smooth writing surface without the aid of any sizing material. Each sheet is then folded and paper is usually sold in bundles of 20 (1. Kori).

5.4 Improved Paper-Making

The following is an outline of the manufacturing process developed with Japanese technical assistance by the Dept. of Cottage and

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* Nowadays the sieve is rarely used probably because the finer quality papers, previously exported to Tibet, are no longer made (Trier, 1972).

Village Industries and described by Hikaru Shionome (1971) in his book 'guide to the hand-making of paper'.

i) SOAKING AND RINSING: A bunch of Lokta bark corresponding to 1 dharni (i.e. 2.4 kg) is soaked in water for at least six hours and then rinsed in cold water. This is done to wash out as much of the greasy, water soluble organic material present in the bark as possible and to remove dirt and foreign matter. If necessary, further cleaning or scraping can be carried out by hand.

ii) BOILING THE BAST: The bast is boiled for 2 to 4 hours in a vat containing a solution of caustic soda (Na OH), 10% - 15% by weight of bark, depending on initial cleanliness of the raw material, soda ash (Na_2CO_3), lime (C_aO) or wood ash (KOH). This part of the process serves to remove non-cellulose organic matter and to separate the cellulose fibres prior to bleaching and beating.

iii) BLEACHING: This is not always carried out because the paper produced has the defect of increased water absorbency which reduces its value as writing paper. Moreover, the market demand for Nepali paper is due in part to its peculiar 'traditional' colour.

When bleaching is carried out, the liquor is prepared in a separate tank by adding approximately 45 kg of bleach powder ($Ca(Ocl)_2$) to a $3M^3$ tank of water or C. 10% bleach powder by weight of bark. The cooked bark is immersed in this solution for about 2 hours and then transferred to a washing tank.

iv) WASHING: The bleached bark can either be washed in running water or 2 to 3 times in a tank of fresh water to remove caustic soda and bleach. Either way, a considerable volume of water is required and it is therefore necessary for paper manufacturing plants to be situated near a reliable natural or commercial water supply.

v) BEATING: The cooked and bleached bark is then beaten with a hammer or mallet to reduce its size before transferring it to a manual or hydraulic Hollander-type beating machine. Here, the bark

mixed with water is beaten for 15 to 30 minutes to produce the pulp from which the paper will be made. The process of beating achieves several aims: fibre aggregates are separated to produce single fibres; fibres are cross-cut or split; the fibres swell and their surfaces become gelatinized. These effects endow the fibres with certain desirable properties such as: the ability to intertwine or fuse, flexibility, plasticity, surface sizeability and viscosity.

vi) SHEET FORMATION: The pulp is next transferred to the pulp tank, usually made of wood, concrete or steel (this latter type is the least desirable as it is apt to gather rust which will discolour the paper). Some form of vegetable mucilage (e.g. extract of Hibiscus root - Manihot edulis) or polyethylene oxide is added to the pulp in order to: a) prevent the fibre from precipitating; b) keep the pulp evenly distributed throughout the tank; c) prevent aggregation of fibres; d) to retard drainage of water when pulp is on the screen; thus allowing time for the pulp to be shaken sufficiently to aid even distribution of fibres over the screen surface, resulting in a finer more evenly formed sheet.

At the Dept. of Cottage and Village Industries paper is usually moulded using the 'nagashizuki' (Jap. vern.) or 'flowing method'. The paper making frame made of wood with a wire mesh (or as in Japan with bamboo slats and a silk or nylon mesh) is hung from the ceiling over the tank suspended from a flexible spring-arm of bamboo.

The vatman slides the frame into the tank at an angle until it is completely submerged and then raises it from the liquor, again angling the frame so that the pulp 'flows' across the frame in a wave motion and the excess pulp is returned to the tank. The process is repeated several times, depending on the thickness of paper required and to allow cross-meshing of the fibres. The characteristic of this method is that the pulp liquor in the frame is constantly vibrated in all directions causing the fibres to overlap thus giving added strength to the completed sheet (size when trimmed C. 76 x 49 cm/30" x 19").

An alternative process used to produce a comparatively thicker paper is the 'Tamezuki' (Jap. vern.) or 'laying up' method. Here the frame is dipped into the pulp and raised horizontally. While the paper layer is being formed the pulp liquor in the frame is agitated to prevent 'dust' settling to the bottom and precluding a fine finish. A light intensity mucilage (nouri - polyethylene oxide) only, is added to the pulp allowing a more accelerated water drainage necessary to produce thicker paper.

vii) COUCHING: Once the sheet has been formed it is carefully peeled off the mould and stacked alternately with cotton or hessian cloths to form a 'post'. This is done to facilitate sheet separation after pressing to remove moisture.

viii) PRESSING: The 'post' of wet paper is subjected to pressure (up to 150 mt) using one of the following types of press:

a) A stone weighted lever press. Stones are hung from the end of the lever arm; more stones being added to increase pressure as desired.

b) A screw press which is massive and cumbersome; the screw is turned by means of a long wooden lever and the sheets are pressed between platens.

c) A Jack press. This type is used at the Dept. of Cottage and Village Industries; pressure is applied to the post (usually consisting of 30 to 40 sheets per post) using a heavy-duty vehicle jack.

d) A Hydraulic press.

Pressing performs two functions, dehydration and strengthening of the newly formed sheets. Before removing the sheets from the press it is well to scrape off the excess water from the edges of the sheets and couching cloths with a wooden paddle, to prevent water running back into the felts and paper when the press is opened.

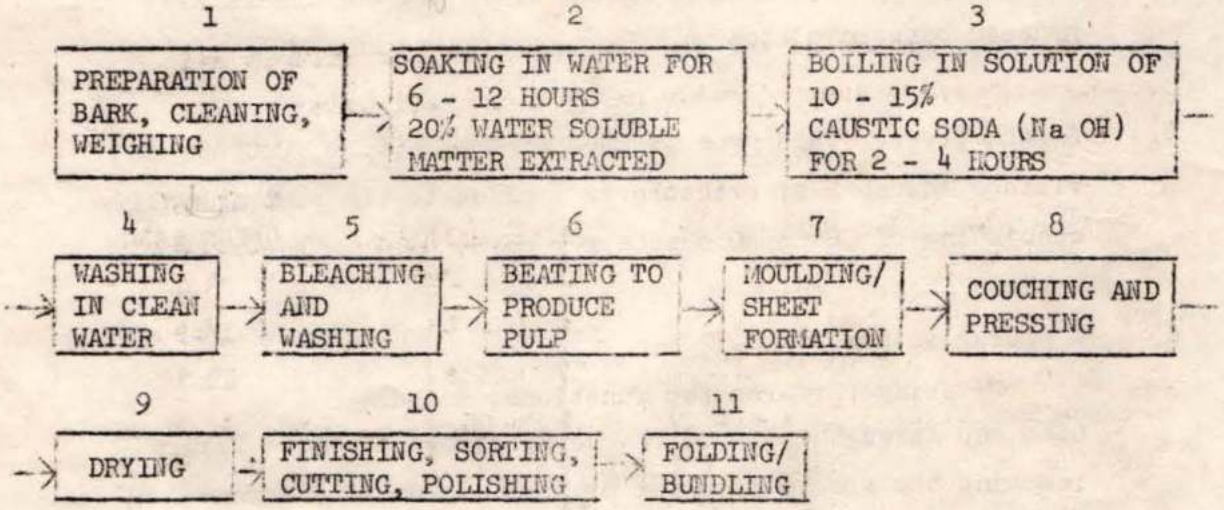
ix) DRYING: Sheets of damp paper can be dried in a variety of ways; they can be hung from hair ropes to be air dried in a purpose-made drying loft; or laid on the ground, pasted to boards, walls or metal sheets to dry in the sun or alternatively dried by direct heat from a fire.

At the Dept. of Cottage and Village Industries the following method is used. The individual sheets are carefully flattened onto an aluminium sheet using a brush and are then either exposed to the sun or hot air, by forming an acute angled triangle of two metal sheets.

x) FINISHING - SORTING, TRIMMING AND POLISHING: After sorting for quality control, the sheets are graded and then trimmed to size according to demand, rough deckle edges can be removed with a sharp knife or guillotine. An electric paper cutting machine, presented by the Japanese government, is used at the Dept. and most of the paper produced there is machine trimmed.

A smooth finish can be applied to the sheets to produce a more suitable writing surface either by hand polishing (as in traditional manufacture) or by calendering between steel rollers.

TABLE 3: Summary of the Improved Paper Production Process



5.5 Characteristics Making Lokta a Superior Raw Material for Paper-Making

Both Daphne bholua and Daphne papyracea consist of about 7% outer bark, 18% inner bark (the raw material for paper pulp) and 75% wood (Saikia et.al., 1972). Approximately 30 to 40 gm of inner bark (dry weight) can be collected from a mature plant of 2 m. (Industrial Services Centre, 1976/77).

Tests have shown that Daphne fibres have a high length to width ratio, length varying from a minimum of 2 mm to a maximum of about 12 mm, with an average length of between 5 and 7 mm, and an average width of 0.02 mm (for a comparative analysis of Daphne and other fibres, see Appendix 4). Consequently a wide range of papers may be made from the long-fibred cellulose material of the inner bark, including those requiring high tearing-strength.

On testing Towang-made (NEFA, INDIA) Daphne paper it was found that a 26.14 g/m^2 sheet of paper had a breaking length of 5782 m, folding endurance of 441, and a tear factor of 168. Moreover, it possessed superior strength properties compared with the more common bamboo-pulp paper (Saikai et.al., 1972).

5.6 The Chemical Composition of Daphne Bast

A review and summary of the findings of different authors and researchers gives the following major characteristics:

CHEMICAL ANALYSIS	% OF OVEN DRIED BARK	SOLUBILITY IN:	% OF OVEN DRIED BARK
WATER	4.2	ALCOHOL BENZENE	4.2
ASH	3.3 - 4	COLD WATER	18.9
LIGNIN	2.3 - 10.5	HOT WATER	24.5
CELLULOSE (TOTAL)	55.7 - 56.8	1% Na OH	38.4
PENTOSAN	15.1 - 21.1		
*EXTRACT	7.6 - 8.9		

(Data extracted from: Trier, 1972; Shiokawa, 1971; Saikia et.al., 1972; Industrial Services Centre, 1976/77).

* Comprises sugar, soluble mineral salts, resins, fats, tannins etc.

5.7 Pulp Yield

Different digestion processes and times gave the following pulp yields from oven-dried bark: 40 - 60% unbleached pulp and 44.5 - 56.5% bleached pulp (Saikia et.al., 1972).

5.8 Discussion

Research has shown that Daphne bark is an excellent raw material for making specialist papers such as high-stretch, high endurance art and grease-proof paper. In addition, preliminary investigations into the use of the bark for the preparation of electrical paper have shown encouraging results (Saikai et.al., 1972).

The cellulose fibre of wood is bound by lignin whereas that of bast fibre is bound by pectin (extract) which cannot be completely removed by boiling. The remaining resin and pectin in the pulp enhance the strength properties of the paper and give it its unique gloss. Most importantly, the extremely long fibres present in Daphne bast permit the manufacture of strong, high quality paper. The main quality parameters for the production of high value paper are, that ratio of cell length to diameter and that of lumen to cell diameter should be high, as these improve the tear resistance and flexibility. Both these qualities are present in Daphne fibres (Maiti, 1979).

5.9 Uses of Bast Fibre Paper in Nepal

Trier (1972) lists the following different uses: books, letters, documents and manuscripts; single leaves for magical and ritual purposes; woodcuts, written slips and ritual cards; horoscopes; fortune-telling cards; paintings; masks; festival decorations; wrapping paper; string; windows; ceiling coverings; lining and backing sheets; wound dressings; headache cures; incense sticks; cartridges; fireworks and kites; boxes; albums, briefcases; blotting paper; maps; playing cards; and occasional newsheets. To this list can be added, greeting cards; note books and note pads; calendars; lampshades and envelopes.

5.10 Other Products From Daphne

Quite a number of species in the family Thymelaeaceae have acrid and vesicant properties and contain toxic resins. Animals appear to avoid these plants under normal conditions, but nevertheless several cases of poisoning among livestock and humans have been recorded all over the world (Chopra, Badhwan and Ghosh, 1965). In indigenous Medicine Daphne papyracea yields a bitter purgative and febrifuge (HMG Dept. of Med. Plants, 1976). The bark and leaves are used in preparations for skin infections (Chopra, Nayar and Chopra, 1956), and a decoction of the roots is used as a digestive. An antileukemic principle has recently been isolated from seeds of Daphne mezereum (Kupchan and Baxter 1975) and a nematicidal constituent from Daphne odora (Kogiso et.al., 1976).

SECTION 6: PESTS AND DISEASES

6.1 Introduction

Field studies of natural stands of Daphne in Central Nepal indicate that the genus is relatively disease free in the wild. Specimens of galls and cankers affecting small branches have been collected for identification and low levels of insect defoliation have been recorded. As previously mentioned the seed is supposedly prone to weevil attack (Campbell, 1983).

6.2 Pests and Diseases of the Genus in Other Parts of the World

Pirone, Dodge and Rickett (1960) write that the genus is chiefly prone to attacks from fungi and several species of aphid.

i) LEAF-SPOTS. (Gloeosporium mezerei and Marssonina daphnes). Both these fungi produce small, thick, brown spots which appear on both sides of the leaves. Infected leaves turn yellowish, wilt and die. Twigs are also attacked.

Control: pick off infected parts and burn. Spray with Bordeaux mixture, copper or dithiocarbamate fungicides.

ii) CROWN-ROT. (Pellicularia rolfsii, P. filamentosa and Sclerotium delphinii). The first two are common throughout the tropics and the latter is found in North India. They cause crown and stem rot especially of plants growing in shady places, characteristic mycelia or sclerotia may be found at the base of the plant and on the ground nearby. A species of Phytophthora has also been reported as causing stem-rot.

Control: In the nursery, use clean soil or sterilize old soil.

iii) TWIG-BLIGHT. (Botrytis spp.). This has been recorded in India and the north-east and Pacific north-west of the U.S.A.

Control: Cut off and burn infected parts.

iv) CANKER (Nectria cinnabarina). This is a cosmopolitan, weakly parasitic fungus, common on severely wounded or recently cut or pruned bushes. It produces rough cankers covered with many small, reddish fruiting bodies and occurs mainly on twigs and branches.

Control: as iii).

v) VIRUSES (Marmor cucumeris and M. medicaginis). In the Pacific North-West U.S.A. Many plantings of Daphne odora (closely related to D. bholua) with mottled leaves, were found to harbour cucumber and alfalfa mosaic viruses.

Control: remove and burn infected plants. Control insect vectors with suitable sprays.

vi) INSECTS. Several species of aphid, the citrus mealybug and three species of scale-insects grey citrus, greedy and yellow, infest Daphne, causing defoliation.

Control: with suitable insecticide.

Peace (1962) records Mosaic (Brierley 1944; Smith 1962; Beaumont 1956; Milbrath and Young 1956) on Daphne mezereum and D. odora. It apparently does considerable damage to the former in Britain, resulting in a severe reduction or complete absence of flowers. It is becoming increasingly widespread.

Most of the above pests and diseases are tropical or cosmopolitan in distribution and are therefore likely to occur on Daphne in Nepal. However, the control measures outlined above would only be economically feasible in a horticultural or plantation context.

SECTION 7: FUELWOOD AND TIMBER REQUIREMENTS

7.1 Introduction

Throughout Nepal, as in many other developing countries, fuelwood supplies from native forests are dwindling at an alarming rate. This is chiefly due to a number of related factors such as, increases in human and domestic animal populations, the conversion of forest to farmland; the over-exploitation of existing natural resources, often for short-term economic gain; improved road access both to forest areas and urban markets; industralization and the consequent increased demand for forest products; tourism and so on. In Nepal, approximately 90% of domestic energy consumption is from fuelwood. Recently, steps have been taken in an attempt to remedy the situation by initiating Community Forestry Projects. However, consumption trends at both the domestic and industrial levels are not being matched either by reforestation and afforestation or management of existing forest resources for sustained yield. Thus any planned expansion of the craft-paper manufacturing industry should address the problem of present and future fuelwood shortages and endeavour to establish a range of ecologically sound options to ensure fuelwood supplies commensurate with current and increased output.

7.2 Specific Fuelwood and Timber Requirements for Paper Production

When paper is manufactured in rural areas using traditional methods, the demand for wood per production unit is relatively high often resulting in serious degradation of the surrounding forest area.

Wood is required for the following purposes:

i) Construction of temporary workshops, living quarters and basic manufacturing equipment. (Trier 1972 pp. 76-77, records 13 separate species utilized for different purposes by the paper-makers in the Solu Khumbu region).

SECTION 8: SOME ALTERNATIVE FIBRE PRODUCING SPECIES

8.1 Introduction

Up to the present, the paper-makers in Nepal have almost exclusively utilized the white inner bark (bast) of the genus Daphne as the fibre-material for the manufacture of paper. However, the recent increase in demand for indigenous paper, coupled with growing concern for the future conservation of the resource, has made it necessary for other sources of pulp-fibre to be investigated.

A list of potential pulp-fibre species is given in Appendix 5. Of the species listed, a review of the available literature suggests the following as the most promising for small-scale paper production units.

8.2 Other Species of Thymelaeaceae in Nepal

i) Edgeworthia gardneri (Wall.) Meisn. is distributed through forests and shrubberies from Uttar Pradesh to South-West China, having an altitude range of between 1,500 and 3,000 m. In Nepal it is usually found between 1,500 and 2,400 m and is supposedly rarer than Daphne bholua (Trier, 1972).

It is a large, much-branched shrub about 2 m or more in height, having elliptic-lanceolate, acuminate leaves 7.5 to 12.5 cm., glabrous above, pubescent or silky beneath with a hairy midrib. The flowers are joined, 40 or more in dense, pendulous, globular clusters; they are small, golden-yellow, sweet-scented and tubular (Polunin and Stainton, 1984) (Trier, 1972).

A similar species, Edgeworthia papyrifera Sieb., known in the vernacular (Jap.) as 'Mitsumata', is commonly used to produce high-quality paper in Japan; in particular the well-known 'Imperial Vellum' (Hunter, 1978). According to Wallich (1820) the bast has better fibre properties for paper-making than either Daphne bholua or D. papyracea. However, Trier's investigations show that although

the paper made from Edgeworthia bast is indeed softer, it has less satisfactory properties for writing purposes. He gives the following data: fibre length 1.5 - 5 (7.5) mm, fibre breadth 0.004 - 0.020 (0.25) mm.

ii) Wikstroemia canescens (Wall.) Meisn., is distributed from 1,500 to 3,000 m from Afghanistan to Sikkim usually growing gregariously in shrubberies or light forest. It is also found in Sri Lanka and China.

Commonly, a small shrub attaining heights of up to 2 m with many slender branches. The leaves are narrow, 3 to 6 cm long, hairless except on the midbrib beneath, elliptic and papery in texture. The small yellowish, tubular flowers appear in rounded or sometimes elongate short-stalked clusters. They are usually 8 to 12 mm long, silky haired outside, with 4 short, blunt, spreading lobes and with 4 linear nectar-scales. The fruit is narrow, ovoid and black when ripe (Polunin and Stainton, 1984) (Trier, 1972).

In Japan there are six species of Wikstroemia known in the vernacular as 'Gampi' and each of them provides an excellent fibre which is used particularly to make thin paper (Shionome, 1971). The length of the fibres varies between 0.5 and 4 mm, and the breadth between 0.004 to 0.02 mm (Trier, 1972). In tests carried out at the Dept. of Cottage and Village industries with bark samples collected from Kaulithana, Nuwakot, fibre lengths of between 1.5 and 4 mm, and breadths of between 0.01 and 0.02 mm. were recorded. Sheets of paper (0.05 mm thick) produced during tests, from pulp boiled with 10% Na OH for 40 minutes and with 0.05% polythylene oxide added, were found to have slightly less strength but better ink resisting capacity than similar sheets made from Daphne bast (Pokharel and Shrestha, pers. comm., 1984).

iii) Stellera Chamaejasme L. (syn. Wikstroemia chamaejasme (L.) Domke). This species occurs in North and Central Asia extending westward as far as the Caucasus, and from Uttar Pradesh to Central Nepal, Bhutan, Tibet and Northern China. It is a high altitude

plant of grassy mountain slopes and bare arid tracts between 2,500 and 4,500 m.

It is an entirely glabrous shrublet producing numerous slender, leafy, upright annual shoots 15 to 40 cm high from a woody, up to 6 or 7 cm thick, rhizome. The leaves are numerous, overlapping, almost sessile, very variable in shape, linear-lanceolate to elliptic-oblong 1 to 2 cm by 2.5 to 5 mm the upper forming an involucre round the flower heads. These are globular, many flowered, 2.5 to 3.5 cm in diameter, with hairless receptacle tubes 1 to 1.5 cm long and 5 short perianth lobes (rarely 4). The flowers are sweet-scented, white with pinkish tubes.

The dry fruit is a small blackish nut, included in the persistent base of the receptable tube (Trier, 1972) (Polunin and Stainton, 1984).

In Tibet paper is made from the bast fibre of the unusually thick roots of this plant. It is grey, soft and good for writing purposes. In many of the higher regions of Tibet the roots of this shrub were the only raw material available to the paper-makers. Moreover, paper made from these fibres was regarded as high quality and used for special purposes such as the manufacture of currency notes. In Nepal, in or south of the Great Himalaya where other sources of fibre are relatively abundant, Stellera chamaejasme is not usually used for making paper. However, according to Corneille Jest of the Musee de l'Homme, Paris, the plant is sometimes used for this purpose in the Dolpa area of Western Nepal (Trier, 1972). Trier gives the following microscopical data: fibre length 0.5 to 3.5 cm, breadth 0.004 to 0.02 mm.

iv) Daphne involucrata Wall., is distributed throughout further India, northern Assam, Bangladesh, the Khasia hills and the East Himalaya including eastern Nepal from 1,200 to 1,800 m.

It is a tall shrub or small tree up to 6 m high; the leaves are alternate (rarely opposite), oblong-lanceolate, pale beneath, thin with many secondary nerves. The flowers are white and the fruits black (Trier, 1972).

G.B. Shah writes that paper-makers in East Nepal sometimes mix 'baruwa' (probably D. bholua) bast with the hard bast fibres from the 'arghali' tree (D. involucrata). This is said to be done to produce more paper, however, it is coarse and of inferior quality and is mainly used as wrapping paper. Trier gives the following data: fibre length 2 to 6.5 mm, breadth 0.003 to 0.02 mm.

v)* Daphne sureil W.W. Smith and Cave., is distributed through southern Assam, Bhutan, Sikkim, the Darjeeling area and also eastern most Nepal from C. 1,300 to 1,700 m.

An upright shrub 1 to 2.5 m high, with branches almost in whorls. The bark is greyish-brown and smooth. The leaves alternate, blade stalked, lanceolate to oblong-lanceolate, acutely acuminate, 5 to 13 cm by 1.6 to 3.5 cm (according to Smith and Cave, 1913 P. 49, average is 9 cm x 2.5 cm), thinly leathery, glabrous, dark green and somewhat glossy above, and paler light green beneath; secondary nerves very oblique, 9 to 12 on each side. Inflorescences of C.12 to 20 flowers in a rather lax head borne on terminal or lateral branches up to 4 cm long. Flowers faintly scented, borne on densely, finely tomentose stout stalks up to 3 mm long. Perianth 4 lobed, up to 2.5 cm and a dull ivory white. Fruits red-orange. According to Smith and Cave it differs from D. bholua in the colour of the flowers and fruit, and in the form of the perianth; and from D. papyracea in the leaves being less coriaceous and more pointed, and in the longer and narrower perianth (Smith and Cave, 1913) (Brickell and Mathew, 1976) (Cowan and Cowan, 1929) (Trier, 1972).

vi) Daphne retusa Hemsl. Distributed from Kashmir to South-West China in alpine shrubberies and on open slopes between 3,300 and

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* Some botanists/taxonomists consider this a variety of D. papyracea.

3,700 m uncommon. A dense much-branched evergreen shrub, twigs rather stout young branches green then light brown, with small shiny green broadly oblanceolate leaves 2.5 to 4 cm long, narrowed towards the base, apex rounded, glabrous, sessile, margins inrolled. Flowers pinkish-purple to white, very fragrant in terminal bracteate clusters; slender tubes, glabrous, lobes 7 to 10 mm, ovate. Fruit orange to red nearly globular 8 to 10 mm. Trier writes that although this species has not been used much for paper-making in Nepal it is used in Assam, Tibet and Kumaon. He also gives the following data: fibre length 3 to 5.5 mm, breadth 0.006 to 0.02 mm.

8.3 Other Plant Fibres for Quality Paper-Making, Trees and Shrubs

i)* Broussonetia papyrifera, Vent. This is commonly called the 'paper mulberry' or in the Japanese vernacular 'Kozo'.

It occurs naturally throughout the Indo-Malayan region, China, Japan and the Pacific islands. It thrives in both temperate and tropical climates given good moist soil conditions. It has not succeeded where tried on poor ground or where there is a heavy growth of grass (Troup, 1921). It is a middle sized deciduous tree with leaves ovate, dentate often lobed, upperside rough, underside softly tomentose. The male flowers are cylindrical catkins, the female occur in globose pedunculate heads.

The bast fibre is widely used for paper-making in Japan, Thailand, Burma and other far-eastern countries. The tree grows rapidly with stems attaining heights of 20 m and diameters of 20 to 30 cm in 5 to 7 years. It is common in Japan and is often cultivated along the borders of fields. According to a survey conducted in 1953 the area planted with Paper Mulberry was C. 8,000 ha, yielding an annual bark production of C. 8,000 Mt (Shionome, 1971). It propagates readily,

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* B. papyrifera also provides fodder in the form of leaves and twigs and timber suitable for manufacturing matchsticks or for use as relatively low quality fuelwood.

not only from seed but also by means of root suckers which it sends up in great profusion from its superficial roots. In Japan, this and other related species are usually grown from suckers and managed on a short coppice rotation of about three years. The shoots are harvested, cut into short lengths and steamed, the bark then being stripped off and soaked to facilitate the removal of the dark outer bark (Hunter, 1978) (Troup, 1921).

The bast is comprised of long fibres 4 to 12 mm long and 0.01 to 0.03 mm in breadth (Shionome, 1971) (Pokharel and Shrestha, pers. comm., 1984).

It is important to note that this species can become a troublesome weed given the right conditions and hence caution should be exercised in its cultivation (Troup, 1921) (Howland, pers. comm., 1984).

ii) Morus Macroura (previously Morus alba L.). Originating in China where it grows wild, often attaining a large size, it has now spread throughout Asia, Europe and Japan. In the Himalaya it may be found growing as high as 2,000 m. In Nepal it occurs as a smallish rather straggling deciduous tree with smooth light coloured bark, becoming darker and vertically fissured with age. The leaves are variable in shape, 5 to 7 cm long, oval or lanceolate, sometimes with irregular dentate margins and occasionally lobed. The leaf base is three-veined, rounded occasionally cordate. The flowers are small white, with male and female on different stalks. The fruit is a small oblong purple or white berry (Storrs and Storrs, 1984).

In Japan, mulberry paper has been manufactured since about 400 A.D. It renders a relatively low bast yield which is difficult to refine. However, according to Shionome (1971) it provides an excellent fibre suitable for the manufacture of handmade paper. He gives the following technical data: fibre length 2.8 to 13.8 mm, breadth 0.009 to 0.03 mm.

8.4 Bamboos and Grasses

i) Bambusa and Dendrocalamus species. Bamboo is a potentially important raw material for the manufacture of handmade paper, especially Dendrocalamus hamiltonii which is the commonest and most widely distributed of the Nepalese species. It is abundant in many parts of the Siwaliks in Nepal from the Terai up to about 2,000 m (Stapleton pers. comm., 1984). According to Bhatt (1977) the Terai and Babhar "abound in raw materials" for the pulp and paper industry, and every year vast quantities of bamboo, Sabai grass and Bombax malabaricum are exported to India for pulping.

In the orient for many centuries the bamboo and especially Phyllostachys pubescens furnished the basic raw material for the manufacture of paper. In India and Pakistan Dendrocalamus arundinacea, a fast growing tropical species can be cropped every 3 to 4 years, yielding c. 1 ¾ Mt of cut cane per hectare per annum. Chemically the bamboo contains four principal substances; starch, pectin, lignin and cellulose, the latter being the basic material used in the manufacture of handmade paper. The suitability of bamboo pulp for paper-making is largely dependent on its fundamentally fibrous structure; the cellulose molecule consists of a chain of approximately 100 glucose-like units connected end to end in a filamentous pattern. The quality and individual characteristics of the paper are greatly influenced by both the species and the pulping process employed. Trials carried out in the U.K. during the 1940's suggest bamboo could supply a high-quality, yet cheap substitute for more orthodox pulp materials (Lawson, 1968). This suitability of bamboo fibres for making paper was demonstrated centuries ago by Chinese artisans, and today as a result of recent fibre-dimension studies and improvements in mill techniques, fine papers of many varieties and adaptions can now be made from the pulp of certain bamboos. High grade bamboo pulps can be used in the pure state for coated or uncoated book and magazine papers. The pulp of other bamboo species is excellent for the manufacture of soft facial tissues and for thin, India-type papers where opacity is important. Fibre dimensions with a high length to diameter ratio give many bamboo pulps a special versatility (McClure, 1966) (McClure, 1928) (Sung, 1929).

Hunter (1978) describes the method of processing bamboo for pulp as carried on by the Chinese in the 1940's. After splitting, the lengths of bamboo are placed in layers in a sunken pit lined with stones, layers of cane alternating with layers of lime. The pit is then filled with water and the bamboo allowed to soak thoroughly for several months. After this intense treatment in lime solution the bamboo is removed from the pit and rinsed in clean water to remove all traces of the lime. The bamboo is then beaten to render the fibres suitable for sheet formation. Technical data: fibre length 1.09 to 2.33 mm, breadth 0.009 to 0.014 mm (Shionome, 1971).

ii) Eulaliopsis binata (Vern. Sabai grass or babio), is found throughout the Terai occurring on the slopes of the hills in the Babhar and Duns.

Large quantities are purchased annually from the Forest Department by the Indian pulp mills. It is used locally for weaving mats and ropes and for making brooms.

Other grasses occurring naturally in the Terai which could be used for pulp production are; Saccharum munja (munj), Imperata cylindrica (khar) and Anthesteria gigantea (ulla), (Bhatt, 1977) (Grant, 1964).

The Department of Cottage and Village industries give the following technical data for Sabai grass: fibre length 1.9 to 2.6 mm, breadth 0.0075 mm (Pokharel and Shrestha, pers. comm., 1984).

iii) Rice and other Cereal Straws. In 1976/77 a series of pulping experiments were carried out by the Industrial Services Centre, Balaju to test the feasibility of using agricultural waste as both a substitute for, and an addition to Daphne bast for handmade paper production. Cereal wastes/residues were selected for the tests because of their widespread availability throughout the kingdom.

The paper produced from rice straw had good sheet formation qualities but poor tearing resistance. The addition of 3% sizing liquor to the pulp was sufficient to produce paper with good water resistance.

The chemical composition of other cereal straws (i.e. barley and wheat) being similar to rice straw, it has been inferred that a paper of equal quality could be produced. However, paper produced from corn stalks (maize) was not suitable for writing purposes but was good enough to be utilized as packaging material.

It was concluded from the series of experiments that a 50:50 mix of straw and Daphne bast was the most viable in terms of both paper strength and quality, and costs of production. The following technical data is given for cereal straws: Average fibre length 1 mm, breadth 0.013 mm (Suvedhi and Raymajhi, 1977).

8.5 Herbaceous Plants

i) Hibiscus cannabinus (Kenaf), is a non-native, but naturalized, fast-growing fibrous plant, well suited to tropical and subtropical climates which is currently grown on a commercial scale in about 20 countries including Australia, India, Mexico, Thailand, the United States of America and the USSR. It produces high fibre yields on a wide range of soils including acid peats, alluvial and colluvial silty loams, sands and sand clay loams, alkaline and saline desert soils, latasols and many others. It grows to a height of more than 3 m in three to four months and can be harvested and prepared for the pulp mill with relatively inexpensive machinery used for other crops such as sugarcane and forage.

Kenaf has characteristics favourable for the manufacture of many paper products including high-quality writing and printing stock and moderately strong packaging and wrapping paper. It has exhibited the quality of "dimensional stability" much prized in the printing trades (Ceres, 1984).

ii) Boehmeria nivea (Ramie). Two varieties of this species are recognized: i) Var. nivea, a native of China and Japan and, ii) Var. tenacissima, a native of Malaya which is better suited to tropical conditions.

The stem yields a bast fibre which is one of the longest, 6 to 30 cm in length and 0.33 mm in breadth, strongest, most lustrous and durable of plant fibres; highly resistant to water but somewhat lacking in elasticity and flexibility. It has a tensile strength greater than cotton which increases on wetting ; however, it is difficult to decorticate and to separate the fibres from the gummy pectin which coats them. Thus, to produce quality fibres harsh degumming methods are necessary to remove persistent pectic adhesions e.g. boiling in lye, bleaching, treating with acid and retting with suitable bacterial species.

In the past the principal uses for Ramie have been the manufacture of fishing nets, cords, firehoses, hats, fabrics, thread and occasionally paper. Trier (1972) says that of the few preserved 13th to 15th century manuscripts which he has analysed, the majority are executed on paper made of Ramie or Hemp (Boehmeria nivea and Cannabis sativa). It has been found to be suitable for the production of thin, strong paper (Technical Section of the British Paper and Board Maker's Association, 1950).

Other species of the family Urticaceae occurring in Nepal such as 'Allo' (Girardinia diversifolia), Urtica dioica, Laportea terminalis and Urtica hyperborea could probably be used to manufacture paper of a similar quality (Purseglove, 1974) (Schery, 1954) (Maitie, 1979).

iii) Crotalaria juncea L. (Sunn/San Hemp). India, where it has been cultivated since ancient times, is probably its country of origin. It is second in importance to Jute (Corchorus capsularis), having greater tensile strength and greater durability under exposure. It is essentially a cordage fibre but is also utilized to produce high quality currency paper, cigarette and tissue paper. The fibres are coarse, white and lustrous and contain a high proportion of cellulose.

It is a fast growing, hardy, drought-resistant species adapted to most soil types. For quality fibre production light, loamy, well-drained soils are preferred; on low lying clay soils it makes

vigorous growth, but the fibre is coarser and yields are lower. (Purseglove, 1974) (Maitie, 1979).

iv) Linum usitatissimum (Flax). Flax has been cultivated for at least 5,000 years, primarily for the manufacture of linen cloth. It is a fast-growing plant yielding a soft, highly lustrous and flexible fibre (average length 25 mm, breadth 0.02 mm), stronger than cotton, rayon or wool.

It is difficult to produce a heavy quality paper from linen pulp, but when carefully prepared and bleached linen is a pure form of cellulose and as such, is ideal for the manufacture of durable, high-quality papers e.g. currency and cigarette paper. It blends well with other fibres and can be used to impart additional strength to the sheet. (Technical Section of the British Paper and Board Makers' Association, 1950) (Maitie, 1979) (Schery, 1954).

v) Cannabis sativa L. (Hemp). A native of Central Asia and of very ancient cultivation in Asia and Europe, occurring in most tropical and temperate countries. It is naturalized in parts of India and Nepal as a weed of wasteland areas.

The plant produces a soft, white bast fibre valuable for its length, strength and durability. The crude fibre, containing about 75% cellulose, is very similar to flax, occurring in bundles of cells 1 to 2 m long and little more than 1 mm wide. The 'ultimate' or true fibre has a length of between 2 to 5 cm and a breadth of 0.02 mm and yields an extremely strong, durable paper that can be used for the manufacture of bank-notes, cigarette and other strong tissues, insulating and similar papers. (Technical Section of the British Paper and Board Makers' Association, 1950) (Purseglove, 1974) (Schery, 1954).

vi) Corochorus spp. (Jute). Grown chiefly in India in areas with warm humid climates, it yields crude fibre strands that occur in bundles 2 to 3 m long. These fibres are soft and pliable when first extracted but deteriorate easily and are comparatively weak.

The fibre contains about 60% cellulose and is mostly used for manufacturing coarse cloth and bagging. The 'ultimate' or true fibre is about 2 mm long and 0.02 mm in breadth. Like other bast fibres it fibrillates readily on beating and when bleached gives bulky and opaque paper similar in general quality to that produced from Esparto grass. It can be used for wrapping paper, board and as an addition to cigarette paper. (Purseglove, 1974) (Technical Section of the British Paper and Board Manufacturers' Association, 1950) (Schery, 1954).

SECTION 9: DISCUSSION AND PRELIMINARY RECOMMENDATIONS

9.1 Discussion

Present concern for the conservation of natural stands of Daphne reflects the growing scarcity in many areas (e.g. Baglung; Myagdi; Barhabise) of a previously abundant resource. It can be argued that currently high levels of exploitation are a direct result of the recent increased demand for Lokta paper, which in turn has induced cutters to set a higher price per dharni (2.4 kg) of raw Lokta. To cite an example, cutters working in Kalinchok forest above Suspa, Dolakha district, are receiving Rs. 10 per dharni and can cut up to 3 dharni (dry weight) of Lokta bark per day, giving them a possible daily wage of Rs. 30 which compares very favourably with the average labourer's wage rarely exceeding Rs. 20. However, field observations suggest that higher renumeration may encourage wasteful practices. Examination of randomly selected sections of discarded outer bark revealed that often as much as ¼ of the useable bark (inner bast) still adhered after the cleaning/separation process had been completed. The wasted bark would probably require a little more time and effort to remove but this is probably unacceptable to the cutters as long as a fairly abundant supply of Daphne still exists.

Increased demand has also affected the price per sheet fixed by the paper-makers, especially those using improved methods and technology; at Suspa the current price is Rs. 1 per sheet but is likely to be raised to Rs. 1.50 by next year. Hence, with a daily output of 200 to 300 sheets, each of the 6 families involved receives a gross income of between Rs. 30 and Rs. 50 per day. Moreover, the difficulty of controlling both illicit cutting and monitoring legal quotas is a further factor contributing to the threat already posed to the future conservation of natural Daphne stands. There is substantial evidence suggesting that legal quotas are often exceeded and that Lokta poaching is on the increase (Anon, pers. comm., 1984). Furthermore, haphazard and unplanned exploitation of the forest ecosystem for timber, fuelwood, fodder and other forest products results in serious damage to the species' habitat and a consequent decline in the Daphne population.

A general lack of product quality control at the manufacturing level is reflected in the grades of Lokta paper available from Kathmandu stationers - Star, A, B, and C. The B and C quality paper is considerably inferior and really only suitable for use as wrapping paper. Paper of this quality, portered up from Kathmandu, is used for wrapping cheese at Kyangjin gompa cheese factory in the Langtang National Park. This would seem to be an example of a peculiarly wasteful use of an already scarce and valuable resource.

9.2 Recommendations

a) Forest and Daphne management

i) Paper-makers should be encouraged to supply their fuel-wood requirements from plantations or woodlots to assist in reducing habitat damage.

ii) Optimal management regimes commensurate with maximizing sustained bark yield and resource conservation must be established; ideally only harvesters with management training would receive cutting permits (for a description of licensing system see Appendix 6).

iii) As an interim measure, existing cutting quotas should be carefully monitored and individuals exceeding quotas should have their permits rescinded.

iv) There should be no increase in present quota levels (i.e. Metric tons of harvestable Lokta p.a.) until sufficient scientific data is obtained, enabling optimum rotation lengths and management regimes to be established.

b) Harvesting techniques

v) Every effort should be made to reduce waste during cutting and cleaning, and different harvesting techniques should be scientifically examined to determine optimum methods

APPENDIX 3 (cont'd...2)

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
5)						
i) Lithocarpus pachyphylla (Stainton)	L. pachyphylla (Quercus) Q. lamellosa, Q. lineata,	East Himalayan Nepal between the Tamur river and the Sikkim border, lower down it merges with type 4, higher with 7	2400-3000M 8000-9500'	Moist	1750-3500MM	D. bholua
ii) East Himalayan wet temperate forests; subtype high level Oak (Champion)	Ilex spp. Magnolia sp. Rhododendron spp. Alnus nepalensis (along water courses and landslips)	Canopy 80-100'				
6)						
i) Lower temperate mixed Broadleaf (Stainton)	Michelia kisopa, Lithocarpus elegans, Quercus glauca,	East Himalaya, rarely west midlands, mostly in shady gullies in Q. incana forest; on south side of lekhs separating Jumla from midlands	1500-2200M 5000-7000'	Moist	1750-3500MM	D. papyracea
ii) East Himalayan wet temperate (Champion)	Castanopsis tribuloides, Machilus spp.					
7)						
i) Upper temperate mixed Broadleaf (Stainton)	Acer spp., Magnolia campanulatum Osmanthus suavis, Ilex spp., with Sorbus, Alnus Prunus, Betula, Populus, Rhododendron, Tsuga dumosa and Quercus lamellosa often present but not dominant.	Central and East midlands of Nepal, Mostly north & west facing slopes. The Kali Gandaki is the approximate dividing line between this type & the Aesculus-Juglans-Acer type of the west midlands	1800-2750M 8000-10500'	Moist, loams predominate often acid humus in spruce forest		D. bholua D. papyracea
ii) East Himalayan wet temperate (Champion)						

APPENDIX 3: A SUMMARY OF ECOLOGICAL REQUIREMENTS FOR THYMELAEACEAE, MAJOR PAPER-MAKING SPECIES

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
1)	Q. dilatata, Q. incana, Q. semecarpifolia, Tsuga dumosa	Western Himalaya from Afghanistan to Nepal, Fairly common in the West Midlands	1500-3300M 7000-9500'	Moist loams deep rich humus		D. bholua
i) Quercus dilatata (Stainton)	Abies pindrow, Betula alnoides, Alnus nepalensis, Acer spp.					
ii) Q. dilatata-Acer (Champion)		Canopy upto 100'				
2) Q. semecarpifolia (Stainton, Champion & Dobremez)	Q. semecarpifolia, Tsuga dumosa Ilex dipyrena, Acer spp. Rhododendron arboreum, Prunus spp.	Himalaya to south China, almost pure overstorey in some areas of the mid west. Absent in the far East. Canopy upto 100'	2400-3100M 800-10000'	Moist and deep	heavy snow-fall, frosts from sept. Hail from Apr to May	D. papyracea Wikstroemia canescens
3)	Castanopsis spp., Q. lamellosa, Lithocarpus spp.	i+ii, in East Himalaya i, extending west into Kumaon, ii+iii, unrecorded West of Okhaldhunga Canopy 80-100'	2100-2600M 6000-9500'		1500+MM	D. bholua D. papyracea E. gardneri
i) Castanopsis tribuloides						
ii) Castanopsis hystrix (Stainton)						
iii) Q. lamellosa and Castanopsis hystrix (Dobremez)						
4)	Quercus spp., Lithocarpus elegans	East Himalaya & West China. Absent west of the Kali Gandaki Canopy upto 100'	2100-2600M 6000-9500'	Gneissic, Sandy loams. Rich humus layer, Moist	1500-3500MM	D. bholua D. papyracea E. gardenri
i) Q. lamellosa (Stainton)						
ii) East Himalayan wet temperate, subtype Buk Oak (Champion)						
iii) Q. lamellosa & Lauraceae (Dobremez)						

APPENDIX 1 (cont'd...7)

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
13953	Amatya & Bhattacharya	1973	Shivapuri	5800'	Flowers yellow, open shade
9360	Stainton, Sykes & Williams	1954	Shivapuri	8000'	Flowers yellow
4359	Thapa	1965	Shivapuri	7000'	Flowers yellow
2593	Shrestha	1964	Shivapuri	6000'	Flowers yellow
75/777	Joshi & Rajbhandari	1975	Shivapuri	2570M	Flowers yellow, in Oak
1125	Roy & Rajbhandari	1977	Nigale, Dolakha	2450M	Open, East facing oak forest

5. EDGEWORTHIA PAPYRIFERA Sieb. et Zucc. (Exotic species)

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
19321	M. Togashi	1966	Yase, Near Kyoto, Japan	-	Exotic

commensurate with maximizing bark production and natural regeneration.

c) Fuelwood

vi) Given the relatively high fuelwood requirements for the manufacturing process (see 7.2), greater attention should be paid to increasing the efficient use of fuel through innovation in stove design etc.

d) Product quality and marketing

vii) The current trend towards the manufacture of high quality paper is to be recommended. However, care should be taken to avoid producing paper ultimately indistinguishable from the commercially available kraft-type; and every effort should be made to retain the unique characteristics for which Nepali paper is justifiably famous; hand-made appearance, colour, texture, strength, durability etc.

viii) The aim should be to produce a high quality, high value added product that will continue to appeal to specialist buyers at home and abroad (e.g. International agencies, government departments, the legal profession, artists, tourists).

ix) Finally, it should be accepted that there is no potential for the establishment of large-scale commercial pulp mills based on Lokta, and thus emphasis should be on upgrading the existing cottage industry by improving manufacturing efficiency and developing ecologically sound management of Daphne and fuelwood crops.

SECTION 10: A SUMMARY OF PRIORITIES FOR THE SECOND PHASE OF THE FIBRE RESEARCH PROGRAMME, 1985 - 1986

10.1 Management, Growth and Yield Trial Plots

In December 1984, a series of replicated management trials will be set up at Sundarawati in Kalinchok forest, Suspakhemabati panchayat, Dolakha district. These will be established with logistical support from HMG/N/SATA and ADB, with local villagers providing labour.

The plots will be located in an area of Quercus semecarpifolia and Tsuga dumosa forest at altitudes of between 2,700 and 2,760 m. There will be five treatments reflecting five management/harvesting options: a) Control, to reflect growth under natural conditions with no management or harvesting pressure. b) Suspa, to represent local harvesting practices. The stems will be snapped through at about 20 cm above ground level, the bark then being stripped downwards to the root stock and severed leaving a stump with approximately $\frac{1}{3}$ of the bark still adhering. c) Baglung, following the traditional local practice in this area stems will be cut through 1 m above ground level and the bark stripped downwards to the root collar. This effectively damages the root stock (arguably stimulating vigorous root-suckering) and leaves no bark adhering to the stump, thus precluding coppice regrowth. d) UNICEF, following recent recommendations plants will be cut through at about 15 cm (6") above ground level to leave a stump with the bark intact. Bark will be removed from the stem only after severing. e) Clear-fell, all plants above 30 cm will be felled to create an even-aged structure.

The harvested material from all plots will be measured and the yield (bark) recorded to provide a complete record of production from the date of treatment. The plots will be remeasured on an annual basis to enable increment, and the effect of the different harvesting techniques on regeneration to be quantified.

It is intended to replicate the experiment at Pulchoki and eventually to establish further replications at higher elevations in Kalinchok forest.

10.2 Biomass Studies

Biomass is one approach to forest quantification; it measures the tree or forest yield in terms of weight rather than the traditional unit of volume. This is advantageous where the resource is of irregular form or where small quantities are involved per tree. Hence, the biomass approach will be adopted for Lokta yield studies.

The following methodology will be used:

a) A sample representative of the population is selected. Initially the population of one area is sampled ensuring the sample contains individuals of all size-classes.

b) On the sample trees the components of interest, and easily measured predictor parameters are recorded.

c) The relationships between the components of interest and the predictor variables are statistically determined. The optimum model is selected, based on the precision of prediction and ease of use, and biomass tables are generated from this model.

d) The biomass tables are then validated for that area by selecting an independent sample, and comparing predicted, with actual yield of the components.

e) The biomass tables are then validated for other areas in the same way.

Biomass studies will be carried out with the following objectives:

a) The biomass tables generated for the product (in this case the inner bark or bast) allow for the quantification of the current resource through standard forest inventory procedures. A knowledge of the current state of the resource is vital for management, planning and control.

The tables permit the estimation of increment through repeated measurement of the predictor variable on permanent plots. This also allows the plants' response to various imposed treatments (as in the management trials) to be measured in terms of yield. The estimation of increment is vital for sound management decisions such as harvesting intensity and cycle.

b) Biomass tables generated for the other components (i.e. leaf, top and branches, stripped stem, and total bark) permit the study of the growth habit of the plant in quantitative terms. The distribution of the total plant biomass between components changes with size, and this may affect management decisions such as rotation length. The tables also permit post-harvesting efficiency studies by enabling the total weight of inner bark to be predicted from the residual stems. Furthermore, they allow for the quantification of residues which could have other uses (e.g. as fuelwood).

Biomass studies will be carried out in the East (Tehrathum and Sankhuwasabha), the Central region (Dolakha, Simbhanjyang and Pulchoki/Lalitpur), and the West (Baglung).

10.3 Stem Analysis

Initial examination of stem discs indicate that annual growth rings may be detectable. Samples have been sent to the Commonwealth Forestry Institute, Oxford, U.K. for detailed microscopic analysis and assessment of wood structure.

Under-bark: over-bark diameter relationships are being established so that stand tables can be generated from ring analysis should this prove reliable. Stem analysis will be carried out to determine height development.

10.4 Artificial Cultivation

A series of shade intensity trials will be established at Kaulethana nursery using captive seedlings. These trials will have the following objectives:

a) To determine the optimum artificial shade required - 100%, 75%, 50%, 25% or no shade - for the growth of artificial stands of Daphne.

b) To assess the feasibility of establishing Daphne as a cultivated crop in pure stands or under existing fuelwood/timber plantations.

10.5 Artificial Propagation

Further studies will be carried out to determine the best method of artificial propagation using a range of techniques: different cutting types; layering; root-severing and seedlings.

These studies will be established at Kaulethana and Chalnakel nurseries and in the field at Pulchoki.

10.6 Processing

A study will be made of processing methods under both the traditional and improved manufacturing systems, to determine if any improvements can be made to reduce bast waste, and improve paper quality.

10.7 Fuelwood

A study will be undertaken to quantify fuelwood requirements for paper manufacturing under both the traditional and improved systems. Where possible, recommendations will be made aimed at improving the efficient use of fuelwood and minimizing waste.

10.8 Alternative Fibre Yielding Species

Investigations will be continued into the potential of a range of fibre-producing species for the craft paper manufacturing industry.

These will consist of propagation and growth trials, in conjunction with manufacturing test runs carried out in cooperation with the DCVI.

Species currently under investigation include: Edgeworthia gardneri (Argali), Wikstroemia canescens (Phurke pat), Broussonetia papyrifera (Paper mulberry), Girardinia diversifolia (Allo), and Engelhardtia spicata.

10.9 Resource Survey

An intensive survey by district of the Daphne resource should be undertaken to complement and enhance the data already provided by the FSRO Preliminary Survey Report (1984).

10.10 Staffing and Counterpart

At present the programme is staffed by one British Volunteer Fibre Research Officer. It is therefore recommended that a suitable Nepali counterpart be provided as soon as possible to permit the uninterrupted continuation of the research programme during and after the Volunteer's term of service.

10.11 Transport

At present transport is not provided, and this serves as a severe constraint militating against the efficient running of the research programme. It is therefore recommended that suitable transport be provided to enable, in particular, the nursery research programme to be undertaken effectively.

10.12 Meetings

It is recommended that a programme of regular meetings (perhaps on a quarterly basis) be established, for all individuals and organizations involved in Lokta research, and the craft paper making industry.

This would permit: research priorities to be continually updated; information and ideas to be exchanged; cooperation between interested parties; and prevent research being duplicated.

MAPS
AND
APPENDICES

MAP No1 SHOWING ESTIMATES OF LOKTA RESOURCE IN METRIC TONS

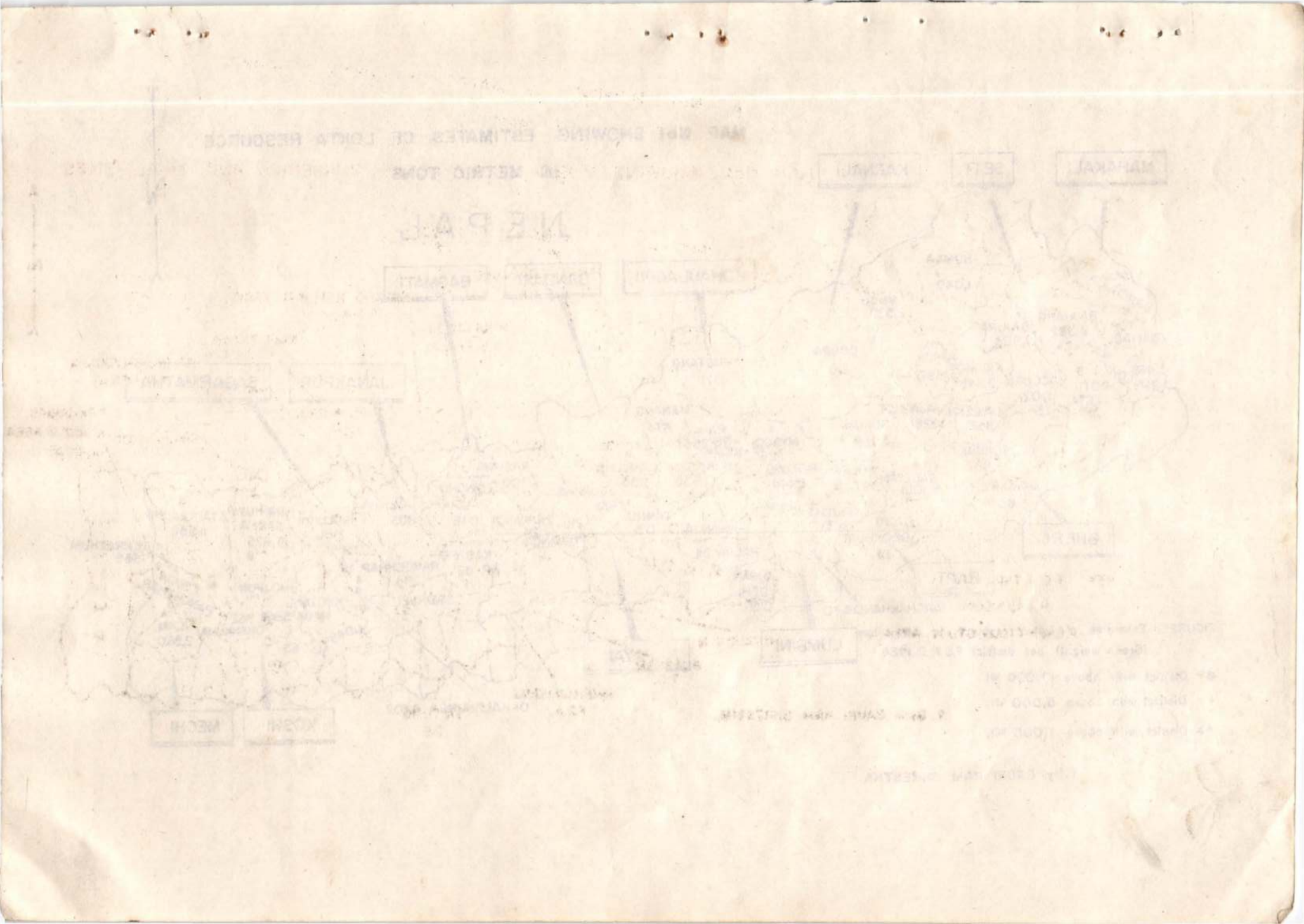
FIGURES = Estimates of Lokta resource in metric tons (Green weight) per district F.S.R.D. 1984

● = District with above 10,000 Mt.

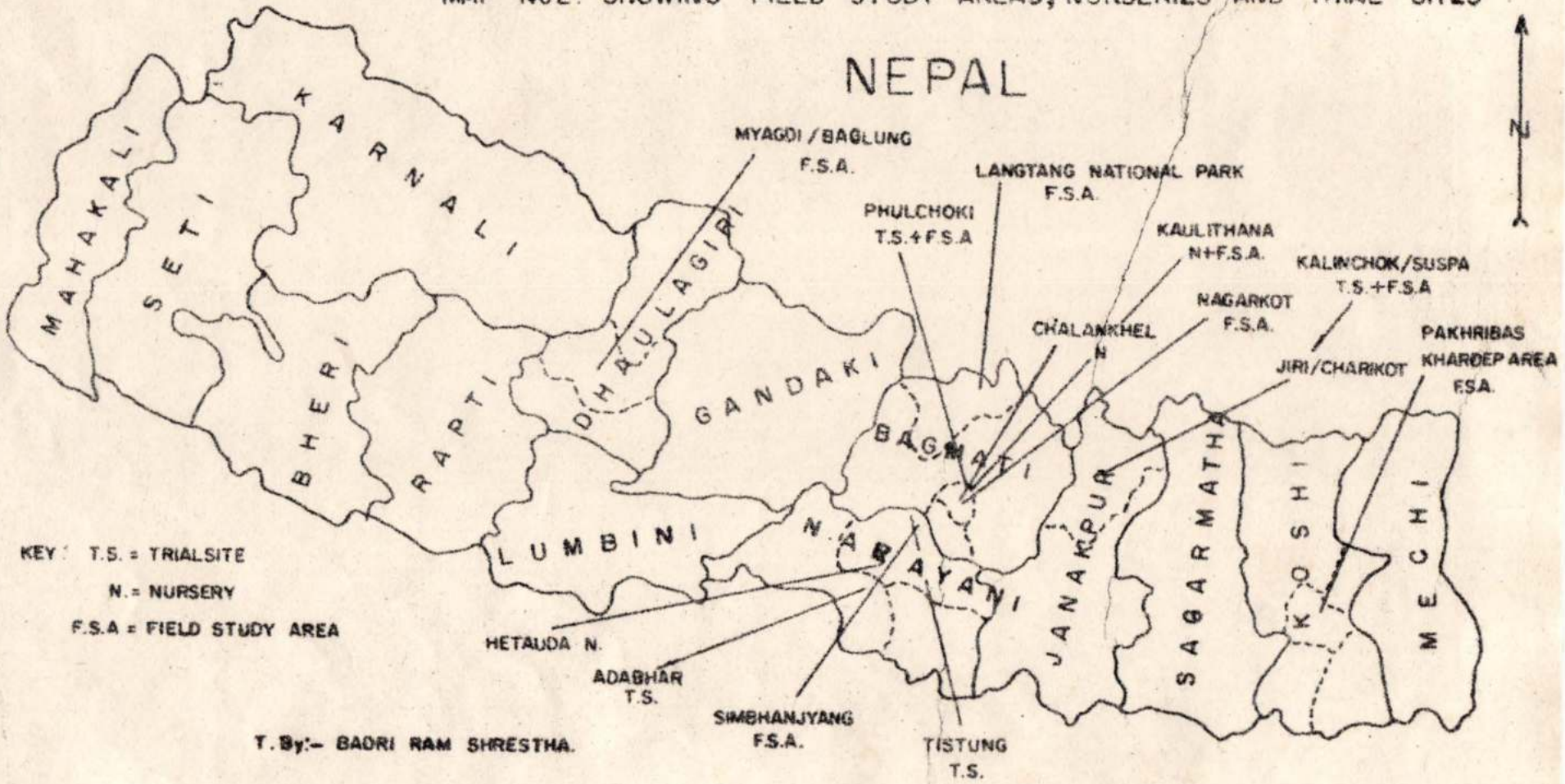
+ = District with above 5,000 Mt.

▲ = District with above 1,000 Mt.

T.By: BADRI RAM SHRESTHA.



MAP No2. SHOWING FIELD STUDY AREAS, NURSERIES AND TRIAL SITES



T. By:- BADRI RAM SHRESTHA.

APPENDIX 1: HERBARIUM SPECIMEN LIST FOR THYMELAEACEAE
GODAVARI BOTANICAL GARDENS, NEPAL, MAY 1984

1. DAPHNE PAPYRACEA, Wall. ex Steud.

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
2675	Stainton, Sykes & Williams	1954	Nr Bongakhani	7000'	Mixed Broadleaf forest Fruit Orange-Red
634	Dobremez	1970	Nagarkot	2000M	Landes
692	Dobremez	1970	Tilje	2200M	Foret de chenes (oak)

2. DAPHNE BHOLUA, Buch. - Ham. ex D. Don (Syn. D. Cannabina Wall.)

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
1748	Manandhar and Adhikari	1979	Jiri	2700M	in shade
75/1807	Joshi & Rajbhandari	1975	Sheopuri lekh	2700M	Oak forest
1535	Manandhar and Adhikari	1979	Nr Kyatang	2740M	Shady, moist ground
5973*	Basukala	1966	Nr Manichur Daha	-	Flowers white
137	Suwal & Malla	1961	Manichur forest	7000'	Flowers white pink at tip of corolla
13954	Amatya and Bhattachariya	1973	Sheopuri Danda	8000'	in oak shade
12782	Amatya	1969	Chitre Shivapuri	7000'	in shade
11131	Kanai	1969	Bagdwar Sheopuri	2300M	-
4358*	Thapa	1965	Bagdwar	7000'	Flowers white
961	R.G. Troth	1976	above Siklis	2700M	Dark mixed, Rhododendron arboreum
73/1164	Joshi & Amatya	1973	Panchase lekh (Kaski)	2300M	shade
73/1096*	Joshi & Amatya	1973	Sattewati lekh	1700M	Mixed oak
1984	Rajbhandari & Roy	1977	Gyangsar, Dolakha	3000M	Quercus semecarpifolia
3389	Manandhar	1979	Bagchhap, Manang	2100M	Shade, moist
73/1122	Joshi & Amatya	1973	Gaja lekh, Baglung	2400M	Shady slope in oak
73/1012*	Joshi & Amatya	1973	Ribdikot	1850M	Shade and moist

* Probably Daphne papyracea misidentified.

APPENDIX 1 (cont'd...2)

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
74/1545*	Joshi & Amatya	1974	Dhwankot, pakhapani panch.	1800M	North facing shady slope
74/1535	Joshi & Amatya	1974	Lunkhu lekh, Parbat	2200M	Shady slope
9220*	Adhikari & Manandhar	1982	Jurichule timmuru	1670M	Shady slope
9237*	Adhikari & Manandhar	1982	Kotmanla, Salyan	1750M	Flowers white, shady slope
14651*	Ramola & Vidya	1973	Babrabarahi	-	Fruit Red
1729	Manandhar & Adhikari	1979	Sherkapti, Dolakha	2320M	On slope
98	Malla & Rajbhandari	1959	Nagarjun	5000'	Flowers pinkish-white, shady open hills
3231	Manandhar	1979	Nuwakot	-	Flowers slightly violet
74/146	Joshi, Rajbhandari & Ghimire	1975	Tham danda	2190M	South slope
8811*	-	1968	Nagarjun	-	Flowers white
965*	Samar & Shrestha	1964	Nagarjun	5500'	Fruit Red, shade Forest margin
2717*	D.H. Nicolson	1966	Gokarna, Kathmandu	1300M	Flowers white mixed forest Nr. pond
75/432	Joshi & Rajbhandari	1975	Mahadeo pokhari, Bhaktapur	2190M	Flower pinkish-white, North slope shade moist
75/31	Joshi, Rajbhandari & Ghimire	1975	Hattiban, S.W. Kathmandu	1750M	Flowers pinkish-white
12	Kanai	1969	Sundarijar, Kathmandu	-	-
4553*	Pradhan & Thapa	1966	Gokarna, Kathmandu	4400'	Flowers white, shade
670671*	Kanai	1970	Gokarna, Kathmandu	-	-
6760*	Pradhan & Thapa	1967	Dholi Ban, Godavari	6000'	Fruit Red, dry place
6722	Pradhan & Thapa	1967	Phulchoki (Kuna khola)	7000'	Flowers white, shade

APPENDIX 1 (cont'd...7)

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
13953	Amatya & Bhattacharya	1973	Shivapuri	5800'	Flowers yellow, open shade
9360	Stainton, Sykes & Williams	1954	Shivapuri	8000'	Flowers yellow
4359	Thapa	1965	Shivapuri	7000'	Flowers yellow
2593	Shrestha	1964	Shivapuri	6000'	Flowers yellow
75/777	Joshi & Rajbhandari	1975	Shivapuri	2570M	Flowers yellow, in Oak
1125	Roy & Rajbhandari	1977	Nigale, Dolakha	2450M	Open, East facing oak forest

5. EDGEWORTHIA PAPYRIFERA Sieb. et Zucc. (Exotic species)

SHEET NO.	COLLECTOR	YEAR	LOCATION	ALTITUDE	OBSERVATIONS
19321	M. Togashi	1966	Yase, Near Kyoto, Japan	-	Exotic

APPENDIX 2: A SUMMARY OF VARIOUS AUTHORS' BOTANICAL AND TAXONOMICAL DESCRIPTIONS

KEY: ? = Probable confusion between species.

C = Daphne cannabina (a synomym for both D.bholua and D.papyracea)

O = Daphne odora (Sometimes a synomym for D. papyracea)

P = Daphne papyracea

B = Daphne bholua

SOURCES	DON (1825)	BRANDIS (1874)	HOOKER (C. 1887)	GUPTA (1901)	BRANDIS (1906)	SMITH & CAVE (1913)
(1) LEAF:						
LANCEOLATE	COPB	COP	COPB	CP	CP	
OBLANCEOLATE	B(?)		B(?)	CP		
ELLIPTIC OBTUSE			COPB			
LENGTH(CM) 5-7			COPB	CP		C/B
" 8-10	COP	COP	COPB	CP	CP	C/B
" 11-13(15)	COP	COP			CP	
(2) FLOWER:						
WHITE			COPB	CP	CP	
WHITE - PINK/RED						C/B
WHITE-PURPLE		COP				
WHITE-YELLOW		COP	COPB			
WHITE-GREEN	COP					
LILAC			COPB		CP	C/B
COROLLA OVATE	COPB		COPB			C/B
COROLLA ACUTE	COP		COPB	CP		
STRONGLY FRAGRANT	COP	COP	COPB	CP	CP	C/B
FAINTLY FRAGRANT						
MONTHS SEP - NOV	COP	COP		CP	CP	
MONTHS DEC - FEB	B				CP	C/B
MONTHS MAR - MAY		COP		CP		
(3) FRUIT:						
ORANGE/RED		COP	COPB		CP	
BLACK						C/B
MONTH FEB						
MONTH MAY				CP		
MONTH JUNE				CP		C/B
(4) DISTRIBUTION:						
UTTAR PRADESH-S.W. CHINA	B(?)	COP	COPB		CP(?)	C/B(?)
PAKISTAN-CENTRAL NEPAL	COP(?)			CP(?)		
(5) ALTITUDE:						
(METERS)						
1000 - 1500		COP	COPB	CP		
1500 - 2000		COP	COPB	CP	CP	C/B
2000 - 2500		COP	COPB	CP	CP	C/B
2500 - 3000		COP	COPB	CP	CP	
3000 - 3500						
(6) CONCLUSIONS	D.bholua & D. papyracea as distinct species	D. papyracea identified	Both D.bholua and D. papyracea confused	D. papyracea	D. papyracea	Probably D.bholua var. glacialis

APPENDIX 2 (cont'd...2)

PARKER (1981)	OSMASTON (1926)	HILLIER (1981)	STORMS (1984)	POLUNIN & STAINTON (1984)	BRICKELL & MATHEW (1976)	TRIER (1972)
(1) CP	CP		B(?)	CP		
CP	CP	B		CPB	P B	P B
					P	P B
CP	CP		B(?)	CPB	P B	P B
CP	CP			CPB	P B	P
CP	CP			CP	P	
(2) CP	CP			CP	P	P
		B		B	B	B
			B(?)		B	B
			B(?)		P	
				CP		
CP	CP			B	B	B
CP	CP			CPB	P	
		B	B(?)	B	B	B
				CP	P	P
CP			B(?)	B	P	P
	CP			CPB	P B	P B
CP	CP			CPB	P B	B
(3)	CP	P	B(?)	CP	P	P
	CP	B		B	B	B
			B(?)			
	CP				B	P B
	CP					B
(4)				B	B	B
CP(?)				CP	P	
(5)						
CP	CP		B(?)	CP	P B	P B
CP	CP		B(?)	B	P B	P B
CP	CP			B	P B	P B
				B	P B	B
D.papyracea	Both D.bholua & D.papyracea confused	D.bholua & D.papyracea as distinct species	Probably D.papyracea misnamed as D.bholua	D.bholua & D.papyracea as distinct species	D.bholua & D.papyracea as distinct species	D.bholua & D.papyracea as distinct species

APPENDIX 3: A SUMMARY OF ECOLOGICAL REQUIREMENTS FOR THYMELAEACEAE, MAJOR PAPER-MAKING SPECIES

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
1) i) Quercus dilatata (Stainton) ii) Q. dilatata-Acer (Champion)	Q. dilatata, Q. incana, Q. semecarpifolia, Tsuga dumosa Abies pindrow, Betula alnoides, Alnus nepalensis, Acer spp.	Western Himalaya from Afghanistan to Nepal, Fairly common in the West Midlands Canopy upto 100'	1500-3300M 7000-9500'	Moist loams deep rich humus		D. bholua
2) Q. semecarpifolia (Stainton, Champion & Dobremez)	Q. semecarpifolia, Tsuga dumosa Ilex dipyrena, Acer spp. Rhododendron arboreum, Prunus spp.	Himalaya to south China, almost pure overstorey in some areas of the mid west. Absent in the far East. Canopy upto 100'	2400-3100M 800-10000'	Moist and deep	heavy snow-fall, frosts from sept. Hail from Apr to May	D. papyracea Wikstroemia canescens
3) i) Castanopsis tribuloides ii) Castanopsis hystrix (Stainton) iii) Q. lamellosa and Castanopsis hystrix (Dobremez)	Castanopsis spp., Q. lamellosa, Lithocarpus spp.	i+ii, in East Himalaya, extending west into Kumaon, ii+iii, unrecorded West of Okhaldhunga Canopy 80-100'	2100-2600M 6000-9500'		1500+MM	D. bholua D. papyracea E. gardneri
4) i) Q. lamellosa (Stainton) ii) East Himalayan wet temperate, subtype Buk Oak (Champion) iii) Q. lamellosa & Lauraceae (Dobremez)	Quercus spp., Lithocarpus elegans	East Himalaya & West China. Absent west of the Kali Gandaki Canopy upto 100'	2100-2600M 6000-9500'	Gneissic, Sandy loams. Rich humus layer, Moist	1500-3500MM	D. bholua D. papyracea E. gardenri

APPENDIX 3 (cont'd...2)

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
5) i) Lithocarpus pachyphylla (Stainton)	L. pachyphylla (Quercus) Q. lamellosa, Q. lineata,	East Himalayan Nepal between the Tamur river and the Sikkim border, lower down it merges with type 4, higher with 7	2400-3000M 8000-9500'	Moist	1750-3500MM	D. bholua
ii) East Himalayan wet temperate forests; subtype high level Oak (Champion)	Ilex spp. Magnolia sp. Rhododendron spp. Alnus nepalensis (along water courses and landslips)	Canopy 80-100'				
6) i) Lower temperate mixed Broadleaf (Stainton)	Michelia kisopa, Lithocarpus elegans, Quercus glauca,	East Himalaya, rarely west midlands, mostly in shady gullies in Q. incana forest; on south side of lekhs separating Jumla from midlands	1500-2200M 5000-7000'	Moist	1750-3500MM	D. papyracea
ii) East Himalayan wet temperate (Champion)	Castanopsis tribuloides, Machilus spp.					
7) i) Upper temperate mixed Broadleaf (Stainton)	Acer spp., Magnolia campanulatum Osmanthus suavis, Ilex spp., with Sorbus, Alnus Prunus, Betula, Populus, Rhododendron, Tsuga dumosa and Quercus lamellosa often present but not dominant.	Central and East midlands of Nepal, Mostly north & west facing slopes. The Kali Gandaki is the approximate dividing line between this type & the Aesculus-Juglans-Acer type of the west midlands	1800-2750M 8000-10500'	Moist, loams predominate often acid humus in spruce forest		D. bholua D. papyracea
ii) East Himalayan wet temperate (Champion)						

APPENDIX 3 (cont'd...3)

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
8)						
i) Abies spectabilis (Stainton)	A. spectabilis, Tsuga dumosa, Q. semecarpifolia, Taxus baccata, Rhododendron spp. Betula utilis, Sorbus spp., Acer spp; Prunus spp. Dense canebrakes where burnt	Throughout Nepal Most extensive in central midlands, usually on south of main ranges, gives way to 7 or 9 below 10,000' Q. semecarpifolia replaced by Rhododendron in the East Canopy to 100'	3000-4200M (upto tree line)			D. bholua (usu. var. glacialis)
ii) Eastern Oak-Fir (Champion)						
iii) Abies spectabilis & Quercus semecarpifolia (Dobremez)			10000-11500'			D. retusa
9)						
i) Tsuga dumosa (Stainton)	T. dumosa, Abies spectabilis, Betula utilis, Q. semecarpifolia, Acer spp., Sorbus spp., Prunus spp., Ilex spp., Symplocos spp., Lindera, Rhododendron spp.	Kumaon eastwards as far as upper Burma Widespread in Nepal. In the east & central midlands sometimes mixes with Q. lamellosa, but more typically with Acer, Magnolia and Osmanthus of 7. Broadleaves are dominant in damp hollows with Tsuga often in pure stands on ridges and dry ground.	2200-3500M			
ii) Eastern oak-Hemlock (Champion)			7000-11000'			D. bholua

APPENDIX 3 (cont'd...4)

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
10) i) Pinus wallichiana (Stainton) ii) Lower Blue Pine iii) High level Blue Pine iv) Western mixed coniferous (Champion) v) Picea smithiana-Pinus wallichiana (Dobremez)	P. wallichiana, Picea smithiana, Abies spectabilis, A. pindrow • Cedrus deodara, Q. semecarpifolia Betula utilis, Alnus nepalensis, Tsuga dumosa, Sorbus spp, Acer spp.	Afghanisthan to Bhutan & south east Tibet. Less abundant in the midlands of Nepal, suggesting Pine invaded after oaks cleared. Occurs mostly on disturbed sites. In Humla and Jumla below 10500' on south slopes often in pure stands. Recolonizes rapidly after fires. Many even-aged stands.	2400-3000M 6000-14500'	Typical of coniferous forest, with well developed 'A'horizon. Often deep, undecomposed humus inimical to regeneration. Podzols or ochre Podzols	1000-1300MM	D. bholua D. papyracea
11) Moist Deodar (Champion & Seth)	Cedrus deodar, Pinus wallichiana, Q. incana, Q. dilatata	Garhwal to North-west Kumaon and Uttar Pradesh. Humla-Jumla	1700-2500M up to 3000M on sunny ridges. 5500-8500'	All geological formations, but avoids poorly drained sites.	1100-1800MM Winter snowfall	D. papyracea

APPENDIX 3 (cont'd...5)

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
12) Schima-castanopsis (Dobremez)	Schima wallichii, Acer oblongum, Castanopsis tribuloides, Q. glauca, Michelia kisopa. In the East: Michelia velutina, Michelia champaca, Albizia spp., Terminalia, Erythrina, Glochodion, Actinidia.	Throughout Nepal	sub-tropics to 2000+M 6500'		1000+MM	D. papyracea
13) i) Abies pindrow (Dobremez) ii) Aesculus-Juglans-Acer (Stainton)	Abies pindrow, Aesculus indica, Juglans regia, Acer sterculiaceum, Ulmus wallichiana, Acer caesium, Acer cappadocicum	Indo-Pakistan border to west Nepal. Forms rare groupings in the hills, Usually pure stands, light canopy cover, often riverain. Rich in species in the far west (Seti Valley). At higher altitudes hybridizes with Abies spectabilis	i) 2100-2400M 6500'-8000' ii) 2400-3000M 8000-10000'	Large block Alluvium	Very variable	D. papyracea

APPENDIX 3 (cont'd...6)

FOREST TYPE	MAIN TREE SPECIES	DISTRIBUTION	ALTITUDE	SOIL	RAINFALL p.a.	THYMELAEACEAE PRESENT
14) Quercus glauca (Dobremez)	Q. glauca (dominant), Pinus wallichiana, Betula alnoides (dominant), Quercus lamellosa, Q. oxyodon, Q. acutissima, Q. dilatata, Picea smithiana, Litsea elongata, L. umbrosa, Magnolia campbellii.	Limited to the west of 87° East & not reaching zone of Annapurnas. Q. glauca is present as secondary species in hill oak forest; Occasionally dominating in large inland vallys e.g. Buri Gandaki, Dudh Kosi, Marsyandi.	Central Nepal: 2000-3100M 6000'-10000' East Nepal 1700-2800M 5500-9500'	Brown soils fairly rich in organic matter. Mull-moder or moder as oak leaves slow to mineralize. Also on Brown Rendzinas, No leaching or Podzolization	C. 1000MM	D. papyracea
15) Subalpine Rhododendron (Dobremez)	Rhododendron spp., Acer spp., Brassaiopsis alpina, Lyonia ovalifolia, Schefflera impressa, Pentapanax parasiticum Sorbus spp., Magnolia campbellii	East of the Arun valley, where given high humidity Rhododendron often dominate. Closed canopy, very dense vegetation, heavy Bryophyte cover on trees and ground Canopy 30'+	3000-4200M 9500-14000'			D. bholua

APPENDIX 4: A COMPARATIVE ANALYSIS OF THYMELAEACEAE AND OTHER PAPER-MAKING FIBRES

SPECIES	FIBRE LENGTH (MM)	FIBRE WIDTH (MM)	CELLULOSE
Daphne bholua	2 - 7.5 (12)	0.000 - 0.020	C. 56%
Daphne papyracea	2 - 7.5	0.006 - 0.020	C. 56%
Daphne retusa	3 - 5.5	0.006 - 0.020	
Daphne involucrata	2 - 6.5	0.003 - 0.020	
Edgeworthia gardneri	1.5 - 5 (7.5)	0.004 - 0.020	C. 55%
Wikstroemia canescens	0.5 - 4	0.004 - 0.020	C. 61%
Stellera chamaejasme	0.5 - 3.5	0.004 - 0.020	C. 60%
Broussonetia papyrifera	4 - 8.5 (12)	0.01 - 0.030	C. 60%
Morus macroura	2.5 - 13.5	0.009 - 0.030	C. 60%
Eulaliopsis binata	1.9 - 2.6	C. 0.0075	
Cannabis sativa	20 - 50	C. 0.020	
Corochorus spp.	C. 2	C. 0.020	
Linum usitatissimum	C. 25	C. 0.020	
Boehmaria nivea	60 - 300	C. 0.030	
Dendrocalamus arundinacea	C. 2.2	C. 0.009-0.16)	
Dendrocalamus hamiltonii	C. 2.4	C. 0.007-0.014)	C. 36%-50+%
Dendrocalamus strictus	C. 2.7	C. 0.007-0.014)	

APPENDIX 5: A SELECTED LIST OF SPECIES WITH POTENTIAL FOR THE CRAFT PAPER MAKING INDUSTRY

BAMBOOS, GRASSES + CEREAL RESIDUES	WOODY SPECIES	HERBACEOUS SPECIES
Bambusa spp. (st)	Morus macroura (B/st)	Linum usitatissimum (st)
Dendrocalamus spp (st)	Broussonetia papyrifera (B/st)	Crotalaria juncea (st)
Eulaliopsis binata (st)	Broussonetia kazinoki (B/st)	Corchorus spp. (st)
Saccharum munja (st)	Bombax ceiba (s.h.)	Cannabis sativa (B/st)
Imperata cylindrica (st)	Artocarpus elastica (B)	Gossypium spp. (s.h.)
Anthosteria gigantea (st)	Ficus natalensis (B)	Musa textilis (st)
Stipa tenacissima (st)	Ficus nekbuda (B)	Hibiscus cannabinus (st)
Rice straw (st)	Ficus padifolia (B)	Girardinia diversifolia (st/B)
Wheat straw (st)	Ficus involuta (B)	Boehmeria nivea (st)
Bagasse waste (st)	Ficus petiolaris (B)	

KEY: B = Bark/Bast fibre; st = stem; s.h. = seed hair fibre.

APPENDIX 6: A SUMMARY OF THE EXISTING LOKTA LICENSING SYSTEM

(1) The individual contractor or cutters' group applies to the DFC for a permit to harvest Lokta, stating the annual quantity (in kgs.) required.

(2) The DFC using recent survey data (FSRO, 1984) calculates the annual amount available for a given area on a sustainable basis.

(3) If the DFC deems the request reasonable, he applies, on behalf of the contractor, for permission from the Department of Forest.

(4) Subject to the request being granted, the cutter pays a fixed royalty, per kg. of Lokta harvested, to the Department of Forest.

(5) The DFC issues the permit which is renewable, usually on a three yearly basis.

(6) A check on the amount cut should be kept at monthly or two monthly intervals by the DFC through his rangers and forest guards.

(7) Abuse, results in the withdrawal of the permit.

Note: The system is liable to abuse as the licence holder is often a contractor - middleman who sub-contracts to cutters and thus has a vested interested in over-exploiting the resource. In addition the cutter is often poorly paid as he is obliged to sell the bark to the middleman who fixes the price and then resells to the paper makers, thus accruing large profits.

It is recommended that the present licensing system be reviewed and adjustments made to enable cutters to receive a greater proportion of the profits, thus encouraging sound management of the resource coupled with harvesting for sustained yield.

BIBLIOGRAPHY

REFERENCES AND SELECTED BIBLIOGRAPHY OF TITLES RELEVANT TO THE BOTANICAL FAMILY THYMELAEACEAE, AND THE CRAFT PAPER MAKING INDUSTRY

* ABDUL, A.A.F.M. (1945). The Daphne Paper of Nepal. Indian Research Institute, Calcutta.

* ACHARYA, B.N. (1975). In, Feasibility Study of Small-Scale and Cottage Industry in Sun Kosi - Khimti Khola area, Section XVII: Nepali Paper. IHDP (SATA/HMG).

ALEXANDER, R.; BHATTARAI, T.D. (1956). Report on Small and Village Industries. Ford Foundation, Kathmandu (mimeo).

AMATYA, P.M. (1982). Simple Techniques for the Propagation of Stem-cuttings in various plants. Nepal Forestry Technical Information Bulletin, No. 7, Oct.

* AMSLER, A.M. (1953). Daphne. Journal of the Royal Horticultural Society, Vol. LXXVIII.

ANTONIUK, N.I.E.; IVANOVA, Z.I.A.; SYDORUK, B.S. (1981). Propagation of Daphne cneorum. Introduktsiia ta aklimatizatsiia roslyn na ukraini (18).

* ARGLES, G.K.; ROWE-DUTTON, P. (1969). The Propagation of Daphnes. Nurseryman and garden centre. 149.

ARMITAGE, F.D. (1958). Atlas of the Commoner Paper-Making Fibres; An Introduction to Paper microscopy. London.

ARTS, METIERS ET CULTURES DE LA CHINE (1815). Papier de Bambou. Paris.

ATKINSON, E.T. (1980). Economic Botany of the Himalayan Regions. Cosmo publications, Delhi.

BAILEY, L.H. (1935). The Standard Cyclopedia of Horticulture Vol. 1. Macmillan.

BAJRACHARYA, R.D. (1983). The Paper-Making Art of Nepal. Cottage Industry Quarterly Vol. 1, No. 4.

* BEATTY, W.B. (1962). The Handmade Paper of Nepal. The Paper Maker, Vol. 31, No. 2.

BERRISFORD, J. (1975). The Small Shrub Garden. Faber and Faber.

BHATT, D.D. (1977). Natural History and Economic Botany of Nepal. Chs. VI & XIV. Orient Longman Ltd.

BHOLA, M.P. (1918). Paper-Making from Daphne cannabina (Wall.) in Garhwal, U.P. Indian Forester No. 44.

BLANCHET, A. (1900). Essai sur l'histoire du Papier et de Sa fabrication Paris.

BOR, N.L. (1953). Manual of Indian Forest Botany. Oxford Univ. Press.

* BRANDIS, D. (1874). The Forest Flora of North-West and Central India Bishen Singh Mahendra Pal Singh, Dehra Dun (Reporint).

BRANDIS, D. (1907). Indian Trees. Archibald Constable and Co.

BRICKELL, C.D.; MATHEN, B. (1976). Daphne the genus in the Wild and in Cultivation. The Alpine Garden Society.

BROWN, G.E. (1972). The Pruning of Trees, Shrubs and Conifers. Faber and Faber.

* BURTT, B.L. (1936). A note on the Himalayan Daphnes. Kew Bulletin.

CAMPBELL, A. (1836). Notes on the states of the Arts of Cotton spinning, weaving, printing, and dyeing in Nepal. Journal of the Asiatic Society of Bengal, Vol. V.

CAMPBELL, M.W. (1978). Seed collection times for Afforestation species in Nepal. Nepal-Australia Forestry Project, Kathmandu, (mimeo).

CAMPBELL, M.W. (1980). Plant propagation for reforestation in Nepal. Nepal-Australia Forestry Project, Dept. of Forestry, A.N.U.

CAMPBELL, M.W. (1983). Propagation of Daphne bholua known as "Lokta" in Nepali. Nepal-Forestry Technical Information Bulletin No. 8.

CARPENTER, C.H.; LENEY, L. (1952). 382 Photomicrographs of 91 paper-making fibres. New York.

* CARTER, A.R. (1979). Discussion Group Report: Daphne Propagation (varieties) Combined Proceedings of the International Plant Propagators' Society. Vol. 29.

CARTER, T.F. (1925). The Invention of Printing in China and its spread Westwards. New York.

CERES (March - April 1984). Kenaf is providing non-wood source of paper. F.A.O. Journal, Review on Agriculture and Development Vol. 17, No. 2.

CHAMPION, H.G. (1936). A preliminary survey of the Forest types of India and Burma. Indian Forest Records (New Series) Silviculture I.

* CHAMPION, H.G.; SETH, S.K. (1968). Forest types of India. Manager of Publications, Delhi.

CHANDLER, G.P. (1968). Rooting Daphne from cuttings. Proceedings of the International Plant Propagation Society No. 19.

CHAUDHARY, Y.S. (10/4/1936). Handmade Paper in India. J.C. Kumarappa, Lucknow, India.

CHOPRA, R.N.; BADHWAR, R.L.; GHOSH, S. (1965). Poisonous Plants of India Vol. II. Family LXXIII - THYMELAEACEAE. Indian Council of Agricultural Research, New Delhi.

CHOPRA, R.N.; NAYAR, S.L.; CHOPRA, I.C. (1956). Glossary of Indian Medicinal Plants. Council of Scientific and Industrial Research, New Delhi.

CLAPPERTON, R.H. (1934). Paper. An historical account of its making by hand from the earliest times down to the present day. Oxford.

COHEN, D.; LE GAL, P.M. (1976). Micropropagation of Daphne X Burkwoodii Turrill. Combined Proceedings of the International Plant Propagators' Society (26).

COWAN, A.M.; COWAN, J.M. (1929). The Trees of Northern Bengal. Bengal Secretariat Book Depot.

CURTIS'S BOTANICAL MAGAZINE (1891; 1924; 1933). Three References:
i) Edgeworthia gardneri. Vol. XLVII; TAB 7180. London.
ii) Stellera chamaejasme. Vol. CL, TAB 9028. London
iii) Daphne sureil. Vol. CLVI; TAB 9297. London.

DARLINGTON, C.D.; WYLIE, A.P. (1945). Chromosome Atlas of Flowering Plants. Allen and Unwin.

DASTUR, J.F. (1964). Useful Plants of India and Pakistan. Treasure House of Books, Bombay.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N) (1967). Notes on the Flora of Rajnikung (Gokarna). Dept. of Med. Plants.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N) (1968). Keys to the Dicot. genera in Nepal. Dept. of Med. Plants.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N) (1969). Flora of Phulchoki and Godavari. Dept. of Med. Plants. Bulletin No. 2.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N) (1973). Flora of Nagarjun. Dept. of Med. Plants. Bulletin No. 4.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N) (1976). Catalogue of Nepalese vascular plants. H.M. Government of Nepal.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N Min. of For.) (1976). Flora of Langtang and Cross Section Vegetation Survey (Central zone). Dept. of Med. Plants. Thapathali, Kathmandu.

DEPARTMENT OF MEDICINAL PLANTS (HMG/N Min. of For.) (1976). Medicinal Plants of Nepal, Dept. of Med. Plants. Bulletin No. 3.

DIRR, M.A. (1983). Daphne X Burkwoodii 'Carol Mackie'. American Nurseryman 157, 10.

* DOBREMEZ, J.F. (1976). Le Nepal Ecologie et Biogeographie. Centre National de la Recherche Scientifique, Paris.

* DOMKE, W. (1934). Untersuchungen uber die systematische und geographische Gliederung der Thymelaeaceen. Bibliotheca Botanica. Heft III. Stuttgart.

* DON, D; Cf. HAMILTON, D.D.F. (1825). Prodromus Florae Nepalensis. Gale, London.

EMERSON, H.W. (1908). Monograph on paper-making and Papier Mache in the Punjab. Lahore, India.

EVAN RESS, P. (19/1/1985). Paper-making in Nepal. Secretariat News UNICEF VOL. XL No. 1.

EVANS, A. (1979). A Herbaceous Daphne (Wikstroemia chamaejasme). Royal Botanic Gardens, Edinburgh, U.K.

FOOD AND AGRICULTURE ORGANIZATION (1953). Raw material for more paper, F.A.O.

FOOD AND AGRICULTURE ORGANIZATION (1973). Guide for Planning Pulp and Paper Enterprises, F.A.O. Rome.

FERGUSON, I.K. (1968). Daphne, in Flora Europaea Vol. II.

* FORESTRY SERVICES (March 1983). Daphne Forest Survey of Hatiya Forest Range, Dhaulagiri Forest Division, Baglung. Report to UNICEF Nep. Kathmandu.

FORESTRY SERVICES (Nov. 1983). Instructor's manual for training Lokta collectors in Lokta Harvesting and Management. Report to UNICEF Nep. Kathmandu.

* FORESTRY SERVICES (Feb. 1984). Management Plan for sustained harvest and utilization of Daphne from the Upper Rahughat river forest and vicinity in Myagdi district, Nepal. Report to SECID/RCUP, Kathmandu.

* FORESTRY SERVICES (June 1984). Management Plan for sustained harvest and utilization of Daphne (Lokta) from the Kalinchok and Sailung forest areas, Sindhupalchok and Dolakha districts, Nepal. Report to IHDP/SATA, Kathmandu.

* FOREST SURVEY AND RESEARCH OFFICE (HMG/N) (1984). Preliminary Survey Report of Lokta vegetation. Publication No. 41, F.S.R.O. Dept. of For.

GABRICHIDZE, Z. sh. (1973). Daphne indica and its propagation. Subtropickeskie Kul'tury No. 5.

GAMBLE, J.S. (1881). A Manual of Indian Timbers. Calcutta. Reprint. B.S. Mahendra Pal Singh, Dehra Dun 1972.

GEE, W.H. (1891). Monograph on fibrous manufactures in the Punjab, Lahore, India.

GODE, P.K. (1944). Migration of paper from China to India. Poona, India, Reprinted from 'Paper-making' by K.B. Joshi, Wardha.

GONDHALEKAR, G.H. (Sept. 1952). Hand-made Paper Industry. Indian Pulp and Paper. Calcutta.

GOODALL, R.A.; GUNDRY, S. (1981). Tree Production. Best of the Bunch. Long Ashton Research Station, Bristol, U.K. G.C. and H.T.J.

* GORDON, G. (1876). The Daphnes. The Garden Vol. IX.

GULATI, A.S.; SINGH, K.R.; SUBRAHMANYAM, A. (1981). A note on the physical and mechanical properties of Broussonetia papyrifera from New Forest, Dehra Dun. Indian Journal of Forestry Vol. 4 (I): 37 - 42.

GUPTA, B.L. (1901). Forest Flora of the Chakrata, Dehra Dun and Sahranpur. 3rd Reprint, Govnt. of India Press, Calcutta 1956.

HABERLI, C. (1984). Allo (Himalayan Nettle), Technical Subject Report. IHDP/SATA, Charikot (mimeo).

* HABERLI, C. (21/12/1984). Suspa Paper Making - New (Japanese) Technology. Note submitted to UNICEF/HMG/N Dept. of For. Daphne Forest Policy and Management Workshop.

HAGEN, T. (1960). Nepal. Bern. Switzerland.

HALDA, J. (1972). Daphne. Skalnicky.

HAMAYA, T. (1959). A Dendrological monograph on the Thymelaeaceous plants of Japan. Bulletin Tokyo University of Forests 50.

* HARA, H.; CHATER, A.O.; WILLIAMS, L.H.J. (1982). An Enumeration of the Flowering Plants of Nepal, Vol. III. Trustees of British Museum (Natural History), London.

* HARTMANN, H.T.; KESTER, D.E. (1976). Plant Propagation; Principles and Practices. Prentice - Hall, New Delhi 3rd ed.

HECKER, D. (1962). Papiermacher in Nepal. Der Papiermacher, No. 10.

HIGH POLYMER AND PETRO CHEMICAL ENGINEERING Ltd., (1964). Feasibility Report on Paper Vol. I and II. Nepal Industrial Development Corporation, Kathmandu.

HILLIER, H.G. (1981). Hillier's Manual of Trees and shrubs. David and Charles.

HODGKIN, E. (1961). Daphnes, Journal of the Royal Horticultural Society Vol. LXXXVI.

HODGSON, B.H. (Jan. 1832). On the Native Method of Making the Paper, Denominated in Hindustan, Nipalese. The Journal of the Asiatic Society of Bengal Vol. I.

HOOKER, J.D. (1855). Himalayan Journals; Notes of a Naturalist in Bengal, the Sikkim and Nepal Himalayas, the Khasia Mountains. Vol. I - II. London.

* HOOKER, J.D. (1875 - 1897). The Flora of (British) India Vol. 5. Reprinted: Jayyed Press, Delhi 1980.

HOOKER, J.D.; JACKSON (1895). Index Kewensis Vol. I. Clarendon Press Oxford, Reprint 1960.

HORNE, C. (April 1877). Paper Making in the Himalayas. Indian Antiquary Vol. VI.

HORST, R.K. (1979). Westcott's Plant Disease Handbook. Van Nostrand Reinhold Co., 4th ed.

HOU, D. (Dec. 1960). Thymelaeaceae. Flora Malesiana. Series I. Vol. 6. Part I.

HOWLAND, P. (1984). Personal communication. F.S.R.O. Kathmandu.

* HUNTER, D. (1939). Paper-making by Hand in India, New York.

* HUNTER, D. (1940). The Paper-making Moulds of Asia. Gutenberg Jahrbuch, Mainz.

* HUNTER, D. (1978). Paper-making. The History and Technique of an Ancient Craft. Dover Publications, Inc. New York.

JARMAN, C.G. (May 1978). Banana Fibre in Rural Industries. Alternative Technology Vol. 5. No. 1.

* JEANRENAUD, J.P. (July 1984). A note on the Natural Regeneration of some Daphne species. NEFTIB No. 10, Kathmandu.

KHADDARI, M. (1937). Handmade Paper Industry of India. Kalpi U.P. India.

KOGISO, S.; WADA, K.; MUNAKATA, K. (1976). Odoracin, a Nematicidal Constituent from Daphne odora. Agricultural and Biological Chemistry Vol. 40, No. 10. Nagoya, Japan.

KUNDU, B.C. (1942). The Anatomy of two Indian Fibre Plants, Cannabis and Corchorus, with special reference to the Fibre Distribution and Development. The Journal of the Indian Botanical Society. Vol. XXI.

KUPCHAN, S.M.; BAXTER, R.L. (1975). Mezerein: Antileukemic Principle isolated from (seed of) Daphne mezereum L. Science, 187, New York.

LAMB, J.G.D.; KELLY, J.C.; BOWBRICK, P. (1975). Nursery stock manual. Grower Books, London.

LANCASTER, R. (1981). Plant Hunting in Nepal. Vikas publishing house Pvt. Ltd., Delhi.

LAWRENCE, G. (1963). Taxonomy of vascular plants. Macmillan.

LAWSON, A.H. (1968). Bamboos. A gardeners' guide to their cultivation in temperate climates. Taplinger Publishing Co., New York.

LEANDRI, J. (1930). Recherches Anatomique sur les Thymeleacees. Annales des Sciences Naturelles 10^{me} Serie Tome XII, Paris.

LEGRIS, P. (1963). La Vegetation de L'Inde Ecologie et Flore, Tome IV. Institut Francais, Pondichery.

LESSARD. G.; CHOUINARD, A (eds). (1980). Bamboo Research in Asia. International Development Research Centre.

LONG ASHTON RESEARCH STATION (1979). Trees and Shrubs. Long Ashton Research Station, Report. Bristol, U.K.

* MAITI, R.K. (1979). Plant Fibres, Bishen Singh Mahendra Pal Singh, Dehra Dun.

* MANI, M.S. (1978). Ecology and Phytogeography of High - altitude plants of the Northwest Himalaya. Oxford and IBH publishing Company, New Delhi.

MAY.; BAKER. (1983). Cutting Propagation Leaflet (insert with Seradix rooting hormone) May and Baker.

McCLURE, F.A. (1966). The Bamboos: A Fresh Perspective. Harvard Univ. Press.

McMILLAN BROWSE, P.D.A. (1979). Hardy woody Plants from seed. Grower Books.

* MESSERSCHMIDT, D.A.; PANDEY, S. (Nov. 1983). Harvesting Daphne bark (Lokta/Baruha) in Myagdi district: an income - generating and user group project in collaboration with SFDP and UNICEF sponsored paper making project in Parbat district, Nepal. SECID/RCUP Social Science Component, (photocopy).

MESSERSCHMIDT, D.A. (Dec. 1983). Discussion with Yukio Hoshino, Coordinator, Readymade Garment and Handmade Paper Project.... RCUP/SECID office Memo. (photocopy).

MIEROW, M.; SHRESTHA, T.B. (1978). Himalayan Flowers and Trees. Sahayogi Press, Kathmandu.

MINCKLER, L.S. (Autumn 1983/Winter 1984). Conservation Countdown, Renewable Resources Journal Vol. 2 Nos. 2 and 3.

MOOKERJEE, D.N. (1908). A Monograph on Paper and Papier Mache in Bengal. Calcutta.

NAKAO (Cf. KIHARA, H. ed.) (1955). Flora and Fauna of Nepal Himalaya Vol. I. Kyoto Univ. Kyoto, Japan.

* NEPAL-AUSTRALIA FORESTRY PROJECT (Nov. 1982). Nepal's National Forestry Plan 1976 (2033). An unofficial English translation. 1st ed. A.N.U.

OHTANI, J.; ISHIDA, S. (1978). Pit membrane with torus in Dicotyledonous woods. Journal of the Japan Wood Research Society, Vol. 29, No. 9.

* OSMASTON, A.E. (1926). A Forest Flora for Kumaon. Reprint: Bishen Singh Mahendra Pal Singh, Dehra Dun.

PANDEY,U.; SINGH, J.S. (1981). A Quantitative study of the Forest Floor, litter fall and nutrient return in an Oak - Conifer forest in Himalaya. Acta Ecologica Vol. 2. No. 2.

PANDAY, U.; SINGH, J.S. (1982). Leaf - litter decomposition in an Oak - Conifer forest in Himalaya: the effects of climate and chemical composition. Forestry, Vol. 55, No. 1.

PAPER AND PRINTS (1946). Paper makers of Tibet. Paper and Prints. Winther.

PARKER, R.N. (1918). A Forest Flora for the Punjab with Hazara and Delhi. Reprint: Bishen Singh Mahendra Pal Singh. Dehra Dun and Delhi, 1973.

PEACE, T.R. (1962. Pathology of Trees and Shrubs. O.U.P.

PEARSON, R.S. (1916). Note on the utilization of Bamboo for the manufacture of Paper - pulp. The Indian Forest Records, Calcutta.

PIRONE: DODGE: RICKETT (1960). Diseases and Pests of ornamental plants. Ronald, New York. 3rd ed.

* POLUNIN, O.; STAINTON, A. (1984). Flowers of the Himalaya. O.U.P. Delhi, Bombay, Calcutta, Madras.

POKHAREL, D.; SHRESTHA, D. (1984). Personel communication. Readymade Garment and Handmade Paper Project. D.C.V.I.

PURSEGLOVE, J.W. (1979). Tropical Crops: Monocotyledons and Dicotyledons. Longman, U.K.

RIEBEN, E. (Sept. 1975). La Production Forestiere de Papier en Nepal. La Foret, 28^{e} annee, No. 9.

RISING NEPAL (3/2/1985). New Raw Material for Paper manufacture Discovered. Rising Nepal Vol. XX, No. 51.

RISING NEPAL (6/2/1985). Eureka? (editorial on 'Allo' - Himalayan nettle - as a raw material for paper). Rising Nepal Vol. XX, No. 54.

ROYAL HORTICULTURAL SOCIETY (May 1942). Edgeworthia papyrifera (i.e. E. gardneri) Journal of R.H.S. Vol. LXVII, Part 5.

ROYAL HORTICULTURAL SOCIETY (1974). Dictionary of Gardening. R.H.S.

ROYLE, J.F. (1855). Fibrous Plants of India for Cordage, Clothing and Paper, with account of the cultivation and preparation of Flax. Hemp and their substitutes. London.

RTISHCHEVA, A.I. (1981). Micromycetes (Fungi) occurring on evergreen shrubs, Daphne L. genus. Mikologiia i fitopatolagiia. Vol. 15 (4).

* SAIKIA, C.N.; et.al. (Jan. 1972). Bark of Supkaseng (D. cannabina, i.e. D. bholua ?). A unique Raw Material for Paper making. Indian Pulp and Paper Vol. 26, No. 7.

SASTRI, B.N. (ed). (1952). The Wealth of India Vol. III, Raw Materials D-E. Council of Scientific and Industrial Research, New Delhi.

SCHERY, R. (1951). Plants for Man. George Allen and Unwin, London.

SCHILLING, A.D. (22/8/1984). Personal communication. Letter Ref: AGH 75A.

SCHILLING, A.D. (1987). Article on Daphne in Gardener's Chronicle.

* SEN, S.N. (April 1940). Hand-made Paper of Nepal. The Modern Review.

SHAH, S.B. (Cf. Trier) personal communication to J. Trier.

SHERPA, N.W. (1979). A Report on Firewood Use in Sagarmatha National Park, Khumbu Region, Nepal. Namche Bazar.

* SHRESTHA, T.B. (1982). Ecology and vegetation of North-west Nepal (Karnali Region). Royal Nepal Academy, Silver Jubilee Publication Series, No. 23, Kathmandu.

SINGH, M.M. et.al. (Sept. 1976). Fibre morphology and pulp sheet properties of Indian Bamboos. The Indian Forester Vol. 102, No. 9.

[illegible], J. (1982). Propagation of Daphne odora. Combined Proceedings of the International Plant Propagators' Society, Vol. 31.

* SMITH, W.W.; CAVE, G.H. (in GAMMIE, G.A. (ed)) (1913). A Note on the Himalayan Species of Daphne. Records of the Botanical Survey of India Vol. VI, No. 2, Calcutta.

[illegible], A. (1956). Papier vom Himalaya. Die Papiermacher No. 7.

* STAINTON, J.D.A. (1972). Forests of Nepal. John Murray, London.

STAPLETON, C. (July 1982). Bamboo in East Nepal: Preliminary Findings (Dec. 1981 – June 1982). F.R.S.O., Kathmandu (Restricted circulation).

SASTRI, B.N. (ed). (1952). The Wealth of India Vol. III. Raw Materials D-E. Council of Scientific and Industrial Research, New Delhi.

SCHERY, R. (1954). Plants for Man. George Allen and Unwin, London.

SCHILLING, A.D. (22/8/1984). Personal communication. Letter Ref: ADS TSA.

SCHILLING, A.D. (1967). Article on Daphne in Gardener's Chronicle.

* SEN, S.K. (April 1940). Hand-made Paper of Nepal. The Modern Review.

SHAH, B.B. (cf. Trier) personal communication to J. Trier.

SHERPA, N.W. (1979). A Report on Firewood use in Sagarmatha National Park, Khumbu Region, Nepal. Mardie Baker.

* SHRESTHA, T.B. (1982). Ecology and vegetation of North-west Nepal (Karnali Region). Royal Nepal Academy, Silver Jubilee Publication series, No. 33, Kathmandu.

SINGH, M.M. et.al. (Sept. 1976). Fibre morphology and pulp sheet properties of Indian Bamboos. The Indian Forester Vol. 102, No. 9.

SLYKERMAN, J. (1982). Propagation of Daphne odora. Combined Proceedings of the International Plant Propagators' Society, Vol. 31.

* SMITH, W.W.; CAVE, G.H. (cf. CANDOLLE de C.-(ed)) (1913). A note on the Himalayan Species of Daphne. Records of the Botanical Survey of India Vol. VI, No. 2, Calcutta.

SPOREL, A. (1955). Papier von Himalaya. Die Papiermacher No. 7.

* STAINTON, J.D.A. (1972). Forests of Nepal. John Murray, London.

STAPLETON, C. (July 1982). Bamboos in East Nepal: Preliminary Findings (Dec. 1981 - June 1982). F.D.F.O., Kathmandu (Restricted circulation).