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Atlas of Common Bean (*Phaseolus vulgaris* L.) Production in Africa

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Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

- **Pan-Africa Bean research Alliance**

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Foreword

The *Atlas of Common Bean (*Phaseolus vulgaris *L.) Production in Africa* is a valuable resource for researchers, extension workers, policy makers, and donors concerned with bean production in Africa. It presents detailed information for 96 bean production areas in Africa, and is a result of information obtained through the efforts of many bean researchers.

Bean is a major crop in many parts of Africa, and especially in eastern Africa. An important food to people of all income categories, it is especially important to the poor as a source of dietary protein. Its production is agronomically diverse, being grown in many different crop associations. Bean is grown primarily by small-scale farmers in eastern Africa. Unfortunately, the rate of increase in bean production has been exceeded by the rate of population growth. The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) recognizes research on beans as being of high importance.

Since the mid-1980s, much effective research on beans has been accomplished in eastern and southern Africa, resulting in farm-level impact through improved production technology. National bean research programmes have been strengthened and have effective collaborative activities with the Centro Internacional de Agricultura Tropical (CIAT). The bean research networks, for example, the Eastern and Central Africa Bean Research Network (ECABREN) and the Southern Africa Bean Research Network (SABRN), have facilitated effective exchange of information and germ plasm between countries. Many improved varieties have been released. Alternatives for crop, soil, and pest management have been developed, often with farmer participation, and such technology is being disseminated to farmers.

Challenges remain. Typical bean yields are only 20% to 30% of the genetic potential of improved varieties. Several diseases and insect pests continue to be major constraints to bean production. Bean root rots have worsened in areas where intensity of bean production is high. Soil fertility is continually declining, which decline is an increasingly significant constraint to the production of not only beans, but also of all crops. Problem-solving research must continue. New technology must reach farmers more quickly. Policies need to be fine-tuned and infrastructure improved to enable farmers to achieve higher levels of production and to market surpluses efficiently.

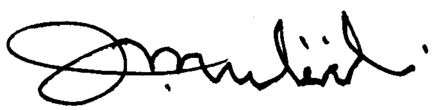
This *Atlas*, and its accompanying bean database, provides information that is needed for undertaking the challenge of increasing bean production in Africa, such as:

- Understanding of the biophysical and socio-economic characteristics of bean production areas enables more efficient exchange of information and germ plasm.
- The diversity of both production systems and bean varieties found in some places indicates the complexity of small-scale farming systems and the need for farmer participation in systems research.
- Opportunity exists to extend the significant impact achieved with climbing bean varieties in the highlands of central Africa to other bean production areas.
- Information on the distribution of bean seed types enables plant breeders to identify sources of germ plasm and to target improved varieties. Organizations providing seed relief to disaster-affected areas should find such information useful in determining the seed types to supply and in identifying appropriate sources of seed.
- Although most beans produced by small-scale farmers are for home consumption, marketing is important.

Information on market flows of beans enables the improvement of policies to increase marketing efficiency.

- Bean is an important crop for women, who are primarily responsible for its production. Beans are also important in the diets of rural families.
- Some diseases and insect pests are of localized or infrequent importance, but others such as angular leaf spot and bean stem maggot are major constraints in most production areas. Breeding for resistance is complicated by the genetic diversity of pathogens.
- Low soil nutrient supplies and soil toxicity problems result in crops that perform poorly because of inadequate plant nutrition and increased susceptibility to diseases and insect pests.
- Bean production is severely constrained by lack of soil water in some bean production areas; the use of available water needs to be made more efficient by planting drought-tolerant and water-use-efficient cultivars and improving methods of water management and use.

I have been privileged to write the "Foreword" to this *Atlas*. It will be a valuable resource in improving research and development efforts for bean production and marketing in Africa for the purpose of greater food security and economic growth. I extend my appreciation to CIAT for its technical support to bean research in Africa; the Rockefeller Foundation, who funded the development of this *Atlas*; and CIDA, DfID, SDC, USAID, and other donors who have given, and continue to give, support to bean research in Africa.



Professor Joseph K. Mukiibi
Chairman, Committee of Directors, ASARECA
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Preface

Common bean, a major food crop in many parts of Africa, is noted for its versatility and diversity. It is adapted to varied climatic and agronomic conditions, and exhibits considerable variation in growth habit and seed type. In Africa, it is grown primarily by small-scale farmers who have limited resources and usually produce the crop under adverse conditions such as low input use, marginal lands, and intercropping with competitive crops. Biotic and abiotic constraints to bean production are numerous. The diversity of this crop and its production implies a need for much information to effectively address the problems involved.

The *Atlas of Common Bean (*Phaseolus vulgaris *L.) Production in Africa* compiles data on beans in Africa to serve information needs of bean researchers, rural developers, policy makers, and emergency relief personnel. It is the result of a collaborative effort by a wide array of bean researchers working in Africa who helped collect data and contributed their expert opinions. The *Atlas* gives information for 59 variables in 96 bean production areas in Africa; these areas are grouped into 14 environmental categories. Most of the information is presented in both maps and tables. The results of a constraints analysis are also presented.

Acknowledgements

The authors thank the many people who contributed their data and expert opinions to the *Atlas,* including many who work with CIAT in Africa or with national bean research programmes. Especially noted for their input are Kwasi Ampofo on bean entomology, Robin Buruchara on bean diseases, and, for bean production, Urs Scheidegger (Great Lakes Region), Vas Aggarwal and Rowland Chirwa (Malawi), and Andries Liebenburg and Rob Melis (South Africa). Peter Jones, consultant, and Andy Nelson and Luz Amira Clavijo of the CIAT Group on “Land Use Dynamics and GIS Analysis” provided valuable assistance in data analysis and map production. Elizabeth Páez edited the manuscript with care and dedication, and Nathan Russell encouraged the work, offering many ideas on the structure of the *Atlas* and overseeing its publication.

We are especially grateful to John Lynam for arranging financial support from the Rockefeller Foundation for the production of this work and for his critical review of the manuscript. The support given by the Canadian International Development Agency, the Rockefeller Foundation, the Swiss Development Cooperation, and the United States Agency for International Development has also enabled us to contribute to the advancement of bean technology in Africa.

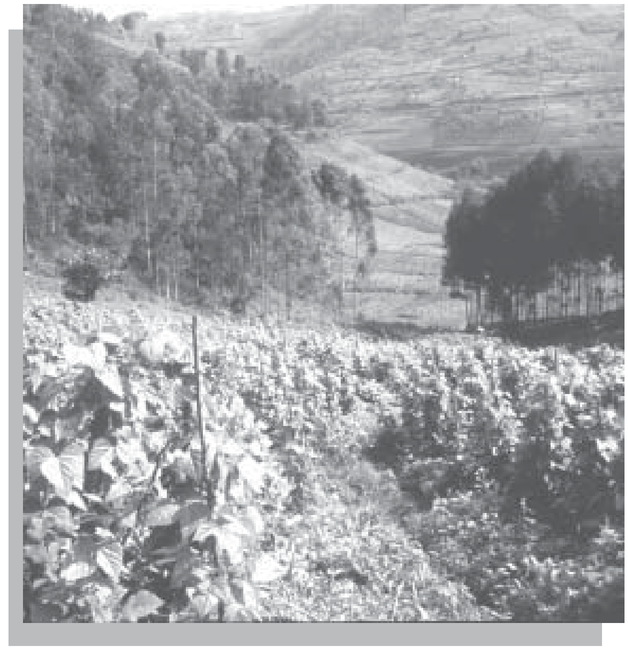
Introduction

Introduction

Common bean (*Phaseolus vulgaris* L.) is a major staple in eastern and southern Africa where it is recognized as the second most important source of human dietary protein and the third most important source of calories (Pachico 1993). Bean consumption in eastern and southern Africa exceeds 50 kg per person per year, reaching 66 kg per person in parts of Kisii, the most populous rural district of Kenya (Jaetzold and Schmidt 1983). Bean provides 60% of dietary protein in Rwanda (MINIPLAN 1988) and is often the principal source of dietary protein for the urban poor. Bean also contributes as much as 30% of dietary energy in the widespread maize-based cropping systems of the mid-altitude areas of eastern and southern Africa. Part of the intercropped bean harvest may be exchanged by poorer rural families to make up for insufficiencies in production of the maize staple (Wandel and Holmboe-Ottesen 1992). National directors of research in eastern and central Africa, and in southern Africa, rank bean second and fourth, respectively, in their priorities for regional collaborative research (ASARECA 1995; SACCAR nd).

“Beans were probably introduced to the eastern Africa coast by Portuguese traders in the sixteenth century (Greenway, 1945). These traders called at Sofala (Mozambique), Zanzibar and Mombasa and their goods, including various new food plants, were carried to the interior by Arab slave traders and by Swahili merchants (Binns, 1976; Merril, 1954; Oliver & Mathew, 1963). Beans became established as a food crop in Africa before the colonial era, but there is little clear indication of the status the crop attained. The wealth of local names given to distinctive cultivars, and the genetic variation, are together evidence of the long establishment of beans as a crop” (Wortmann and Allen 1994, p 1-2).

This document presents information on 96 bean production areas in Africa. It begins with the distribution of bean production in Africa. The African bean environments are characterized, and the hectarage of beans sown is presented with physical information for each bean production area. Socio-economic factors, producer and consumer preferences, and characteristics of bean cropping systems are discussed. Sections follow on the distribution and importance of major categories of seed types, and on agronomic constraints, that is, on diseases, insect pests, and climatic and edaphic stresses, and their overall importance. A final section discusses the sources of information on bean production and the quality of their data.



Classifying Environments of Bean Production Areas in Africa

Classifying Environments of Bean Production Areas in Africa

Distribution of Bean Production

The distribution of beans in Africa is heavily dependent on rural population density and mean temperature during the growing season. The following model accounts for 37% of the variation in intensity of bean production, or percentage of total land area sown to bean annually:

$$I = 25.85 + 0.015 * PD - 0.349 * MT - 2.40 * pH$$

Where,

I = intensity of bean production

PD = population density (people/km^2)

MT = mean temperature (°C)

pH = soil pH

Some areas have particularly high concentrations of bean production (Gray 1990; Wortmann and Allen 1994; Map 1):

1. The Great Lakes Region, consisting of Burundi, Rwanda, south-western Uganda, and eastern Democratic Republic of the Congo (DR Congo);
2. The slopes of Mt. Elgon in Uganda and Kenya, western Kenya, the slopes of Mt. Kenya and the Aberdares in central Kenya, and Eastern Province of Kenya;
3. The vicinity of Lake Malawi, including south-western Tanzania, parts of Malawi, and the Lichinga and Tete Uplands of Mozambique; and
4. The Hararghe Highlands of Ethiopia.

Other notable concentrations include the Tall Grass Zone of Uganda, the Northern and Southern Highlands of Tanzania, and the Kagera Region of Tanzania. Ninety-six bean production areas have been defined with areas of annual bean production ranging from 2,000 to 220,000 hectares.

The above model indicates that bean production might become more intensive north of Lake Victoria and Arua in Uganda, in the Dedza-Shire areas of Malawi, in the Awassa-Areka-Jimma area of Ethiopia, and in Cameroon.

Criteria Used to Classify Environments of Bean Production Areas

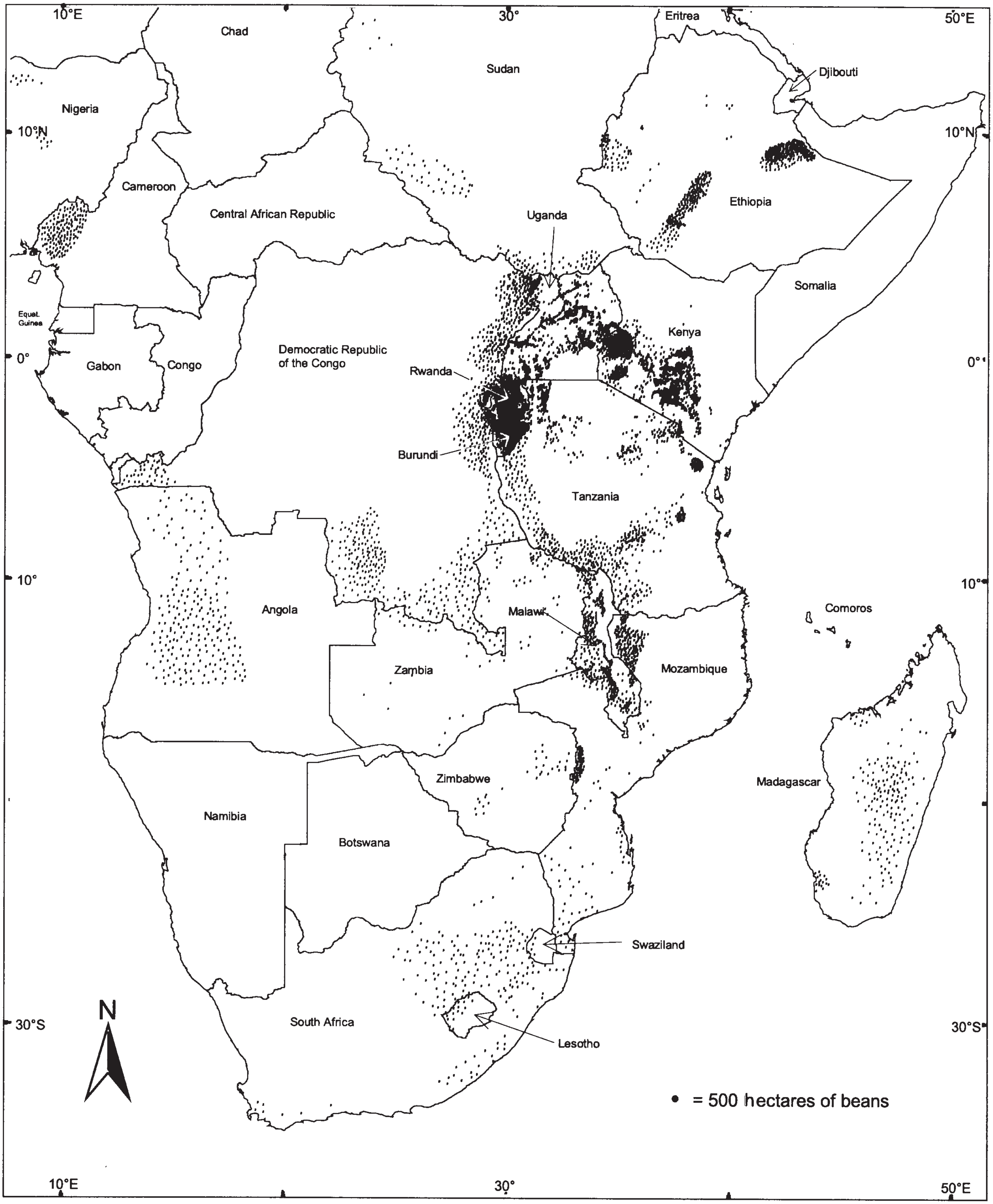
The criteria used to define African bean environments are altitude, precipitation during the growing season, latitude, and soil pH (Map 2, Data table 1). While the levels of these criteria have been set arbitrarily, the cut-off points are of biological significance to the bean crop.

Altitude affects temperature and therefore affects time to maturity, incidence and severity of certain diseases and insect pests, and rates of evapotranspiration. Three altitudes were used in classifying the environments: >1500, 1000-1500, and <1000 metres above sea level (masl).

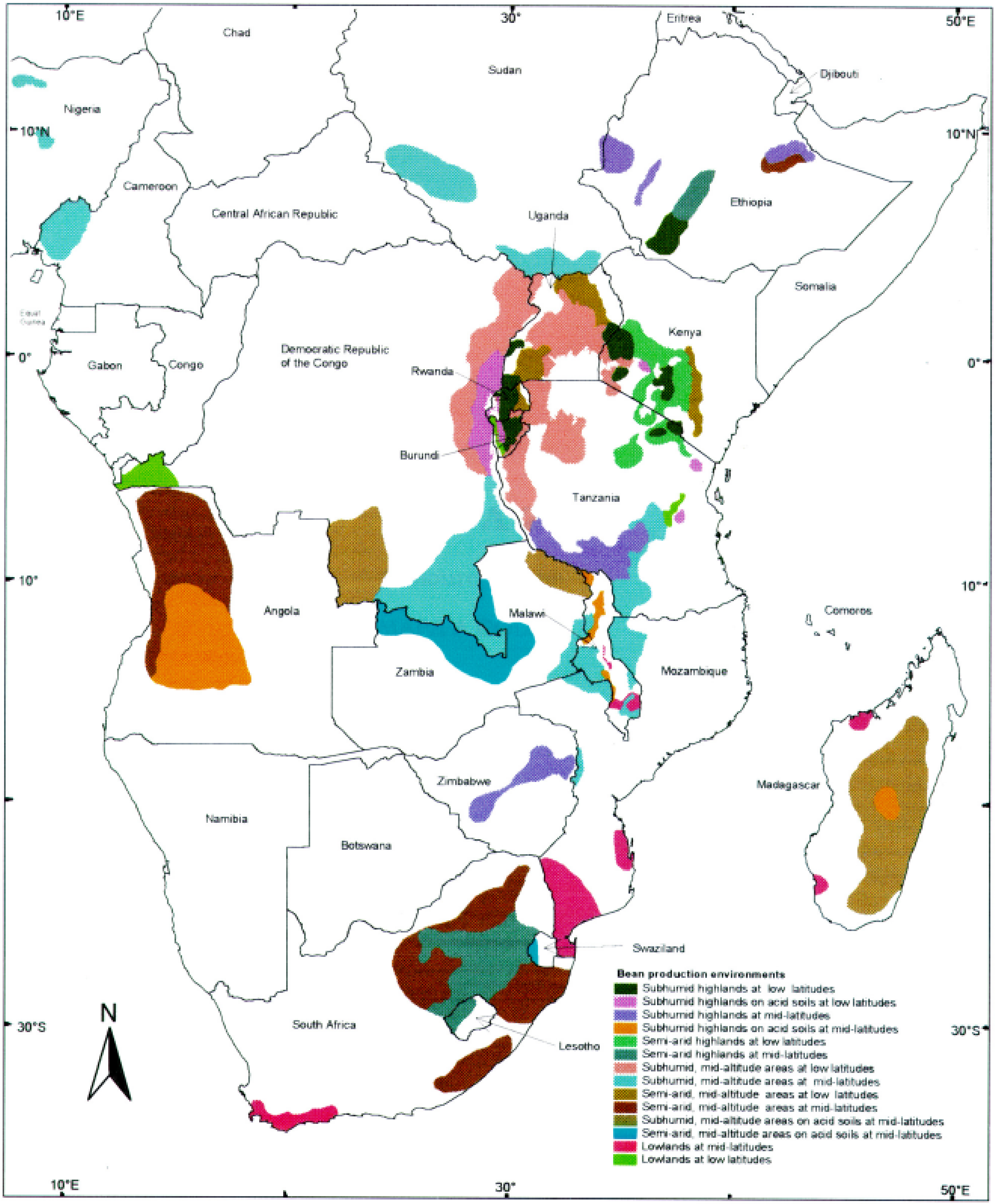
Amount and mode of rainfall determine the probability of soil moisture deficits and the number of important bean-growing seasons per year. Environments were classified as having either more or less than a mean of 400 mm of precipitation available to the bean crop. Rainfall in the low latitudes, a zone extending from about 7° S to 7° N, is effectively bimodal as a consequence of the movements of the Intertropical Convergence Zone (ICZ). The unimodal rainfall pattern of the higher latitudes is associated with significant photoperiod effects in sensitive varieties.

Soil pH relates to both the soil's capacity to supply nutrients and to its aluminium and manganese toxicity problems. Environments were classed as having a mean soil pH either above or below 5.5.

Fourteen African bean environments resulted from this classification (Map 2, Data table 1). The bean production areas are listed for each environment with its area of bean production, latitude range, and main soil types according to the *Soil Map of the World 1:5,000,000* (FAO 1977). An estimated 3,741,000 ha of bean are sown annually in Africa. The subhumid areas of high potential in eastern Africa—highlands (897,000 ha) and mid-altitudes (677,000 ha)—account for 39% of production in Africa.



Map 1. Distribution of bean production in sub-Saharan Africa.



Map 2. Bean production environments in sub-Saharan Africa.

Data table 1. Hectarage (in thousands of hectares) and environmental characteristics of bean production areas of Africa.[a]

Bean production area		Area	Latitude range (°)	Major soil types[b]	Day-length[c]
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes >1500 masl; >400 mm available moisture; soil pH >5.5; bimodal/PPN				
Burundi:	Central Plateau	250	2.5S - 4.0S	Nh	12.1
Ethiopia:	Awassa/N Sindamo	35	6.0N - 8.0N	Ne	12.4
Kenya:	Central Highlands	88	1.0S - 1.5S	Nh, Tm, Ne	12.1
	Western Highlands	168	1.5N - 0.0	Nh, Fo	12.1
	Kisii	25	0.5S - 1.0S	Nh	12.1
Rwanda:	Central Plateau	150	2.0S - 3.0S	Nh	12.1
	North-west	70	1.5S - 2.0S	Tm	12.1
Tanzania:	Northern Highlands	21	3.0S - 3.5S	Nh	12.1
Uganda:	South-west Highlands	45	1.0S - 1.5S	Nh, Tm	12.1
	Western Highlands	20	0.8N - 1.0S	Nh, Tm, Nd	12.1
	Mt. Elgon	25	0.7N - 1.4N	Nh, Tm	12.1
AFBE 2:	Subhumid highlands on acid soils at low latitudes >1500 masl; >400 mm available moisture; soil pH <5.5; bimodal/PPN				
Burundi:	Zaire-Nile Crest	40	2.5S - 3.5S	Fh	12.1
DR Congo:	South Kivu	102	1.0S - 5.0S	Nd	12.1
Kenya:	Tea Zone	14	0.0 - 1.0S	Th	12.1
Rwanda:	Zaire-Nile Crest	40	1.5S - 2.5S	Fh	12.1
Tanzania:	Usambara and Uluguru	35	4.5S - 6.0S	Ne	12.1
AFBE 3:	Subhumid highlands at mid-latitudes >1500 masl; >400 mm available moisture; soil pH >5.5; unimodal/PP+				
Ethiopia:	Hararghe Highlands	95	8.0N - 9.0N	Be, Bd	12.4
	Western	25	8.6N - 10.0N	Ne	12.4
Tanzania:	Southern Highlands	116	6.5S - 10.0S	Be, Nd	12.4
Zimbabwe:	High veld	15	17.0S - 18.0S	Lf	13.0
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes >1500 masl; >400 mm available moisture; soil pH <5.5; unimodal/PP+				
Angola:	Central Highlands	80	11.5S - 14.5S	Fo, Qf	12.9
Madagascar:	Antsirabe	13	19.5S - 20.5S	Be, Bf, Fr	13.2
Malawi:	Chitipa Highlands	10	9.5S - 10.5S	Fh	12.6
	Livingstonia-Nyika	6	10.5S - 11.0S	Fh	12.6
	North Viphya Hills	10	10.8S - 11.5S	Fh	12.6
	South Viphya Hills	12	12.0S - 12.8S	Fo	12.7
	Dedza-Ncheu Uplands	20	14.0S - 15.2S	Lf	12.9
AFBE 5:	Semi-arid highlands at low latitudes >1500 masl; <400 mm available moisture; soil pH >5.5; unimodal/PP+				
Kenya:	Eastern high alt.	130	2.0S - 0.5N	Bc, Ne	12.1
	Rift Valley	61	1.5S - 1.0N	Bc, Bk, Tm	12.1
	Kajiado	30	2.5S - 1.3S	Ne	12.1
Tanzania:	N semi-arid high alt.	43	4.0S - 2.0S	Bc, To	12.1
AFBE 6:	Semi-arid highlands at mid-latitudes >1500 masl; <400 mm available moisture; unimodal/PP+				
Ethiopia:	Rift Valley	64	6.5N - 8.5N	Xh	12.4
Lesotho:	Foothills	7	29.0S - 30.0S	We, Bc	13.6
S Af Rep:	High veld	45	23.5S - 28.0S	Lc	13.5

(Continued)

Data table 1. (Continued.)

Bean production area		Area	Latitude range (°)	Major soil types[b]	Day-length[c]
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes 1000-1500 masl; >400 mm available moisture; soil pH >5.5; bimodal/PPN				
Burundi:	Moso	90	2.0S - 4.5S	Nd, Nh	12.1
DR Congo:	North-east	120	3.0N - 0.0	Fo, Ne	12.1
	West Kivu	28	2.0S - 5.0S	Nh, Nd	12.1
Kenya:	Nyanza	50	1.5S - 0.5N	Fr, Fo	12.1
Rwanda:	Lake Kivu Basin	10	1.5S - 2.5S	Tm, Nd	12.1
Tanzania:	Kagera	75	1.0S - 3.5S	Lf, Fo	12.1
	West (Kigoma)	39	3.5S - 9.0S	Bc, Ne	12.0
	South Lake	25	2.0S - 5.0S	Af, Nd, Vp	12.1
Uganda:	North central	80	1.5N - 3.0N	Fo	12.1
	NW Tall Grass Zone	25	2.0N - 3.5N	Af, Fo, Ne	12.1
	C and E Tall Grass Zone	135	0.5S - 1.5N	Fo, Ne, Af	12.1
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes 1000-1500 masl; >400 mm available moisture; soil pH >5.5; unimodal/PP+				
Cameroon:	North-western	75	5.0N - 6.0N	Ne, Nd	12.1
DR Congo:	Shaba Region	70	5.0S - 13.0S	Fr	12.7
Malawi:	Mzimba Plains	12	11.4S - 12.4S	Fr	12.6
	Lilongwe-Kasungu	16	12.4S - 14.5S	Fo, Lc	12.7
	Dowa-Nchitsi Uplands	7	13.0S - 14.0S	Lf	12.8
	Namwera Uplands	8	14.0S - 14.7S	Fo, Lc	12.8
	Shire Highlands	10	15.3S - 16.3S	Fo, Lc	12.9
Mozambique:	Lichinga (North)	75	11.5S - 14.5S	Fo, Lf, Fr	12.8
	Tete	15	16.5S - 18.0S	Bc	13.0
	Manica Highlands	25	14.0S - 15.5S	Fo, Lf	12.9
Nigeria:	Kano	5	11.5N - 12.5N	Lf	
	Jos Plateau	5	9.5N - 10.0N	Lf	
Sudan:	Southern	50	4.0N - 5.0N	Ne, Lf	12.1
Tanzania:	S mid-altitudes	33	8.0S - 11.5S	Bc	12.5
Zambia:	Eastern	3	12.0S - 14.5S	Fo, Lc	12.8
Zimbabwe:	Mid-veld	6	16.5S - 20.0S	Lf	13.2
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes 1000-1500 masl; <400 mm available moisture; soil pH >5.5; bimodal/PPN				
Kenya:	Eastern mid-alt.	60	0.0 - 2.5N	Lf	12.1
Rwanda:	Eastern	60	2.0S - 2.5S	Fo	12.1
Tanzania:	N and E mid-alt.	14	1.0S - 5.0S	Nd, To	12.1
Uganda:	W Short Grass Zone	45	1.0S - 1.5N	Fo, Af	12.1
	N Short Grass Zone	30	1.5N - 3.5N	Fo	12.1
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes 1000-1500 masl; <400 mm available moisture; soil pH >5.5; unimodal/PP+				
Angola:	Mid-altitudes	30	7.0S - 16.0S	Lf, Fo	12.6
Ethiopia:	Mid-alt. Hararghe	20	8.0N - 9.0N	Bd, Be	12.6
S Af Rep:	Transkei	10	31.0S - 33.0S	Lc	14.0
	Natal	17	28.0S - 30.0S	Lo	13.8
	Mid-veld	17	23.5S - 28.0S	Lc	13.5
Zimbabwe:	Mid-veld fringes	3	16.5S - 20.0S	Lf	13.2

(Continued)

Data table 1. (Continued.)

Bean production area		Area	Latitude range (°)	Major soil types[b]	Day-length[c]
AFBE 11: Subhumid areas at mid-altitudes on acid soils at mid-latitudes 1000-1500 masl; >400 mm available moisture; soil pH <5.5; unimodal/PP+					
DR Congo:	Kasai	70	6.0S - 11.0S	Fx, Fo	12.3
Madagascar:	Central	65	17.5S - 22.0S	Fo	13.3
Zambia:	North-east	15	8.5S - 12.0S	Fo	12.4
AFBE 12: Semi-arid areas at mid-altitudes on acid soils at mid-latitudes 1000-1500 masl; <400 mm available moisture; soil pH <5.5; unimodal/PP+					
Madagascar:	Following rice	10	17.5S - 21.0S	Je	11.0
Zambia:	N central and NW	14	12.0S - 15.0S	Fr	12.8
Swaziland:	High and mid-veld	2	26.0S - 27.0S	Ne, Lc, Fr	13.0
AFBE 13: Lowlands at mid-latitudes <1000 masl; unimodal/PP+					
Algeria:	Northern	3	34.0N - 37.0N	Bk	13.1
Cape Verde:		15	14.5N - 17.5N	To	12.2
Egypt:	Nile Delta	20	30.0N - 32.0N	Jc	12.6
Guinea:	Guinea	30	10.0N - 12.0N	Bf	12.6
Madagascar:	Toliary	8	20.0S - 25.5S	Bk, Qc	11.0
	Mahajanga	5	15.5S - 16.5S	Qc, Bk	11.2
Malawi:	Lake basin (rm)	10	12.0S - 14.5S	Nd, Bc	11.4
	Phalombe Plains	10	15.0S - 16.3S	Fo, Lc	12.9
Mauritius:	(Irrigated)	2	20.0S - 20.5S	Ne	13.2
Morocco:	North	7	34.0N - 36.0N	Lc	12.9
Mozambique:	Southern (rm)	20	25.0S - 26.5S	Bc	10.7
S Af Rep:	Cape Province (irrig.)	3	33.5S - 34.0S	Lc	10.4
Sudan:	Northern (irrig.)	20	16.7N - 18.0N	Jc	12.5
Togo:	Atakpame	5[d]	7.0N - 8.0N	Lf	12.1
Tunisia:	Northern	3	36.0N - 37.0N	Bk	13.2
AFBE 14: Lowlands at low latitudes <1000 masl; bimodal/PPN					
Burundi:	Imbo Plains	20	2.5S - 4.5S	Vp	12.1
DR Congo:	Bas-Zaire (rm)	20	4.0S - 6.0S	Fo, Qf	12.1
Tanzania:	Morogoro	5	6.5S - 7.5S	Bh, Bc	12.1

a. Conventions used throughout the tables are: AFBE = African bean production environment; DR Congo = Democratic Republic of the Congo; masl = metres above sea level; PPN and PP+ = probable importance of photoperiod sensitivity in the AFBE, with PPN indicating neutral conditions and PP+ indicating probable photoperiod effects; rm = production dependent on use of residual moisture; S Af Rep = Republic of South Africa.

b. Codes for the major soil types are: Af = ferric Acrisol; Bc = chromic Cambisol; Bd = dystric Cambisol; Be = eutric Cambisol; Bf = ferralic Cambisol; Bh = humic Cambisol; Bk = calcic Cambisol; Fh = humic Ferralsol; Fo = orthic Ferralsol; Fr = rhodic Ferralsol; Fx = xanthic Ferralsol; Jc = calcaric Fluvisol; Je = eutric Fluvisol; Lc = chromic Luvisol; Lf = ferric Luvisol; Lo = orthic Luvisol; Nd = dystric Nitosol; Ne = eutric Nitosol; Nh = humic Nitosol; Qc = cambic Arenosol; Qf = ferralic Arenosol; Th = humic Andosol; Tm = mollic Andosol; To = ochric Andosol; Vp = pellic Vertisol; We = eutric Planosol; Xh = haplic Xerosol (FAO 1977).

c. Daylength = mean number of hours of sunlight per day during the main bean growing season.

d. According to *Enquêtes et Statistiques Agricoles* (1984), Togo may have a much larger area of bean production than indicated here but their estimate appears to include additional pulses.

Socio-Economic Aspects of Bean Production

Socio-Economic Aspects of Bean Production

Population Density

The importance of bean as a crop and as food is closely associated with human population density (Figures 1A and 1B, Maps 1 and 3). Bean production intensity is greatest in areas of high population density, where farms are tiny and few significant sources of dietary protein exist. During the last 2 decades, population has increased at a higher rate than has bean production. But only since 1985, have national research systems emphasized bean technology. Even so, farmers are adopting improved technology and bean production is expected to increase at a rate sufficient to meet growing needs, despite challenges presented by declining soil fertility and diseases and pests.

Female Farmers and Bean Production

Women are primarily responsible for decisions and labour in smallholder bean production in most sub-Saharan countries (Map 4, Data table 2). For example, women consistently contribute relatively more to the production of

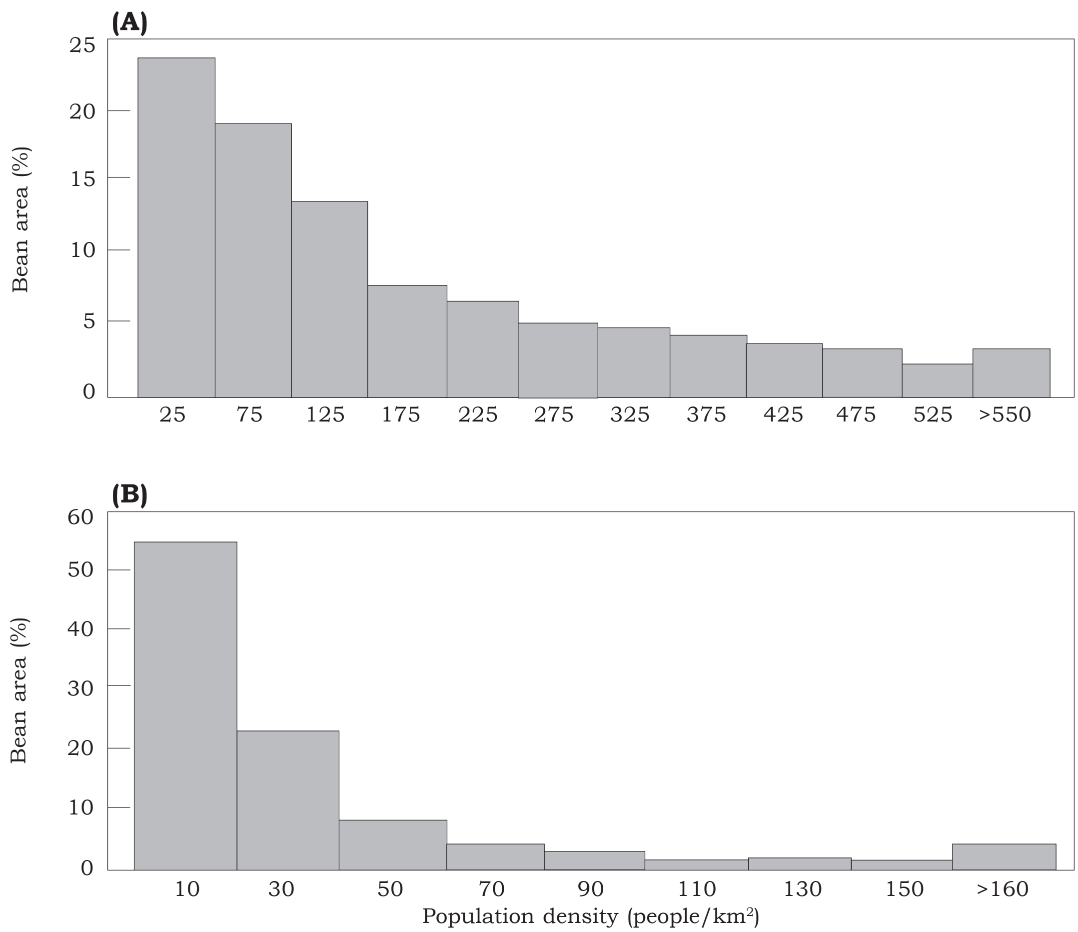


Figure 1. Distribution of bean production area (%) in eastern Africa (A) and southern Africa (B) in relation to population density.

bean than to maize across three very different farming systems in Tanzania, and did so in all farm operations; in some areas, women were also involved in bean marketing (Due et al. 1985).

Aggravating the demands on women's time is firewood collection for beans, which usually require much more cooking than other components of the meal—as much as 3 hours in Rwanda—and consuming more wood, at about 7 kg per kg of beans (Shellie-Dessert and Bliss 1991). For this reason, short cooking times and long retention of flavour after cooking are varietal attributes commonly sought by women.

Because women have relatively less access, less fertilizer is used for bean than for other crops, which receive more attention from male heads of households (Gladwin et al. nd).

The role women play in maintaining genetic diversity is evident from variety names, the women's ability to recognize new types resulting from outcrossing, the women's interest in acquiring new varieties, the numerous varieties maintained on only a few farms, and seed selection criteria, which often place culinary qualities as second to yield (Ferguson and Sprecher 1987).

Bean Consumption Preferences

Genetic diversity of bean on the farm in Africa is usually broader than in Latin America, where bean was domesticated (Grisley and Mwesigwa 1991b), but where consumer preferences are more specialized. Bean crops are often limited to one or two seed types. In Africa, grain appearance alone is less important than a complex of characteristics that often includes appearance, but also culinary quality and taste.

A wide range of seed colours and sizes is acceptable in many bean production areas in Africa (Grisley and Munene 1992; Grisley and Mwesigwa 1991a; Martin and Adams 1987; van Rheenen 1979; Voysest and Dessert 1991). Although preferences exist, they are often associated with known cultivars and are not strongly exclusive. Large and medium-sized seeds are most commonly preferred but small seeds are acceptable, especially by poorer consumers and producers who rely on low-priced food and seed. Unknown seed types gain acceptance if certain criteria are met, as in the case of 'Kablanketi' described below. Even small black-seeded types, the least acceptable class in Africa, are components of mixtures maintained for poor soils and, presumably for this reason, comprise almost 50% of marketed beans in Konso, south-west Ethiopia. Consumption of bean leaves and of green harvested bean is common in many production areas (Data table 2).

Bean mixtures were marketed and consumed more commonly in the past. Their current decline is a result partly of an increasing preference by urban consumers for uniform samples and partly of extension efforts by colonial governments (e.g., Kenya) to eradicate bean varietal mixing as a 'backward practice' (C Robertson, 1990, unpublished data). Grain types are now commonly purchased separately by consumers in all countries except Burundi, Rwanda, and Zaire, although consumer preferences are weakened during times of shortage and high price.

Marketing of Beans

Bean is an important source of cash for small-scale farmers in Africa, whether as part of the total farm income or for providing a marketable product at critical times when farmers have nothing else to sell such as before the maize crop is harvested. The importance of bean as a market crop varies within and across production areas (Map 5, Data table 3); in some densely populated areas of Rwanda and Burundi, less than 20% are marketed, whereas in the Rift Valley of Ethiopia, more than 90% are marketed. Even in areas where only 20%-60% of the production is marketed, farmers are strongly influenced by market preferences when choosing the varieties to plant.

Major bean market flows are usually found within countries, but considerable informal trade also takes place across borders. Prominent within-country flows are (Map 6):

1. From Bunia and Goma in eastern DR Congo to Kisangani and down the Zaire River to Kinshasa;

2. From the Kasai and Shaba areas to Lubumbashi, also within DR Congo;

3. From the Southern Highlands of Tanzania to Dar es Salaam; and

4. From western and eastern Kenya to Nairobi.

The across-the-border movements, although significant, are often localized:

1. From Kivu, south-west Uganda, and western Tanzania to Rwanda and Burundi;

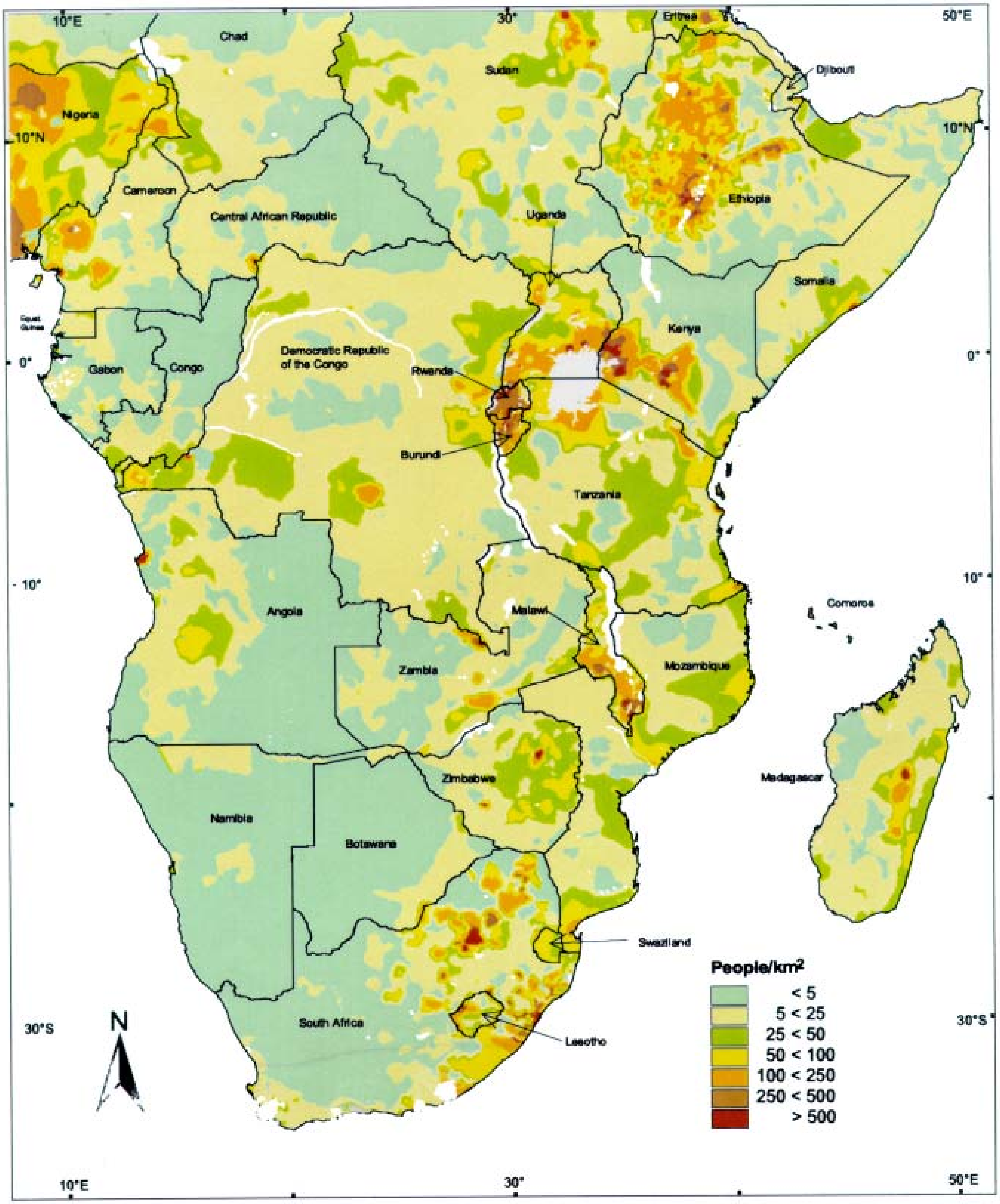
2. From eastern Uganda and northern Tanzania to Kenya;

3. From South Africa to Botswana, Lesotho, Swaziland, and Mozambique;

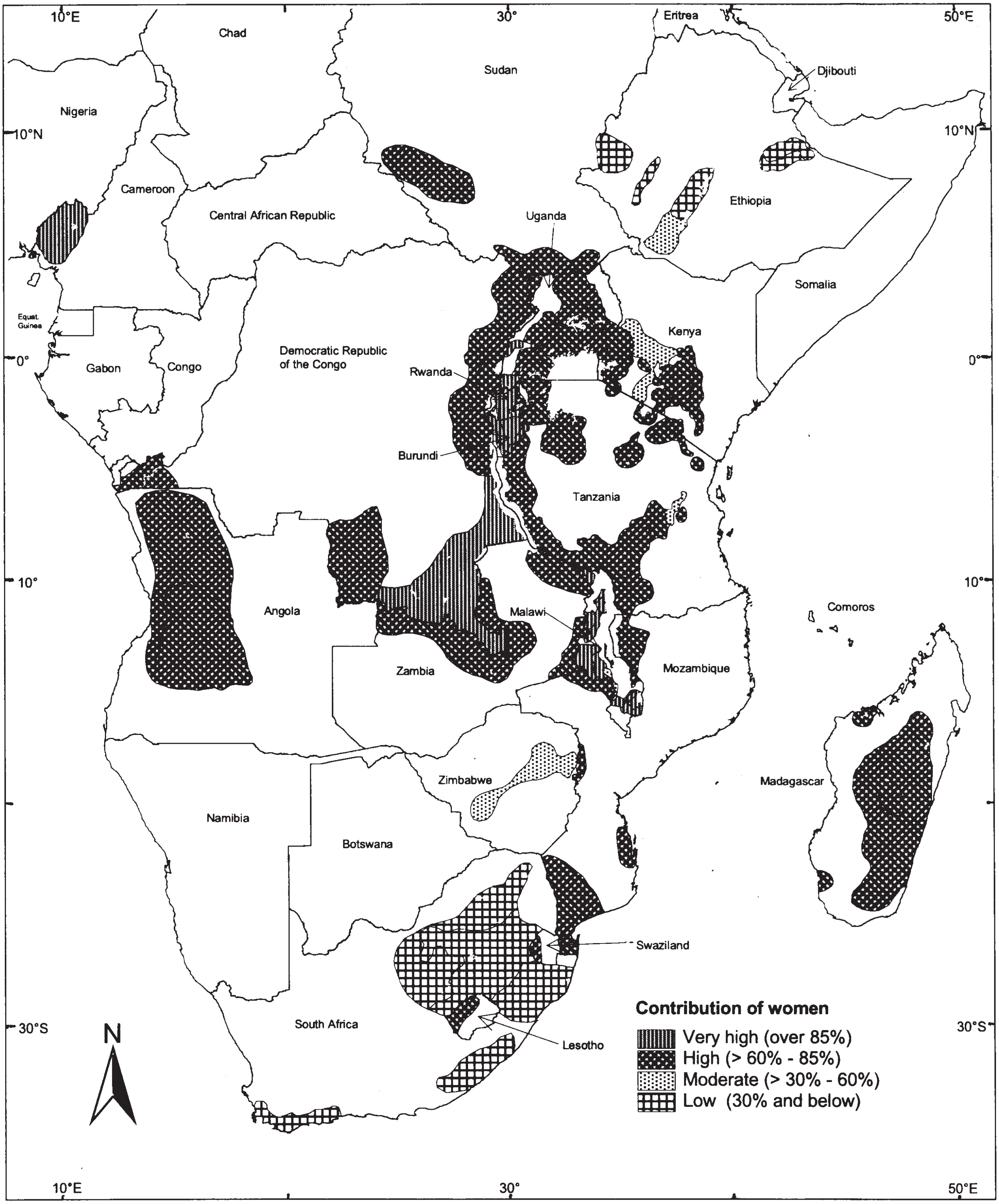
4. From Mozambique to Malawi; and

5. From DR Congo and Uganda to Sudan.

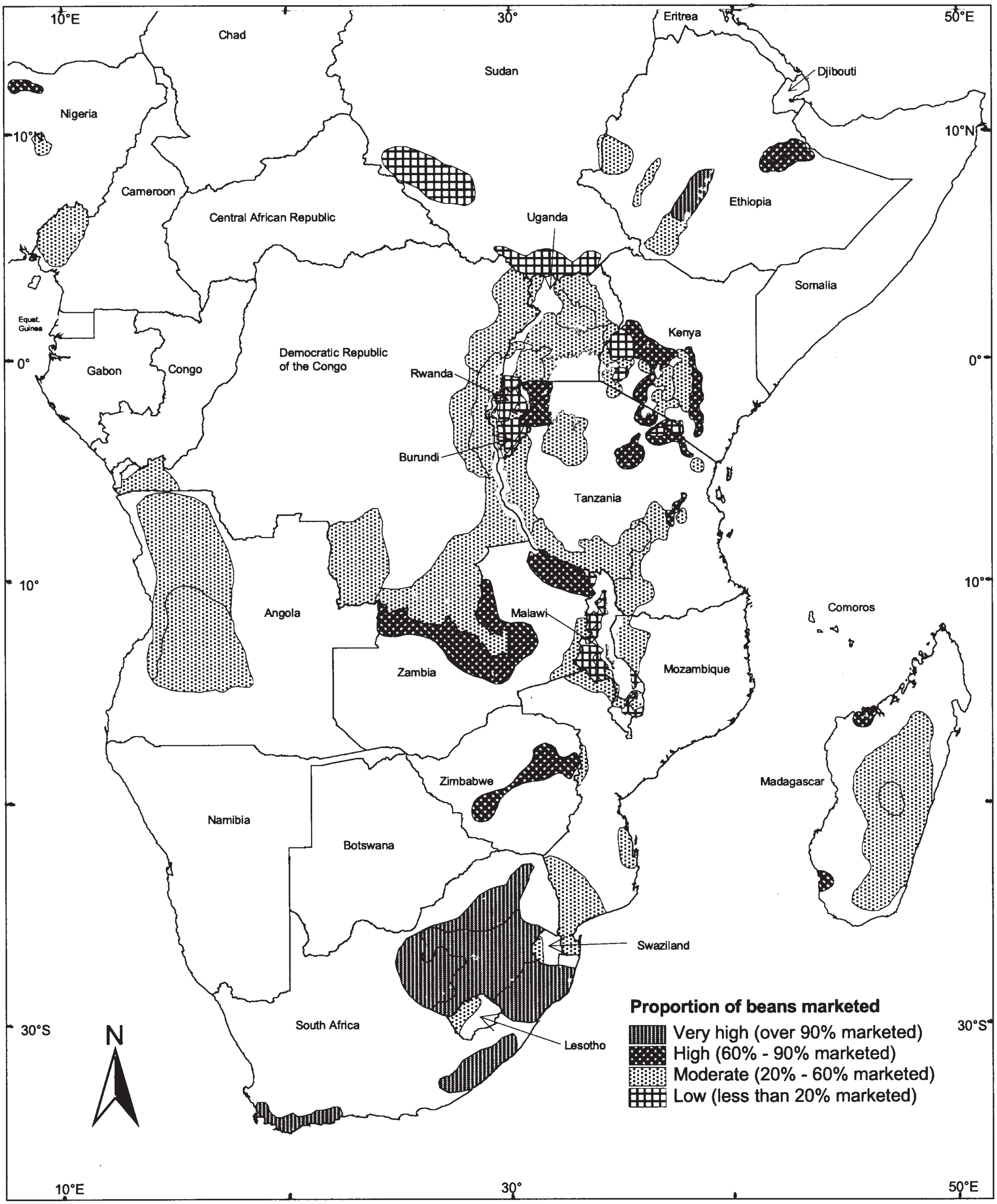
Production areas of prominence for export from sub-Saharan Africa include northern Tanzania, Toliary and Mahajanga in Madagascar, the Rift Valley and Hararghe Highlands in Ethiopia, and Zimbabwe.



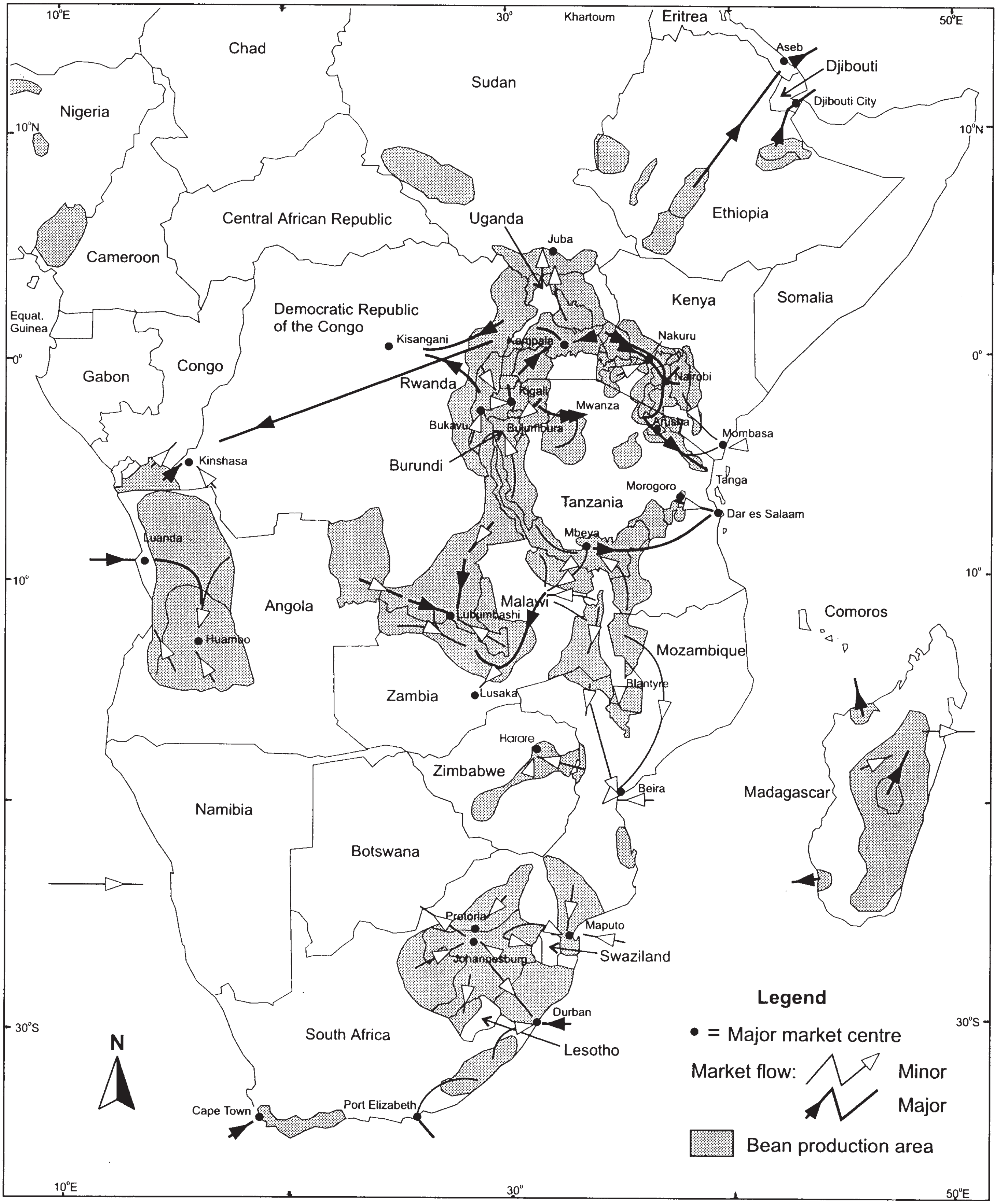
Map 3.   Population density in sub-Saharan Africa.



Map 4. Contribution of women to bean production in sub-Saharan Africa.



Map 5. Proportion of beans marketed in bean production areas of sub-Saharan Africa.



Map 6. Market flows of beans in sub-Saharan Africa.

Data table 2. Socio-economic characteristics of bean production areas of Africa.[a]

Bean production area		Population density[b]	Woman's respons'ty for bean crop (%)	Consumption importance[c]	
				Fresh bean seed	Bean leaves
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes				
Burundi:	Central Plateau	7/8	90	H	H
Ethiopia:	Awassa/N Sindamo	5	50	L	L
Kenya:	Central Highlands	7/8	80	M	L
	Western Highlands	7/8	80	M	L
	Kisii	8	80	M	L
Rwanda:	Central Plateau	8	90	H	H
	North-west	8	90	H	H
Tanzania:	Northern Highlands	7	80	M	L
Uganda:	South-west Highlands	7	95	H	M
	Western Highlands	7	90	H	M
	Mt. Elgon	7	60	H	H
AFBE 2:	Subhumid highlands on acid soils at low latitudes				
Burundi:	Zaire-Nile Crest	6	90	H	H
DR Congo:	South Kivu	5	85	H	H
Kenya:	Tea Zone	6	80	L	L
Rwanda:	Zaire-Nile Crest	7	90	H	H
Tanzania:	Usambara and Uluguru	6/7	80	M	L
AFBE 3:	Subhumid highlands at mid-latitudes				
Ethiopia:	Hararghe Highlands	4	30	L	L
	Western	4	30	L	L
Tanzania:	Southern Highlands	5	80	L	L
Zimbabwe:	High veld	4	40	L	L
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes				
Angola	Central Highlands	4/5	80	M	L
Madagascar:	Antsirabe	6	80	M	L
Malawi:	Chitipa Highlands	6	90	H	H
	Livingstonia-Nyika	5	90	H	H
	North Viphya Hills	6	90	H	H
	South Viphya Hills	5	90	H	H
	Dedza-Ncheu Uplands	8	60	H	H
AFBE 5:	Semi-arid highlands at low latitudes				
Kenya:	Eastern high alt.	6	80	M	L
	Rift Valley	3	60		L
	Kajiado	5	70	L	L
Tanzania:	N semi-arid high alt.	3	70	L	L
AFBE 6:	Semi-arid highlands at mid-latitudes				
Ethiopia:	Rift Valley	5	30	L	L
Lesotho:	Foothills	5	70	L	L
S Af Rep:	High veld	3	10	L	L

(Continued)

Data table 2. (Continued.)

Bean production area		Population density[b]	Woman's respons'ty for bean crop (%)	Consumption importance[c]	
				Fresh bean seed	Bean leaves
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes				
Burundi:	Moso	6	90	H	H
DR Congo:	North-east	4	80	H	L
	West Kivu	4	85	H	H
Kenya:	Nyanza	5	80	M	L
Rwanda:	Lake Kivu Basin	8	90	H	H
Tanzania:	Kagera	6	85	M	L
	West (Kigoma)	5	85	M	L
	South Lake	5	75	M	L
Uganda:	North central	5	80	H	L
	NW Tall Grass Zone	6	80	H	L
	C and E Tall Grass Zone	6	80	H	L
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes				
Cameroon:	North-western	7	90	L	L
DR Congo:	Shaba Region	3	90	M	L
Malawi:	Mzimba Plains	5	90	H	NA
	Lilongwe-Kasungu	7	90	H	H
	Dowa-Nchitsi Uplands		90	H	H
	Namwera Uplands	8	85	M	NA
	Shire Highlands	8	90	M	NA
Mozambique:	Lichinga (North)	3	80	M	L
	Tete	4	80	M	L
	Manica Highlands	3	80	M	L
Nigeria[d]:	Kano	7			
	Jos Plateau				
Sudan:	Southern	2/4	80	M	L
Tanzania:	S mid-altitudes	4	80	L	L
Zambia:	Eastern	3	80	L	L
Zimbabwe:	Mid-veld	4	60	L	L
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes				
Kenya:	Eastern mid-alt.	4	80	M	L
Rwanda:	Eastern	7	85	H	H
Tanzania:	N and E mid-alt.	3	80	M	L
Uganda:	W Short Grass Zone	5	80	H	L
	N Short Grass Zone	4	80	M	L
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes				
Angola:	Mid-altitudes	4	80	L	L
Ethiopia:	Mid-alt. Hararghe	3	30	L	L
S Af Rep:	Transkei	4	30	L	L
	Natal	4	30	L	L
	Mid-veld	3	10	L	L
Zimbabwe:	Mid-veld fringes	4	50	L	L

(Continued)

Data table 2. (Continued.)

Bean production area		Population density[b]	Woman's respons'ty for bean crop (%)	Consumption importance[c]	
				Fresh bean seed	Bean leaves
AFBE 11:	Subhumid areas at mid-altitudes on acid soils at mid-latitudes				
DR Congo:	Kasai	3	85	L	L
Madagascar:	Central	5	70	M	L
Zambia:	North-east	2	80	L	L
AFBE 12:	Semi-arid areas at mid-altitudes on acid soils at mid-latitudes				
Madagascar:	Following rice	5	80	L	L
Zambia:	N central and NW	2/4	85	M	L
Swaziland:	High and mid-veld	5	80	L	L
AFBE 13:	Lowlands at mid-latitudes				
Algeria:	Northern	4	30	L	L
	Cape Verde[d]:				
Egypt:	Nile Delta	5	30	L	L
Guinea[d]:	Guinea	5			
Madagascar:	Toliary	4	80	L	L
	Mahajanga	4	80	L	L
Malawi:	Lake basin (rm)	6	80	L	L
	Phalombe Plains	8	90	M	H
Mauritius:	(Irrigated)	6	50	L	L
Morocco:	North	4	30	L	L
Mozambique:	Southern (rm)	4	80	L	L
S Af Rep:	Cape Province (irrig.)	5	10	L	L
Sudan:	Northern (irrig.)	4	50	L	L
Togo[d]:	Atakpame	4			
Tunisia:	Northern	4	30	L	L
AFBE 14:	Lowlands at low latitudes				
Burundi:	Imbo Plains	6	90	H	H
DR Congo:	Bas-Zaire (rm)	5/7	70	L	L
Tanzania:	Morogoro	4	60	M	L

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. Key to estimated population densities in people/km^2: 1 = <1; 2 = 1-<5; 3 = 5-<10; 4 = 10-<25; 5 = 25-<50; 6 = 50-<100; 7 = 100-<250; 8 = 250-<850 (Carter et al. 1992).

c. H, M, L = high, moderate, and low importance.

d. Blank spaces = insufficient information was available at the time.

Data table 3. Production and market information for bean production areas of Africa.[a]

Bean production area		Varietal diversity[b]	Climbing bean[c]	Marketing of bean[d]
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes			
Burundi:	Central Plateau	VH	T	L
Ethiopia:	Awassa/N Sindamo	M	P	M
Kenya:	Central Highlands	M	I	M
	Western Highlands	H	I	L
	Kisii	M	P	L
Rwanda:	Central Plateau	VH	T	L
	North-west	VH	T	L
Tanzania:	Northern Highlands	M	I	M
Uganda:	South-west Highlands	VH	T	L
	Western Highlands	M	I	M
	Mt. Elgon	H	T	M
AFBE 2:	Subhumid highlands on acid soils at low latitudes			
Burundi:	Zaire-Nile Crest	VH	T	L
DR Congo:	South Kivu	VH	T	L
Kenya:	Tea Zone	M	P	M
Rwanda:	Zaire-Nile Crest	VH	T	L
Tanzania:	Usambara and Uluguru	M	P	M
AFBE 3:	Subhumid highlands at mid-latitudes			
Ethiopia:	Hararghe Highlands	M	L	H
	Western	M	T	M
Tanzania:	Southern Highlands	M	I	M
Zimbabwe:	High veld	M	L	H
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes			
Angola:	Central Highlands	M	I	M
Madagascar:	Antsirabe	M	I	M
Malawi:	Chitipa Highlands	H	T	L
	Livingstonia-Nyika	H	P	L
	North Viphya Hills	M	P	L
	South Viphya Hills	M	P	L
	Dedza-Ncheu Uplands	M	P	M
AFBE 5:	Semi-arid highlands at low latitudes			
Kenya:	Eastern high alt.	M	I	M
	Rift Valley	M	L	H
	Kajiado	M	L	M
Tanzania:	N semi-arid high alt.	M	L	H
AFBE 6:	Semi-arid highlands at mid-latitudes			
Ethiopia:	Rift Valley	M	L	VH
Lesotho:	Foothills	M	L	M
S Af Rep:	High veld	L	L	VH

(Continued)

Data table 3. (Continued.)

Bean production area		Varietal diversity[b]	Climbing bean[c]	Marketing of bean[d]
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes			
Burundi:	Moso	H	L	M
DR Congo:	North-east	M	L	M
	West Kivu	M	T	M
Kenya:	Nyanza	M	L	M
Rwanda:	Lake Kivu Basin	VH	T	L
Tanzania:	Kagera	H	P	H
	West (Kigoma)	M	L	M
	South Lake	M	L	M
Uganda:	North central	M	L	M
	NW Tall Grass Zone	M	L	M
	C and E Tall Grass Zone	M	L	M
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes			
Cameroon:	North-western	M	P	M
DR Congo:	Shaba Region	M	L	M
Malawi:	Mzimba Plains	M	L	L
	Lilongwe-Kasungu	M	L	L
	Dowa-Nchitsi Uplands	M	L	L
	Namwera Uplands	M	L	L
	Shire Highlands	M	L	L
Mozambique:	Lichinga (North)	M	L	M
	Tete	M	L	M
	Manica Highlands	M	L	M
Nigeria:	Kano	L	L	H
	Jos Plateau	M	L	M
Sudan:	Southern	M	L	L
Tanzania:	S mid-altitudes	M	L	M
Zambia:	Eastern	M	L	M
Zimbabwe:	Mid-veld	M	L	M
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes			
Kenya:	Eastern mid-alt.	M	L	H
Rwanda:	Eastern	H	T	L
Tanzania:	N and E mid-alt.	M	L	M
Uganda:	W Short Grass Zone	M	L	M
	N Short Grass Zone	M	L	M
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes			
Angola:	Mid-altitudes	M	L	M
Ethiopia:	Mid-alt. Hararghe	M	L	H
S Af Rep:	Transkei	L	L	VH
	Natal	M	L	VH
	Mid-veld	L	L	VH
Zimbabwe:	Mid-veld fringes	M	L	M

(Continued)

Data table 3. (Continued.)

Bean production area		Varietal diversity[b]	Climbing bean[c]	Marketing of bean[d]
AFBE 11:	Subhumid areas at mid-altitudes on acid soils at mid-latitudes			
DR Congo:	Kasai	M	L	M
Madagascar:	Central	M	L	M
Zambia:	North-east	M	L	H
AFBE 12:	Semi-arid areas at mid-altitudes on acid soils at mid-latitudes			
Madagascar:	Following rice	M	L	M
Zambia:	N central and NW	M	L	H
Swaziland:	High and mid-veld	M		LM
AFBE 13:	Lowlands at mid-latitudes			
Algeria:	Northern	L	L	H
Cape Verde:		M	L	M
Egypt:	Nile Delta	L	L	H
Guinea:	Guinea	M	L	M
Madagascar:	Toliary	L		LH
	Mahajanga	L	L	H
Malawi:	Lake basin (rm)	M	L	M
	Phalombe Plains	M	L	M
Mauritius:	(Irrigated)	M	L	VH
Morocco:	North	L	L	H
Mozambique:	Southern (rm)	M	L	M
S Af Rep:	Cape Province (irrig.)	L	L	VH
Sudan:	Northern (irrig.)	L	L	H
Togo[e]:	Atakpame	L	M	
Tunisia:	Northern	L	L	H
AFBE 14:	Lowlands at low latitudes			
Burundi:	Imbo Plains	M	L	M
DR Congo:	Bas-Zaire (rm)	M	L	H
Tanzania:	Morogoro	M	L	H

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. Key to varietal diversity: VH = >10; H = 7-10; M = 3-6; L = 1 or 2 seed types account for 95% of the production in a typical rural community.

c. Climbing bean: the current status or potential for climbing bean production is indicated as T = traditionally grown and well established; I = introduction well under way; P = high potential for introduction; L = low potential for introduction of climbing beans.

d. Marketing of beans: VH = >90%; H = 60%-90%; M = 20%-60%; L = <20% of bean production normally marketed.

e. Blank spaces = insufficient information was available at the time.

Cropping Systems

Cropping Systems

The bean-growing agro-ecosystems of Africa are numerous and diverse (Allen and Edje 1990). Their potential for production and management requirements are determined by the interplay of many factors, including climate, soil type, and a range of socio-economic and biological factors. Wortmann and Allen (1994) group the bean production areas of Africa into five zones:

1. The eastern African highlands (>1500 masl);
2. The mid-altitude areas of eastern Africa between latitudes 6° S and 13° N and east of longitude 27° E;
3. Southern Africa, that is, south of latitude 6° S;
4. Western Africa, including areas west of longitude 15° E; and,
5. Lowland areas below 1000 masl throughout eastern, northern, and southern Africa.

Determining the Area of Production

Area of production under different cropping systems was estimated by assuming that when:

1. Three systems were named for a bean production area (BPA), then the first, second, and third system occupied 50%, 30%, and 15% of the production area, respectively;
2. Two systems were named for a BPA, then the first and second occupied 60% and 35% of the production area, respectively; and,
3. One system was named for a BPA, then it occupied 95% of the production area.

Eastern Africa

The eastern Africa highland and mid-altitude zones account for 38% and 24% of bean production in Africa, respectively. The major soil order in the highlands is Nitosol (dystric, eutric, and humic). Orthic Ferralsols and dystric Nitosols are common in the mid-altitude areas (Data table 1). The bean crop's quick maturity and tolerance of shading have encouraged its widespread use in intercropping with maize or banana; sole crop production is also important (Table 1, Maps 7-9), accounting for 43%, 15%, and 22% of the area, respectively. Sorghum, cassava, and sweet potato are also crops commonly associated with beans (Map 10). Two crops per year are grown, with sowing times in March to April and September to October, except in parts of Ethiopia and northern Uganda, where the main bean sowing time is in July (Data table 4).

Bean production tends to be more intensive where human population density is high, although a significant proportion of the production does occur in areas of moderately low population density (Figure 1A, Maps 1 and 3). In the eastern African highlands, farm sizes have declined dramatically as population growth rates increased 2.5%-4% annually. In Rwanda, population density reaches 700 persons per cultivated km^2; the average land holding in 1988 was 1.2 ha, and only 0.5 ha in the northernmost prefecture (Ngarambe et al. 1989). Most holdings are below these averages and, although 99% of Rwandan rural households grow beans, most are net purchasers, with only 22% of farms producing a surplus (Loveridge 1989).

Table 1. Estimated percentage of area for cropping systems under which bean is grown.

Cropping system	Eastern Africa	Southern Africa
Sole crop	22	42
Maize intercrop	43	47
Banana intercrop	15	0
Root or tuber crop intercrop	13	6
Sorghum or millet intercrop	3	<1
Other	4	4

Farmers have intensified production with high-yielding climbing beans planted on more productive or manured soils in parts of the eastern African highlands (Graf et al. 1991; Map 11). Elsewhere, the introduction of climbing beans is well under way, and opportunities exist for a more extensive introduction and adoption of this high potential technology. Current efforts to breed climbing bean lines with tolerance of warm temperatures may broaden their range of adaptation (CIAT 1997).

Southern Africa

Southern Africa accounts for about 32% of bean production in Africa, with about 518,000 ha above 1500 masl. Occasional soil moisture deficits constrain bean production in some mid-altitude areas. Several soil suborders are important in this zone but orthic and rhodic Ferralsols and ferric Luvisols are the most important for bean production.

Maize-bean intercropping and sole cropping are the major bean cropping systems in the zone (Table 1, Maps 7 and 8). The main sowing time is November to December, but two crops per year are commonly grown in the Southern Highlands of Tanzania, the Kasai area of Zaire, and north-eastern Zambia. The population density in this area is generally moderate (Figure 1B). However, population density does exceed 100 people/km^2 in much of Malawi and parts of southern Tanzania (Data table 2).

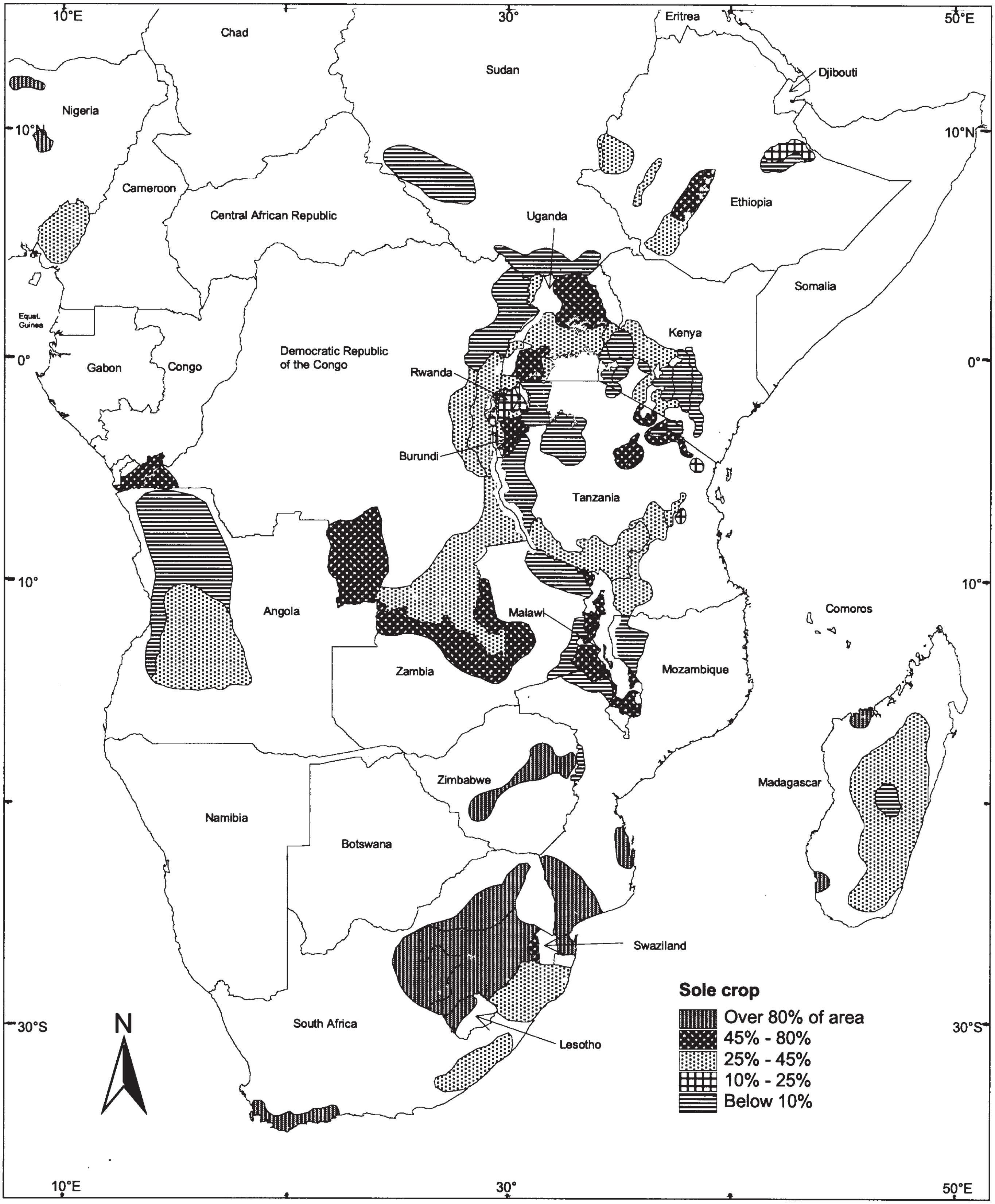
Bean is particularly well adapted to intensification of land use through double cropping, or to cropping in low-lying areas with moisture during the dry season in unimodal systems. Heavy soils in valley bottoms (*bas-fonds*, *mbuga*, *dimba*) are increasingly being brought into cultivation for this purpose, as easier worked soils on hill slopes become fully cultivated or decline in fertility. Another opportunity for further intensification is through increased cultivation of climbing beans in some higher altitude areas (Map 11).

Western Africa

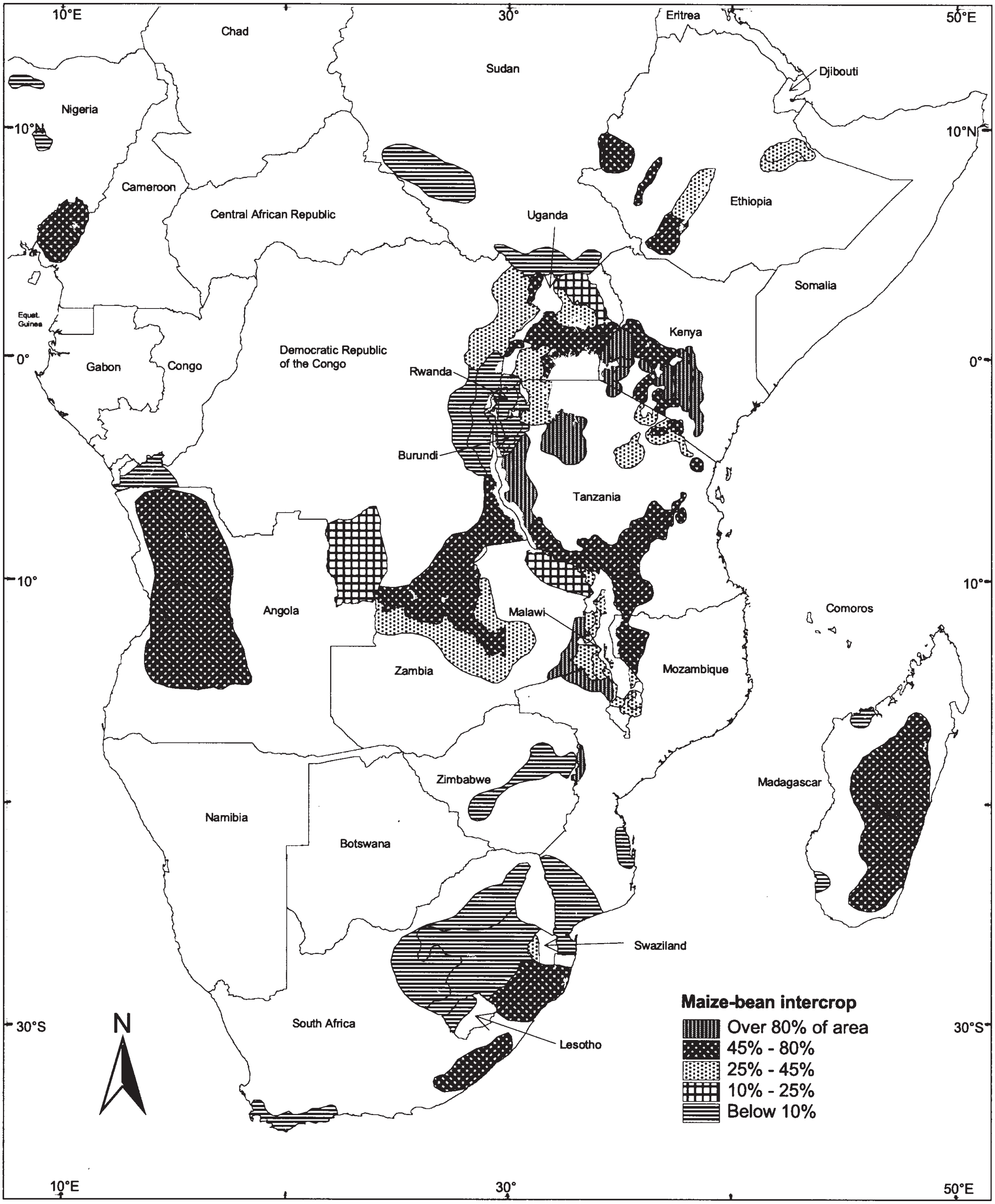
Western Africa is estimated to have 135,000 ha of bean growing primarily on Nitosols, Luvisols, and Cambisols. Maize-bean intercropping is common in Cameroon and Cape Verde, but sole crop production is also important (Maps 7 and 8). In most of the bean production areas, beans are sown twice a year, and human population density is moderately high.

Lowland Bean Production

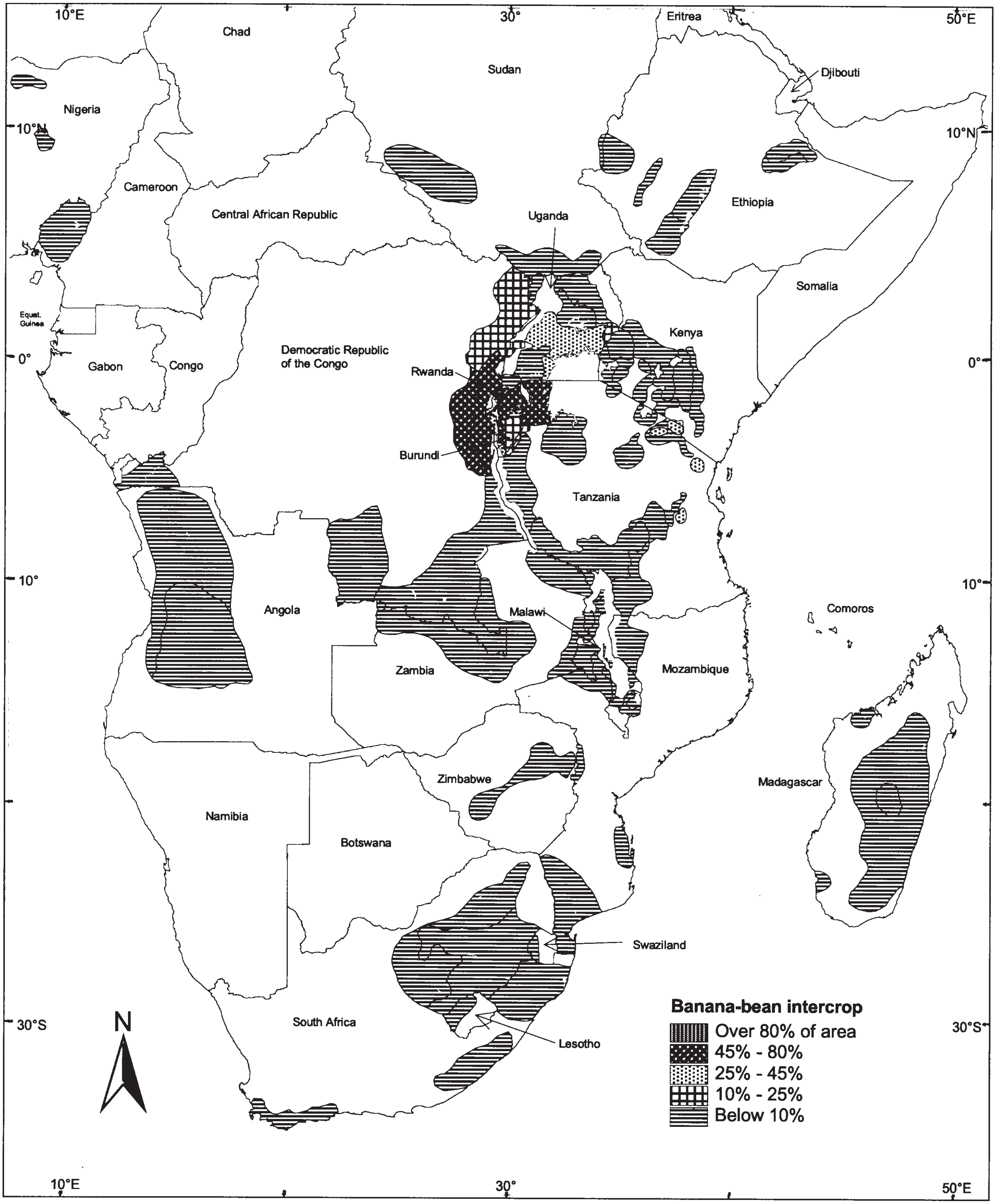
Lowland bean production in Africa is geographically dispersed and accounts for 203,000 ha. Bean is sown after another crop to use residual soil moisture and to take advantage of the lower temperatures of the winter months in lowland areas of Madagascar, Malawi, Mozambique, and DR Congo. Irrigation of bean is practised in Mauritius, the Nile Valley of Sudan, along the Niger River in Mali, and in northern Africa. Production is generally as one sole crop per year. Human population density is generally moderate.



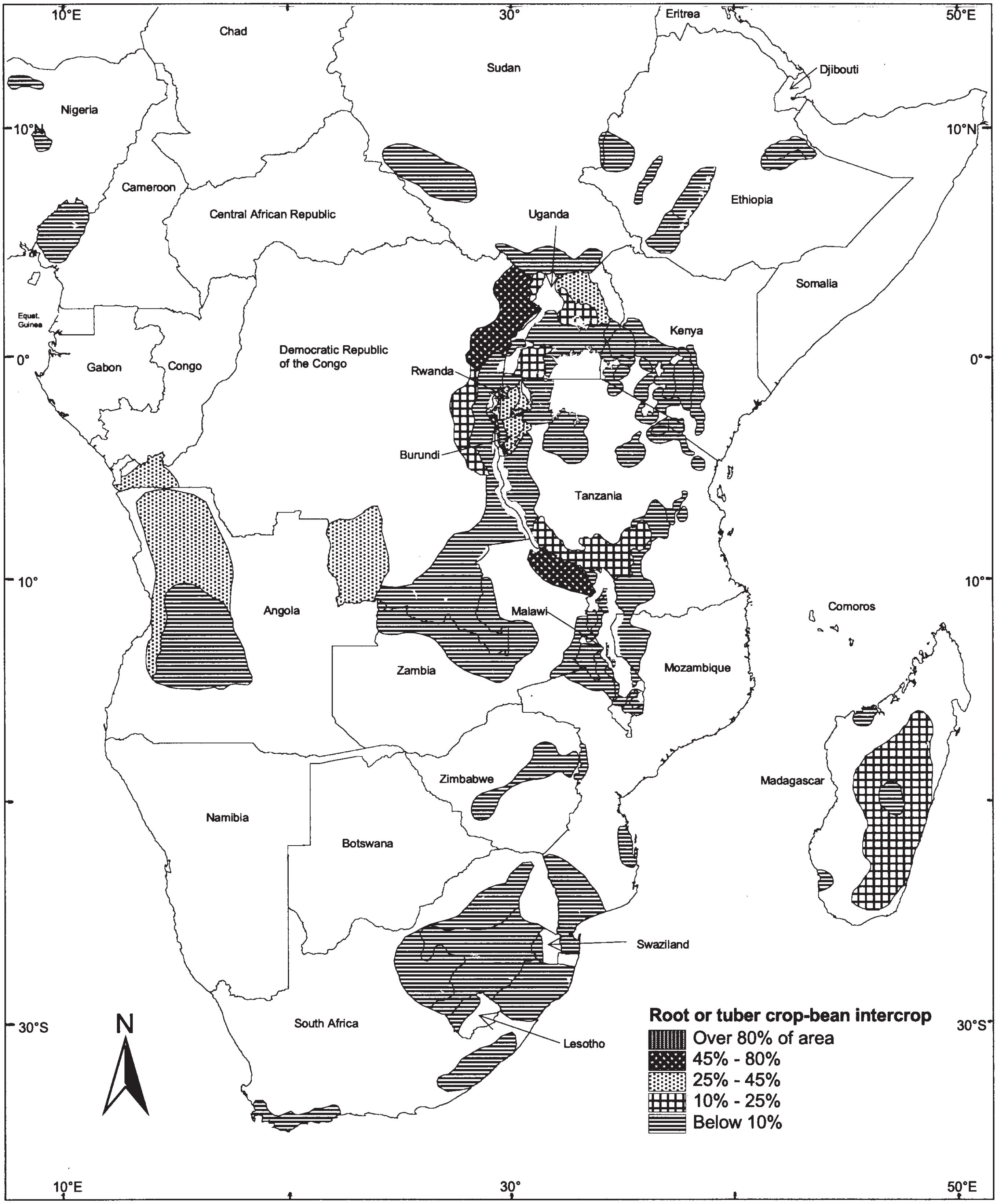
Map 7. Importance of sole crop bean production in sub-Saharan Africa.



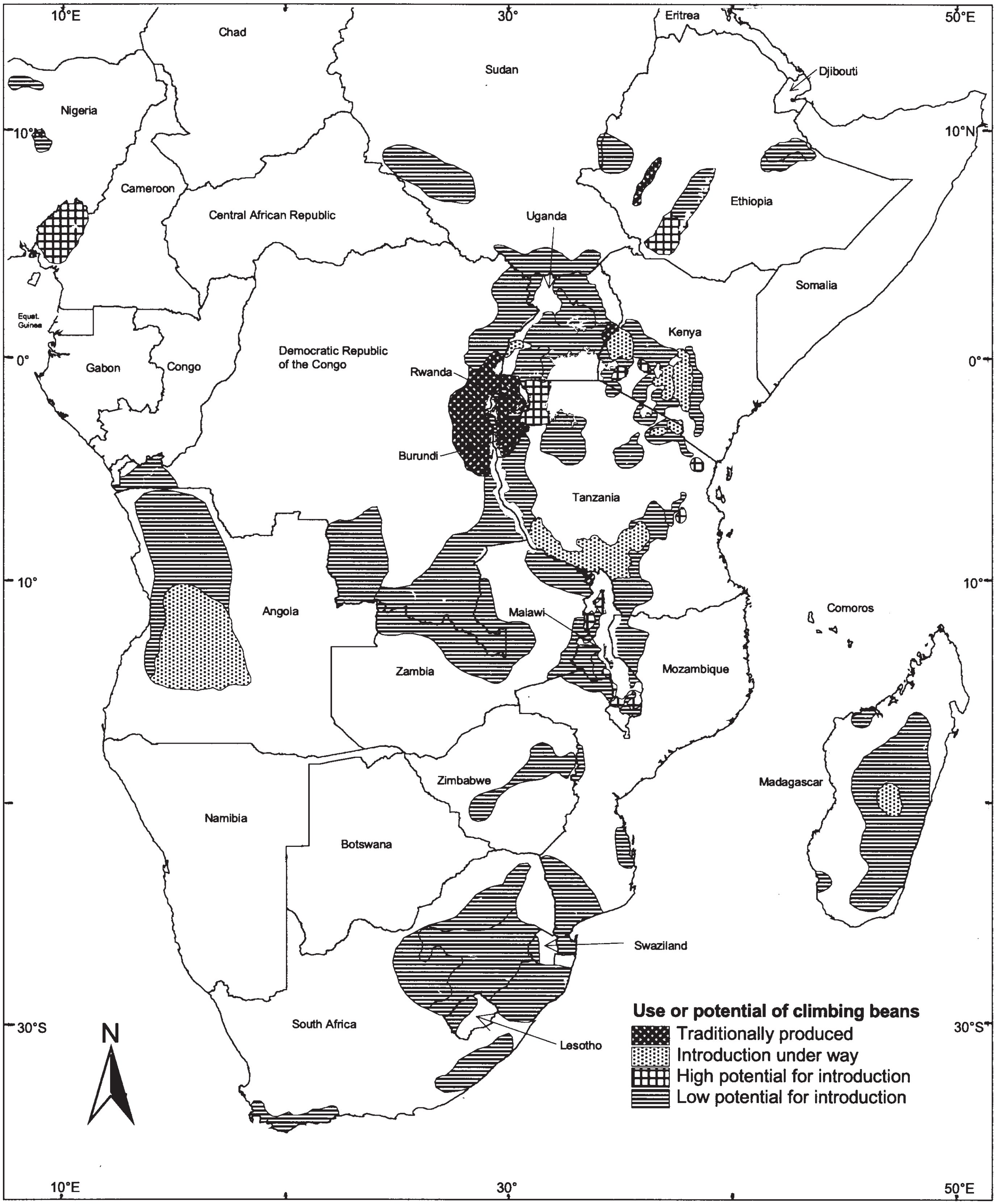
Map 8. Importance of the maize-bean intercrop association in sub-Saharan Africa.



Map 9. Importance of the banana-bean intercrop association in sub-Saharan Africa.



Map 10. Importance of the root or tuber crop-bean intercrop association in sub-Saharan Africa.



Map 11. Status of climbing bean production in bean production areas of sub-Saharan Africa.

Data table 4. Characteristics of cropping systems in bean production areas of Africa.[a]

Bean production area		Major cropping systems[b]	Sowing times	Crops/ year	Intensity of bean production[c]	Input use level[c]
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes					
Burundi:	Central Plateau	SC, TUB, BAN	Feb, Oct	2	VH	L
Ethiopia:	Awassa/N Sindamo	MZ, SC, MZr	Feb, Jul	2	M	M
Kenya:	Central Highlands	MZ	Mar, Sep	2	H	M
	Western Highlands	MZ	Mar, Sep	2	VH	M
	Kisii	MZ	Mar, Sep	2	H	M
Rwanda:	Central Plateau	BAN, TUB, SC	Mar, Sep	2	VH	L
	North-west	BAN, TUB, SC	Apr, Oct	2	VH	L
Tanzania:	Northern Highlands	MZ, BAN, COF	Mar, Oct	2	H	M
Uganda:	South-west Highlands	SOR, SC, TUB	Apr, Oct	2	H	L
	Western Highlands	MZ, SC, BAN	Mar, Sep	2	M	L
	Mt. Elgon	MZ, SC, BAN	Mar, Aug	2	VH	L
AFBE 2:	Subhumid highlands on acid soils at low latitudes					
Burundi:	Zaire-Nile Crest	BAN, SC	Mar, Sep	2	H	L
DR Congo:	South Kivu	BAN, SC	Mar, Sep	2	H	L
Kenya:	Tea Zone	MZ	Mar, Sep	2	M	M
Rwanda:	Zaire-Nile Crest	BAN, SC	Mar, Sep	2	H	L
Tanzania:	Usambara and Uluguru	MZ, BAN, SC	Mar, Oct	2	H	M
AFBE 3:	Subhumid highlands at mid-latitudes					
Ethiopia:	Hararghe Highlands	SOR, MZ, SC	Mar, Jun	2	H	L
	Western	MZ, SC	Mar, Jul	2	L	L
Tanzania:	Southern Highlands	MZ, SC, TUB	Dec, Apr	2	H	L
Zimbabwe:	High veld	SC	Jan	1	L	M
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes					
Angola:	Central Highlands	MZ, SC	Nov	1	M	L
Madagascar:	Antsirabe	MZ, MZr	Oct, Feb	2	M	L
Malawi:	Chitipa Highlands	SC, MZ, MZr	Dec, Mar	2	H	L
	Livingstonia-Nyika	SC, MZ, MZr	Dec, Mar	2	H	L
	North Viphya Hills	SC, MZ	Dec	1	H	L
	South Viphya Hills	SC, MZ	Dec	1	H	L
	Dedza-Ncheu Uplands	SC, MZ	Dec, Aug	2	VH	L
AFBE 5:	Semi-arid highlands at low latitudes					
Kenya:	Eastern high alt.	MZ	Oct, Feb	2	M	L
	Rift Valley	MZ, SC	Oct, Feb	2	M	M
	Kajiado	MZ, SC	Oct, Feb	2	M	L
Tanzania:	N semi-arid high alt.	SC, MZ	Mar, Nov	2	M	M
AFBE 6:	Semi-arid highlands at mid-latitudes					
Ethiopia:	Rift Valley	SC, MZ	Jun	1	H	M
Lesotho:	Foothills	SC	Oct	1	H	M
S Af Rep:	High veld	SC	Dec	1	M	H

(Continued)

Data table 4. (Continued.)

Bean production area		Major cropping systems[b]	Sowing times	Crops/ year	Intensity of bean production[c]	Input use level[c]
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes					
Burundi:	Moso	TUB, SC, MZ	Mar, Oct	2	H	L
DR Congo:	North-east	TUB, MZ, BAN	Mar, Sep	2	H	L
	West Kivu	BAN, SC, TUB	Mar, Sep	2	M	L
Kenya:	Nyanza	MZ	Mar, Sep	2	H	M
Rwanda:	Lake Kivu Basin	BAN, TUB, SC	Apr, Oct	2	VH	L
Tanzania:	Kagera	BAN, MZ	Sep, Mar	2	M	L
	West (Kigoma)	MZ	Oct, Mar	2	M	L
	South Lake	MZ	Oct, Mar	2	L	L
Uganda:	North central	SC, MZ, TUB	Apr, Jul	2	M	L
	NW Tall Grass Zone	MZ, SC, TUB	Apr, Aug	2	H	L
	C and E Tall Grass Zone	MZ, BAN, SC	Mar, Sep	2	M	L
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes					
Cameroon:	North-western	MZ, SC	Mar, Jul	2	M	M
DR Congo:	Shaba Region	MZ, SC	Nov	1	M	L
Malawi:	Mzimba Plains	SC, MZ	Dec	1	L	L
	Lilongwe-Kasungu	SC, MZ	Dec	1	L	L
	Dowa-Nchitsi Uplands	SC, MZ	Dec, Jul	2	H	L
	Namwera Uplands	SC, MZ, MZr	Dec, Mar	2	M	L
	Shire Highlands	SC, MZ, MZr	Dec, Mar	2	H	L
Mozambique:	Lichinga (North)	MZ, MZr	Dec	1	H	L
	Tete	MZ	Dec	1	M	L
	Manica highlands	MZ	Dec	1	M	L
Nigeria[d]:	Kano	SC				
	Jos Plateau	SC				
Sudan:	Southern	SOR, MIL	Mar, Aug	2	L	L
Tanzania:	S mid-altitudes	MZ, SC	Dec	1	M	L
Zambia:	Eastern	MZ	Jan	1	L	M
Zimbabwe:	Mid-veld	MZ, SC	Dec	1	L	M
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes					
Kenya:	Eastern mid-alt.	MZ	Oct, Mar	2	M	L
Rwanda:	Eastern	BAN, TUB, SC	Mar, Sep	2	H	L
Tanzania:	N and E mid-alt.	MZ, SC	Apr, Oct	2	L	L
Uganda:	W Short Grass Zone	SC, MZ, TUB	Mar, Sep	2	M	L
	N Short Grass Zone	SC, TUB, MZ	Mar, Jul	2	L	L
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes					
Angola:	Mid-altitudes	MZ, TUB	Oct, Feb	1	L	L
Ethiopia:	Mid-alt. Hararghe	SOR, MZ	Jul, Dec	2	H	L
S Af Rep:	Transkei	SC, MZ	Dec	1	M	M
	Natal	SC, MZ	Dec	1	L	M
	Mid-veld	SC	Dec	1	M	H
Zimbabwe:	Mid-veld fringes	SC	Nov	1	L	M

(Continued)

Data table 4. (Continued.)

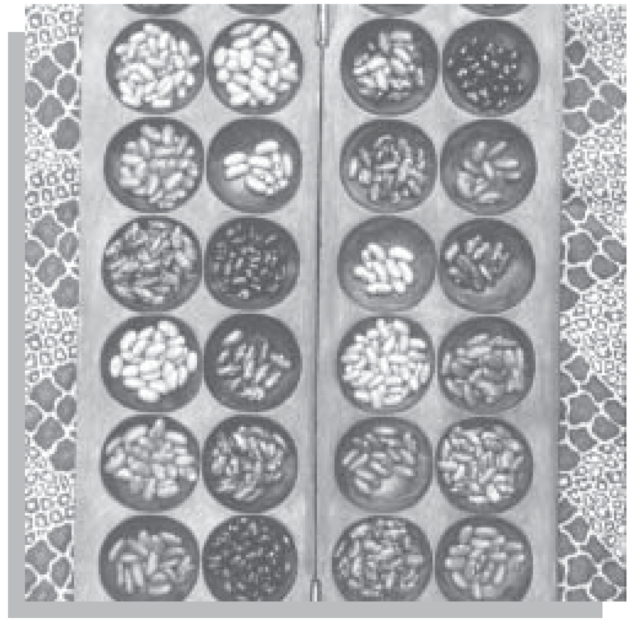
Bean production area		Major cropping systems[b]	Sowing times	Crops/ year	Intensity of bean production[c]	Input use level[c]
AFBE 11: Subhumid areas at mid-altitudes on acid soils at mid-latitudes						
DR Congo:	Kasai	SC, TUB, MZ	Feb, Sep	2	M	L
Madagascar:	Central	MZ, SC, TUB	Nov, Feb	2	M	L
Zambia:	North-east	TUB, MIL, MZ	Dec, Mar	2	L	M
AFBE 12: Semi-arid areas at mid-altitudes on acid soils at mid-latitudes						
Madagascar:	Following rice	SC	Jun	1	L	M
Zambia:	N central and NW	SC, MZ	Dec	1	L	L
Swaziland:	High and mid-veld	SC, MZ	Jan	1	L	M
AFBE 13: Lowlands at mid-latitudes						
Algeria:	Northern	SC	Mar	1	L	M
Cape Verde:		MZ	Aug	1	M	L
Egypt:	Nile Delta	SC	Mar, Oct	2	L	H
Guinea[d]:	Guinea	MZ, SC	Apr	1		
Madagascar:	Toliary	SC	Apr	1	H	L
	Mahajanga	SC	May, Nov	2	M	L
Malawi:	Lake basin (rm)	SC	Jun	1	VH	M
	Phalombe Plains	SC, MZ	Dec	1	M	L
Mauritius:	(Irrigated)	SC	Jun	1	L	H
Morocco:	North	SC	Mar, Oct	2	L	M
Mozambique:	Southern (rm)	SC	Jun	1	L	L
S Af Rep:	Cape Province (irrig.)	SC	Oct	1	L	H
Sudan:	Northern (irrig.)	SC	Sep	1	H	H
Togo[d]:	Atakpame					
Tunisia:	Northern	SC	Mar	1	L	M
AFBE 14: Lowlands at low latitudes						
Burundi:	Imbo Plains	TUB, BAN, SC	Mar, Oct	2	M	L
DR Congo:	Bas-Zaire (rm)	SC	May, Nov	1	M	M
Tanzania:	Morogoro	MZ, SC	Mar, Oct	2	L	M

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. Intercropping systems are BAN = banana; COF = coffee; MIL = millet; MZ = maize; MZr = relay intercropping with maize; SC = sole crop bean production; SOR = sorghum; TUB = root and tuber crops. The systems are ranked in order of importance: when one, two, or three systems are given, percentages produced under each system were assumed, respectively, to be 95; 60 and 35; and 50, 30, and 15.

c. Intensity of bean production and level of input use are qualitatively rated as: VH = very high; H = high; M = moderate; L = low. Intensity of production refers to the economic importance of beans in the systems. Input use level indicates the amount of purchased inputs used.

d. Blank spaces = insufficient information was available at the time.



Distribution of Bean Seed Types

Distribution of Bean Seed Types

Typically, three to six easily distinguished cultivars account for 95% of production in a bean-producing community. Diversity is greatest in the Great Lakes Region and south-west Uganda where beans are produced, marketed, and consumed as complex varietal mixtures (Map 12). In Rwanda, mixtures average 11 components, and may contain as many as 27 varieties (Lamb and Hardman 1985). The farmers maintain and adjust the mixtures according to growing conditions (Voss 1992). In parts of Malawi, Mozambique, Tanzania, and Uganda, production in mixtures is still important even though market sales are now by variety.

"Significant genetic erosion has also occurred and appears to be continuing. The complexity of Rwandan mixtures has declined in the past decade due to the susceptibility of many local varieties to an epidemic of root rots and to the adoption of high-yielding climbing beans in response to land pressure" (Sperling 1997). Genetic erosion has been reinforced in some countries by the more affluent urban sector preferring a small number, usually large-seeded, cosmopolitan varieties (Grisley and Munene 1992).

Poverty may oblige farmers to lose their preferred varieties (Sperling and Loevinsohn 1993) or to compromise their preferences. Long after having been removed from Kenya's list of recommended varieties, Mexican 142, a Navy bean variety with non-preferred culinary qualities, continues as the dominant variety among resource-poor farmers in Kirinyaga. Its low price and small seed size minimize the annual expense of purchasing seed (Franzel and Crawford 1987). Similarly, bean farmers in Malawi fall into four categories: seed secure; self-reliant, except at times of domestic crisis; regularly dependent on off-farm sources for a proportion of their seed; and chronically seed insecure (Cromwell 1991).

Diversity of bean germplasm may be more restricted where production is commercialized and oriented to a specialized market. For example, the limited diversity in Ethiopia's Rift Valley is probably related to the crop's being introduced within the past 70 years (Ohlander 1980) and oriented to a specialized market. Beans are not an especially important part of the diet in this part of Ethiopia.

Estimating Areas under Different Seed Types

The area of production of a seed type was estimated according to ratings of high (40% of total bean production area), moderate (20%), and low (5%) importance.

Seed Types

Calima

Calima seed types are known for their relatively high and stable productivity under moderately good growing conditions. Their cooking time is relatively short, and they are highly marketable.

In eastern Africa, the Calima, or Rosecoco, types account for about 22% of the production, primarily because of their high market preference in Kenya (Grisley and Munene 1992, Table 2, Map 13, Data table 5). In north-west Tanzania, Calima types are gaining prominence with the rapid adoption of 'Lyamungu 90' (David 1997). In southern Africa, Calima types are much less common, and account for about 10% of production. In contrast, Malawian farmers have expressed keen interest in obtaining seed of two recently released Calima varieties (Vas Dev Aggarwal, 1997, personal communication). In Madagascar, farmers are increasingly interested in Calima types (A Rabakaoarihanta, 1997, personal communication).

Table 2. Estimated area (in thousands of ha) sown annually to nine categories of bean seed types.

Seed category	Eastern Africa	Southern Africa
Calimas	650	90
Reds, small and medium-sized	510	160
Reds, large and kidney	230	120
Yellows, and tans	290	90
Creams	240	120
Navy	190	120
White, large and medium-sized	130	90
Purples	150	120
Blacks	100	30

Reds

Large red seed types, including red kidneys, usually account for about 10% of production in eastern and southern Africa (Map 14). These types typically are relatively low yielding under low-input management, and are susceptible to biotic and abiotic stresses. When seed quality is good, red kidneys are highly marketable in many areas and have export potential.

Medium and small reds, including pink types, make up about 20% of Africa's bean production (Map 15). These occur widely and are especially common in the Great Lakes Region, Ethiopia, Madagascar, and in some parts of western Africa. Medium-sized types are much more common than small types, although small reds are often readily adopted when they have a good combination of attributes. This is illustrated by the case of the small red climbing variety 'Umubano', which was widely adopted. The palatability of its leaves especially attracted Rwandan farmers (Graf et al. 1991).

Navy beans

Navy beans are small whites that usually yield well under low-input conditions. They account for only 9% of total production, but are in high demand from the canning industry (Map 16) and in urban areas, where they are popular for their taste and relatively short cooking time. Marketability, however, is affected by blemishes on the seed coat.

Commercial, small-farm production of Navy beans for export to canning markets has long been the dominant pattern in the Rift Valley and Hararghe areas of Ethiopia. Larger scale producers in South Africa and Zimbabwe also grow this type.

Cream-coloured types

Heterogeneous, this category includes pinto, sugar, and carioca types, with local preferences for specific types. The entire category accounts for about 10% of production (Map 17). Pinto beans have good export potential but are relatively low yielding and susceptible to biotic and abiotic stresses. Speckled sugar types are preferred by commercial farmers in the Republic of South Africa. Carioca types are generally noted for their yield potential and tolerance of low soil P availability. A high-yielding carioca variety, released in the mid-1980s, has become commercially popular for supplying the Zambian Copperbelt and sugar estates in Swaziland (JM Mulila-Mitti and ZI Mamba, 1993, personal communication), but, in this case, lower market prices, rather than culinary characteristics, appear to have determined the variety's acceptability to consumers.

Brown, tan, and yellow seed types

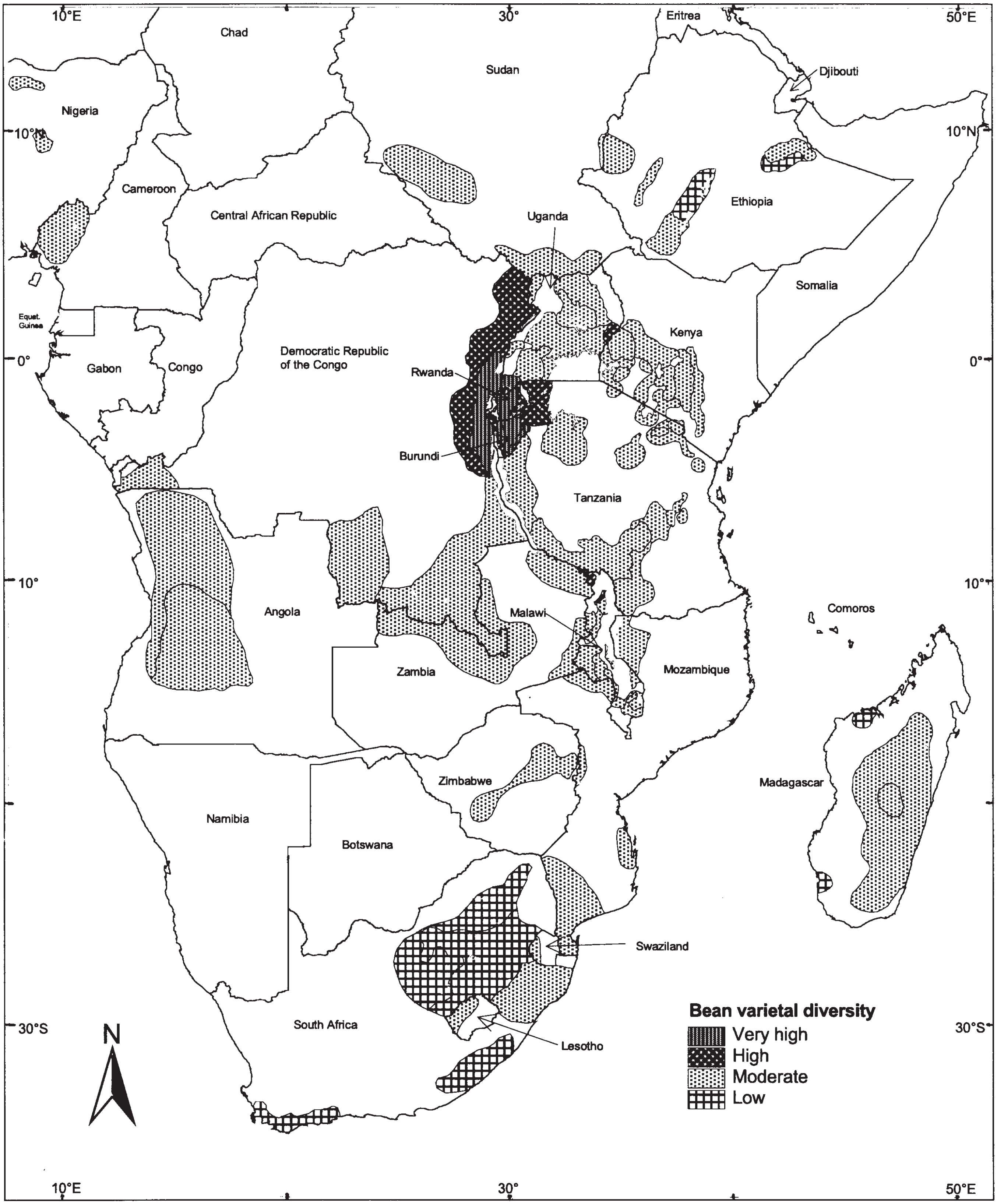
This diverse category of seed types is especially important in Angola and is also grown in a belt of countries extending from south-west Uganda to Mozambique (Map 18). These types account for about 11% of the production in eastern and southern Africa and are often grown in mixtures with other seed types. Small-seeded types appear to be relatively tolerant of low soil fertility conditions, as exemplified by 'Ubososera', which tolerates the low soil pH complex (L Lunze, 1996, personal communication), and XAN 76, which tolerates low soil N and P (Wortmann et al. 1996).

Purples

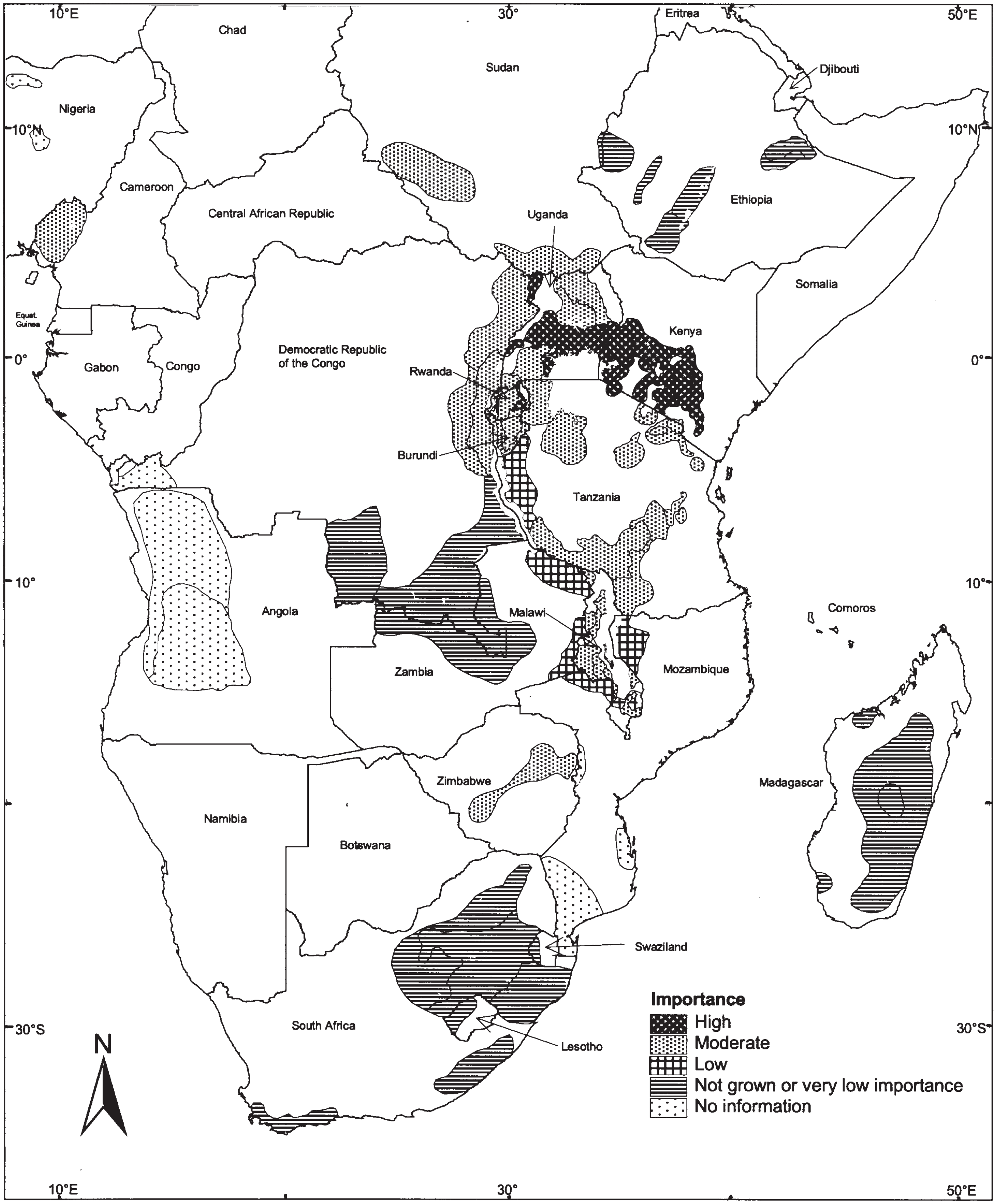
These types occur widely, but account for only 8% of total production, although they are important in some places (Map 19). A local 'mwezi moja' type known as 'Kablanketi' is now the preferred bean in Dar es Salaam because it cooks quickly, tastes sweet, and produces a reddish broth. It spread rapidly, being diffused by merchants to areas as far away as 1200 km from the variety's origin in the Southern Highlands of Tanzania.

Medium and large whites, and blacks

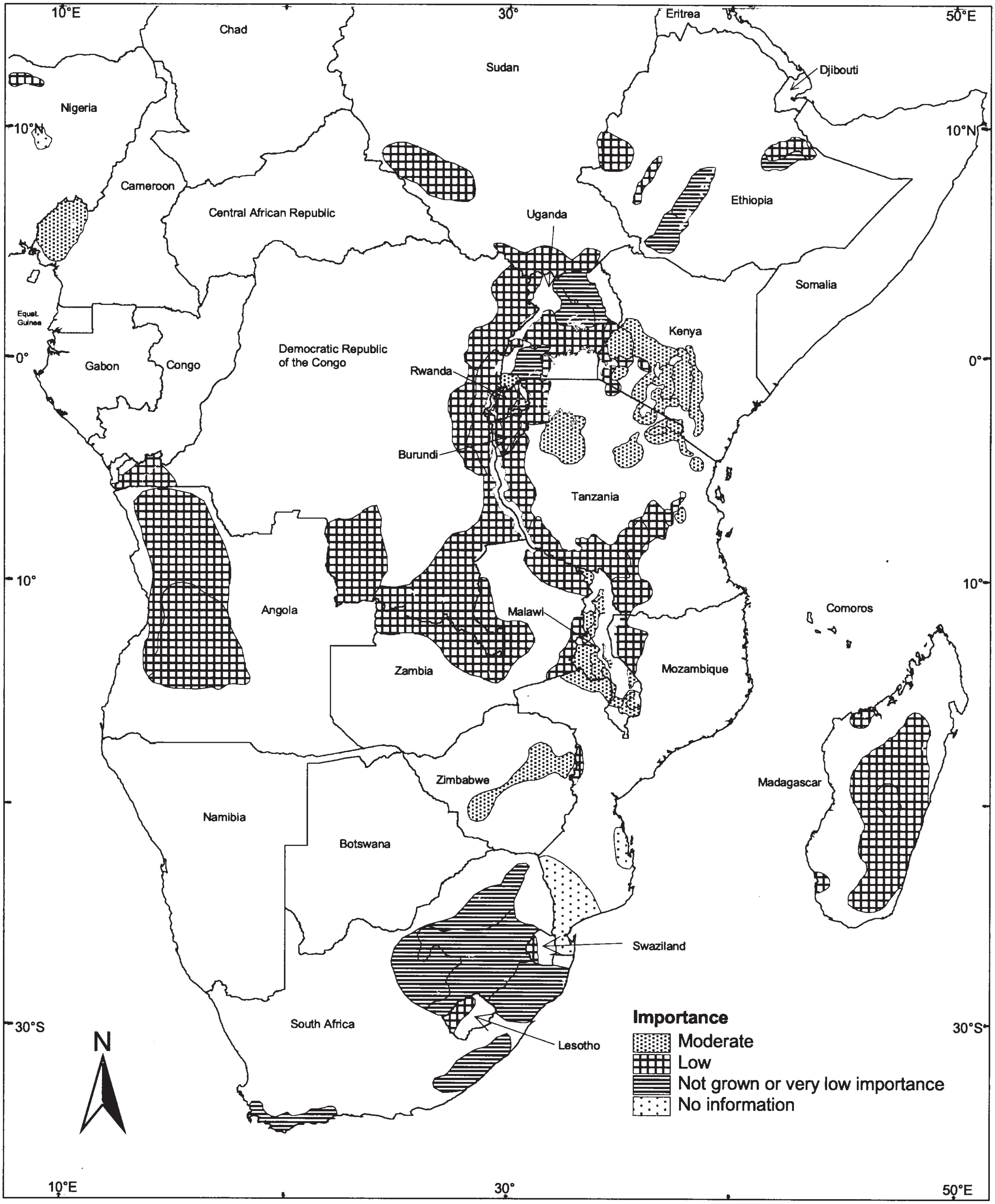
Medium and large white seed types are important in some countries, such as Madagascar and Sudan, and account for 6% of bean production in eastern and southern Africa (Map 20). Black seed types occur widely, but account for only 3.5% of bean production and are of moderate importance only in parts of northern Uganda, southern Ethiopia and Sudan, and in Cameroon (Map 21). Small blacks are often found in mixtures maintained by farmers for low fertility soils.



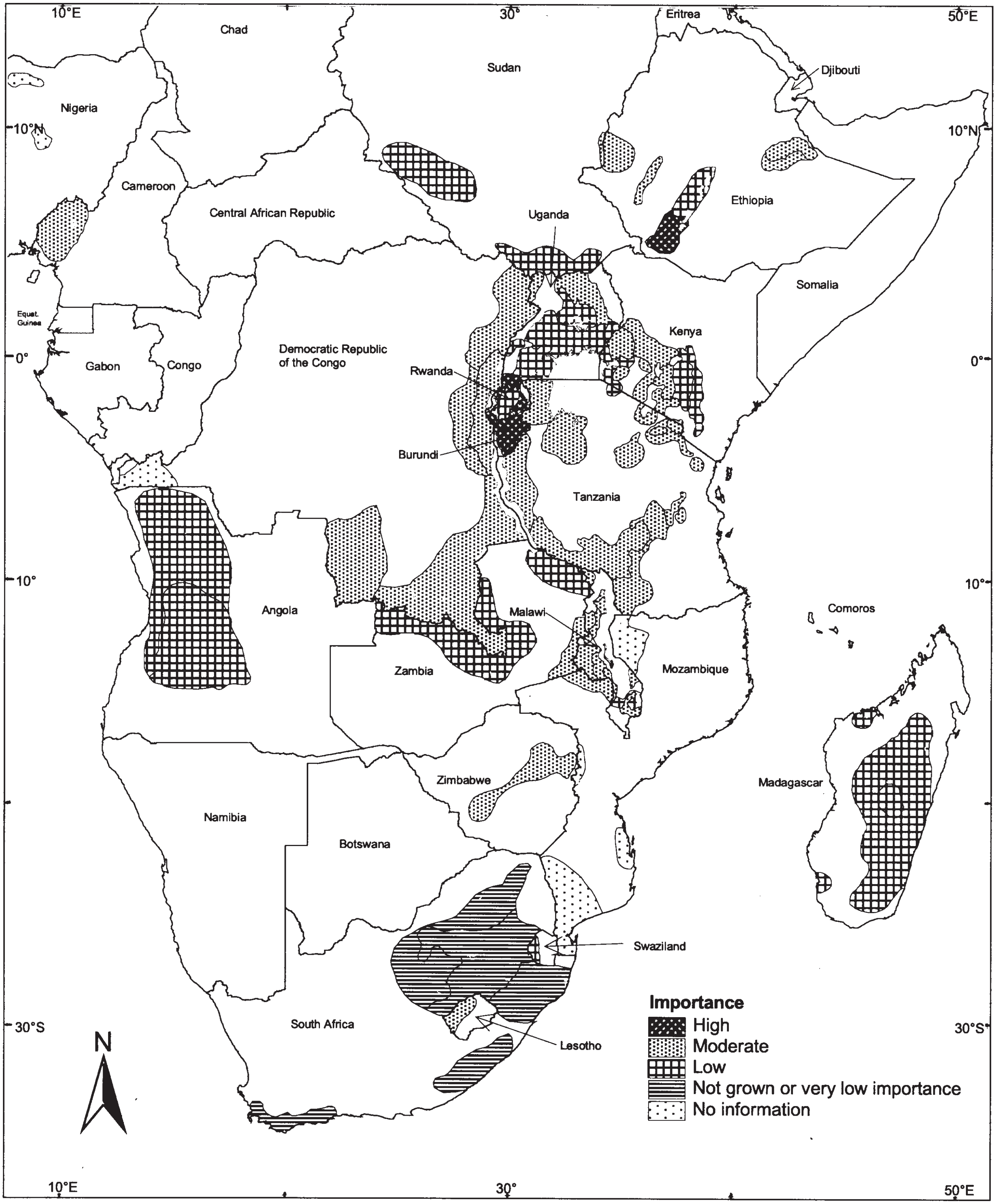
Map 12. Varietal diversity of beans grown in production areas of sub-Saharan Africa.



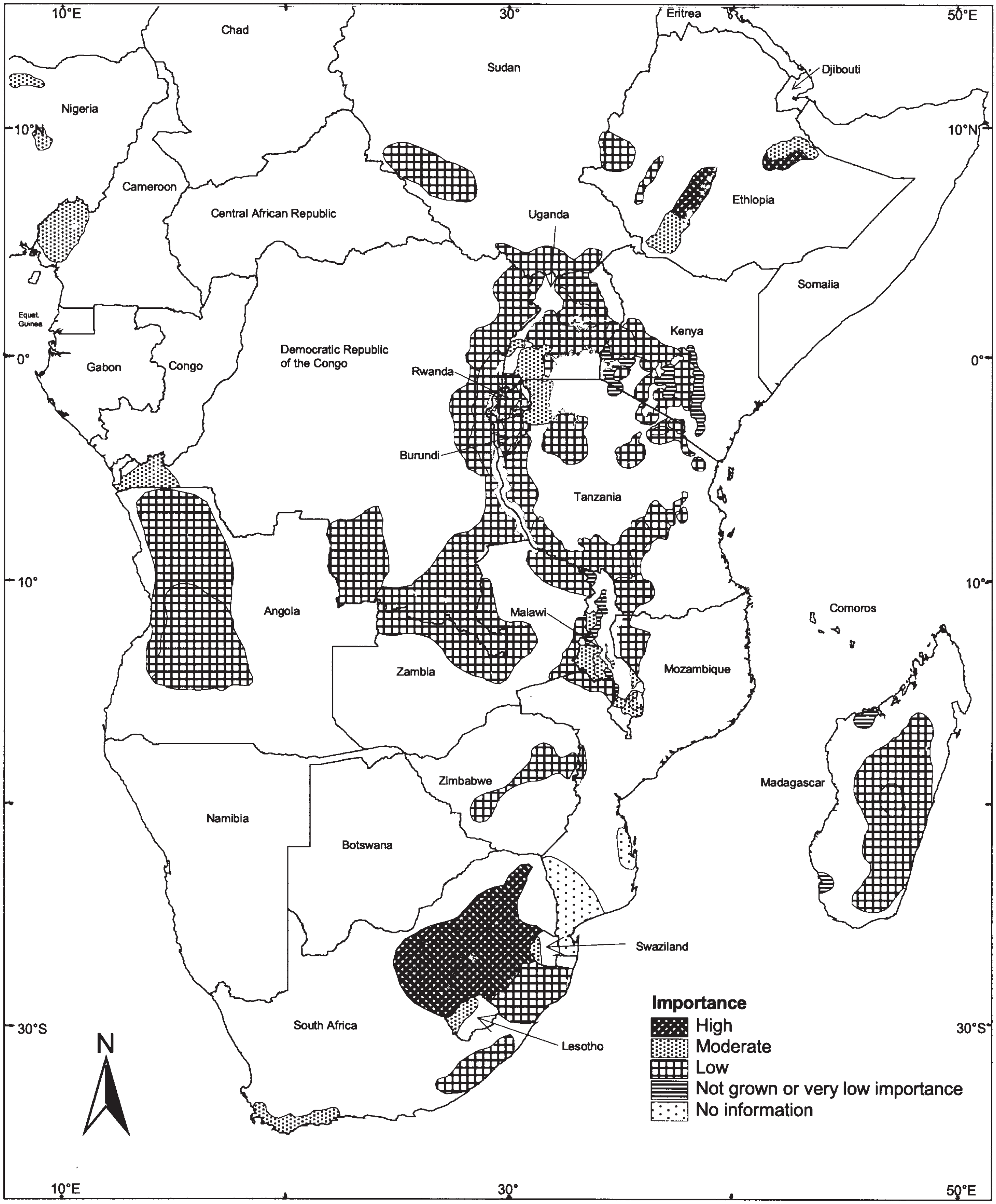
Map 13. Importance of Calima bean seed types in sub-Saharan Africa.



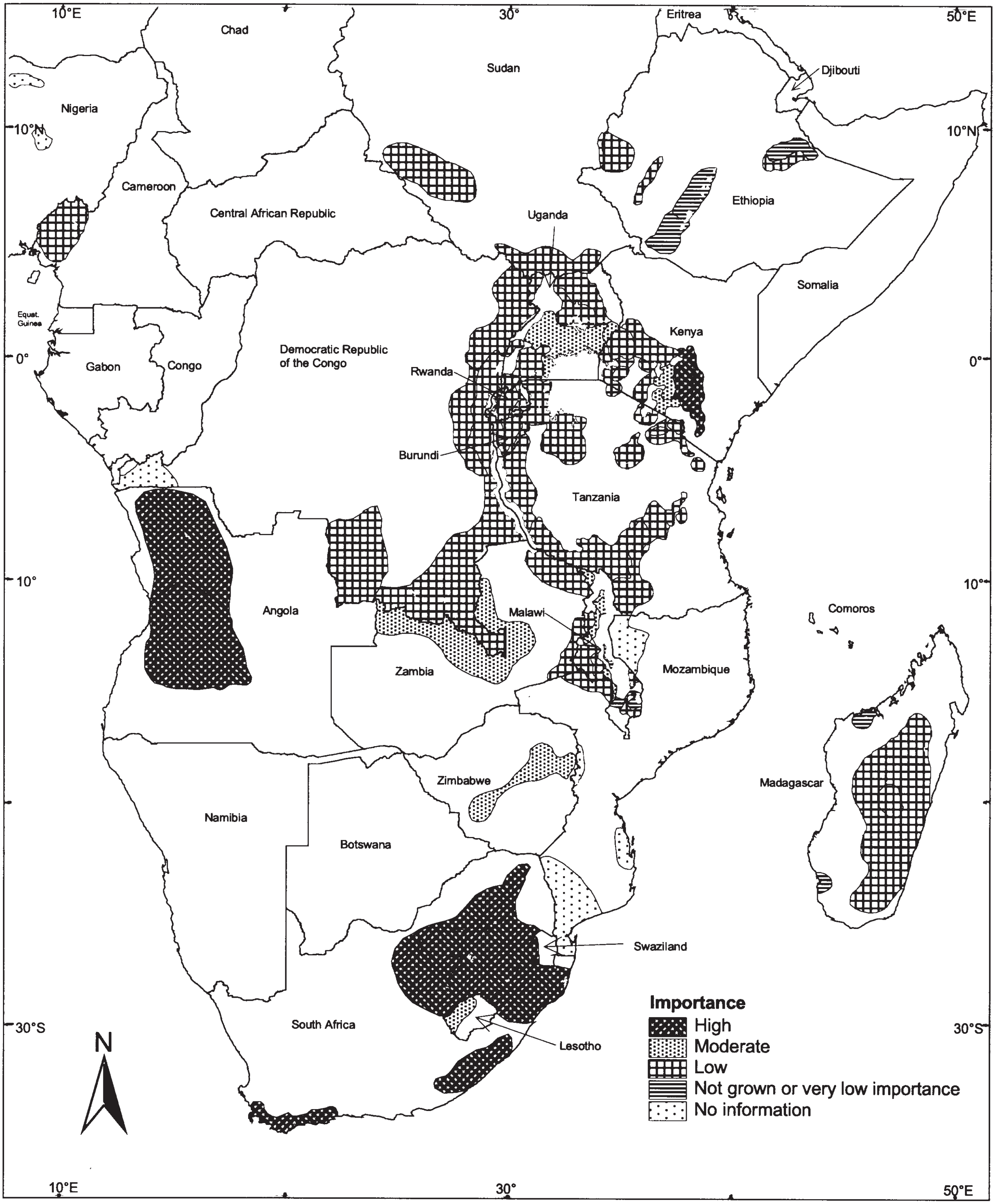
Map 14. Importance of large red bean seed types in sub-Saharan Africa.



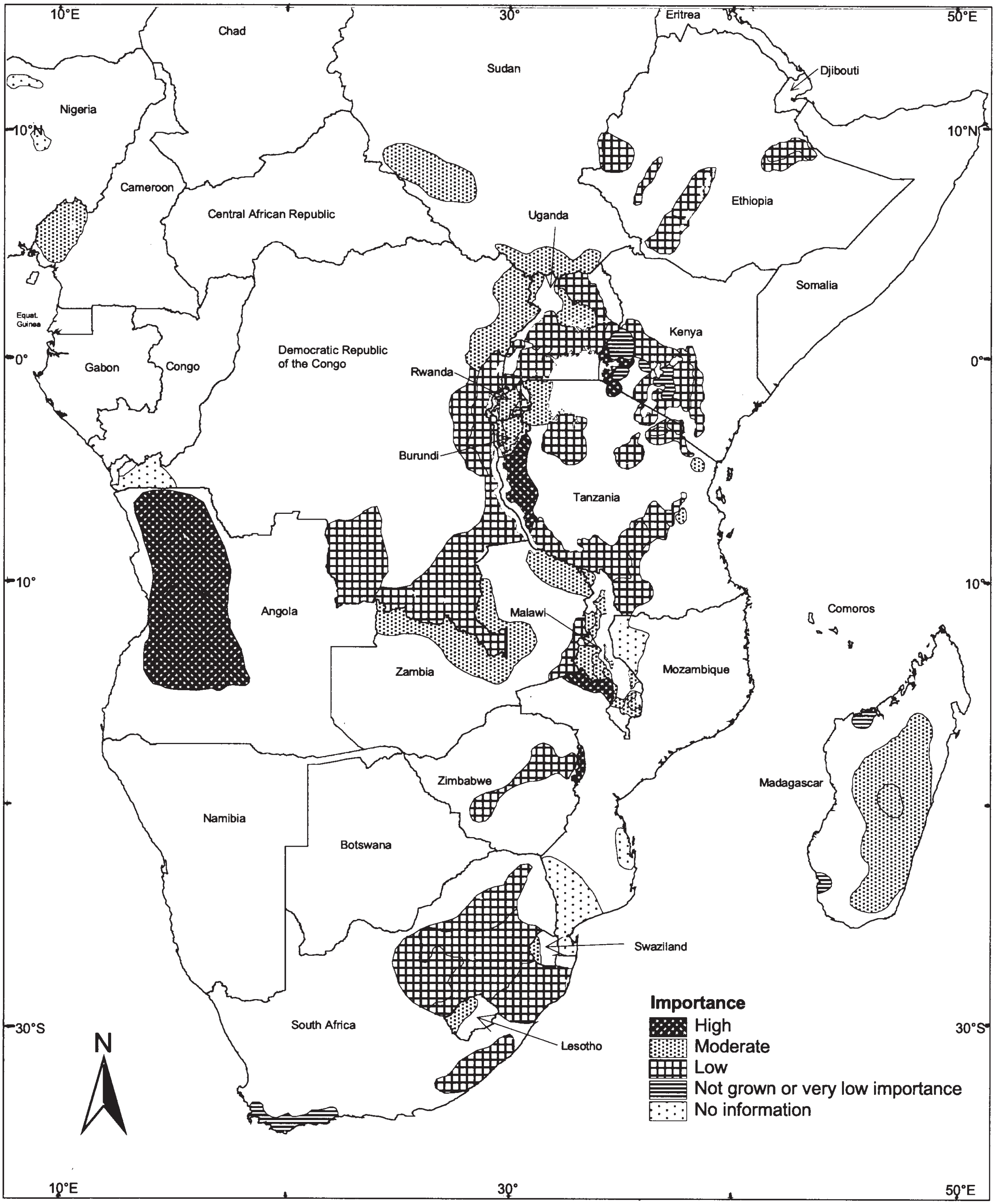
Map 15. Importance of medium- and small-seeded reds, and pink bean seed types in sub-Saharan Africa.



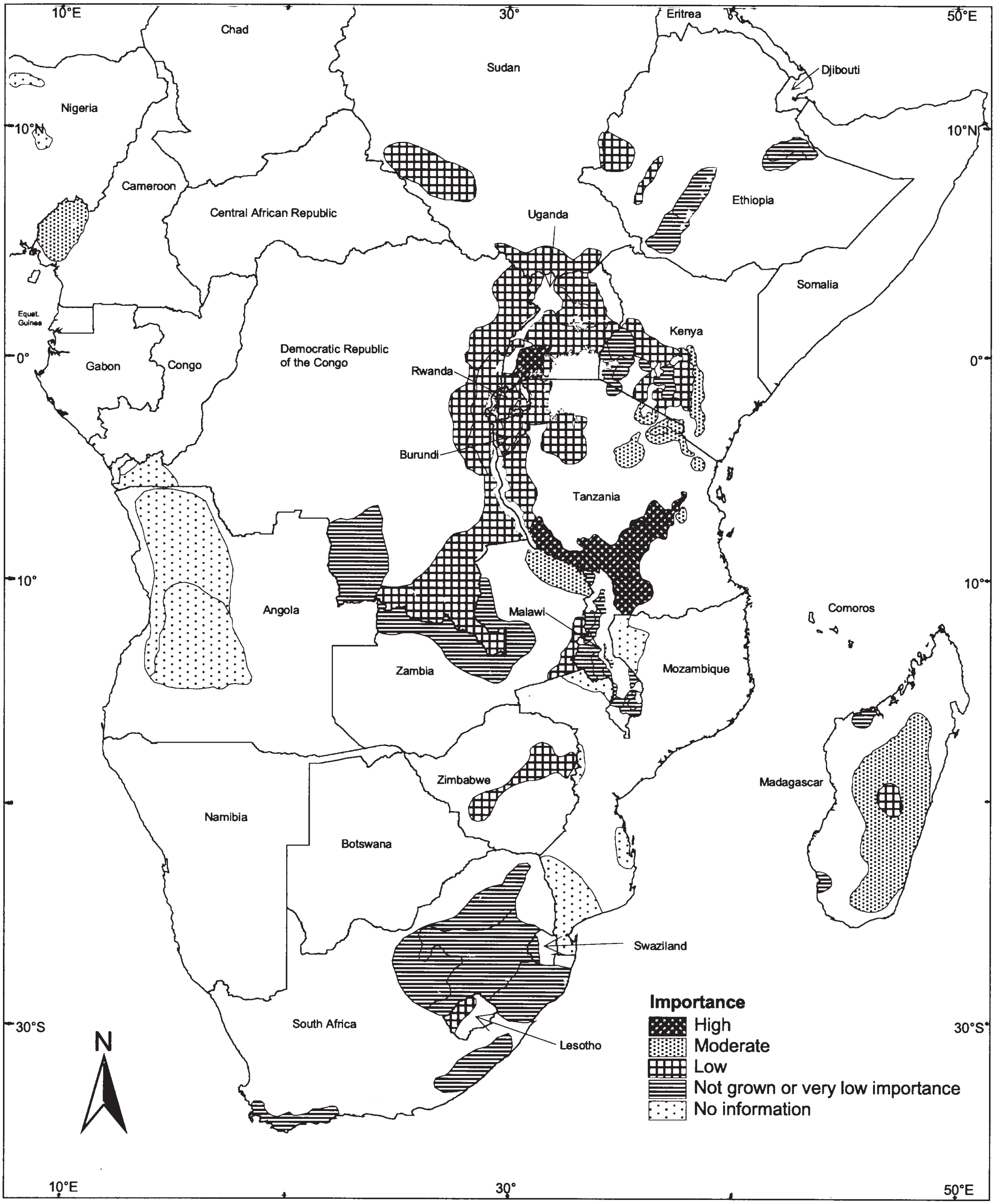
Map 16. Importance of small white and Navy bean seed types in sub-Saharan Africa.



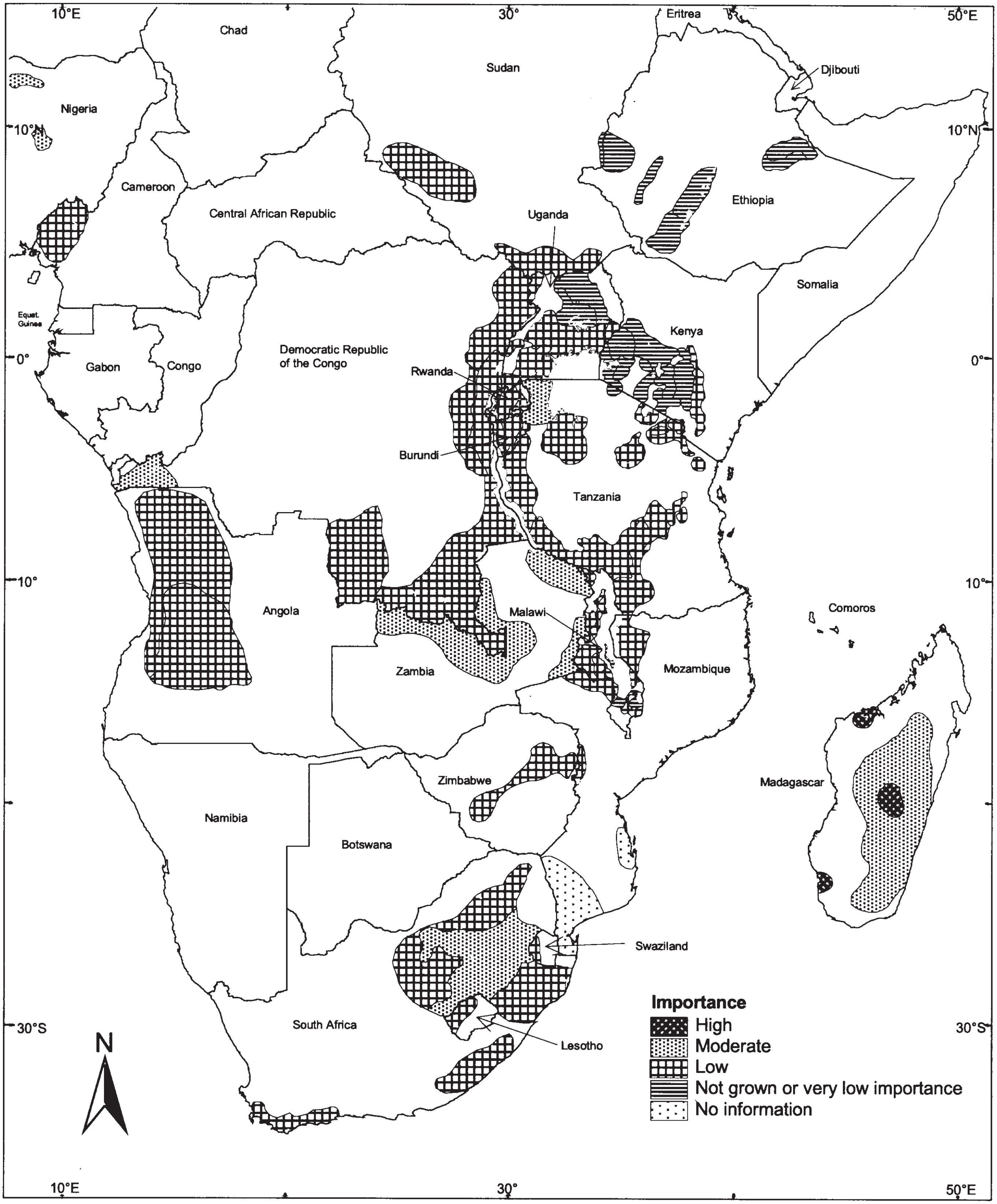
Map 17. Importance of cream and speckled cream-beige bean seed types in sub-Saharan Africa.



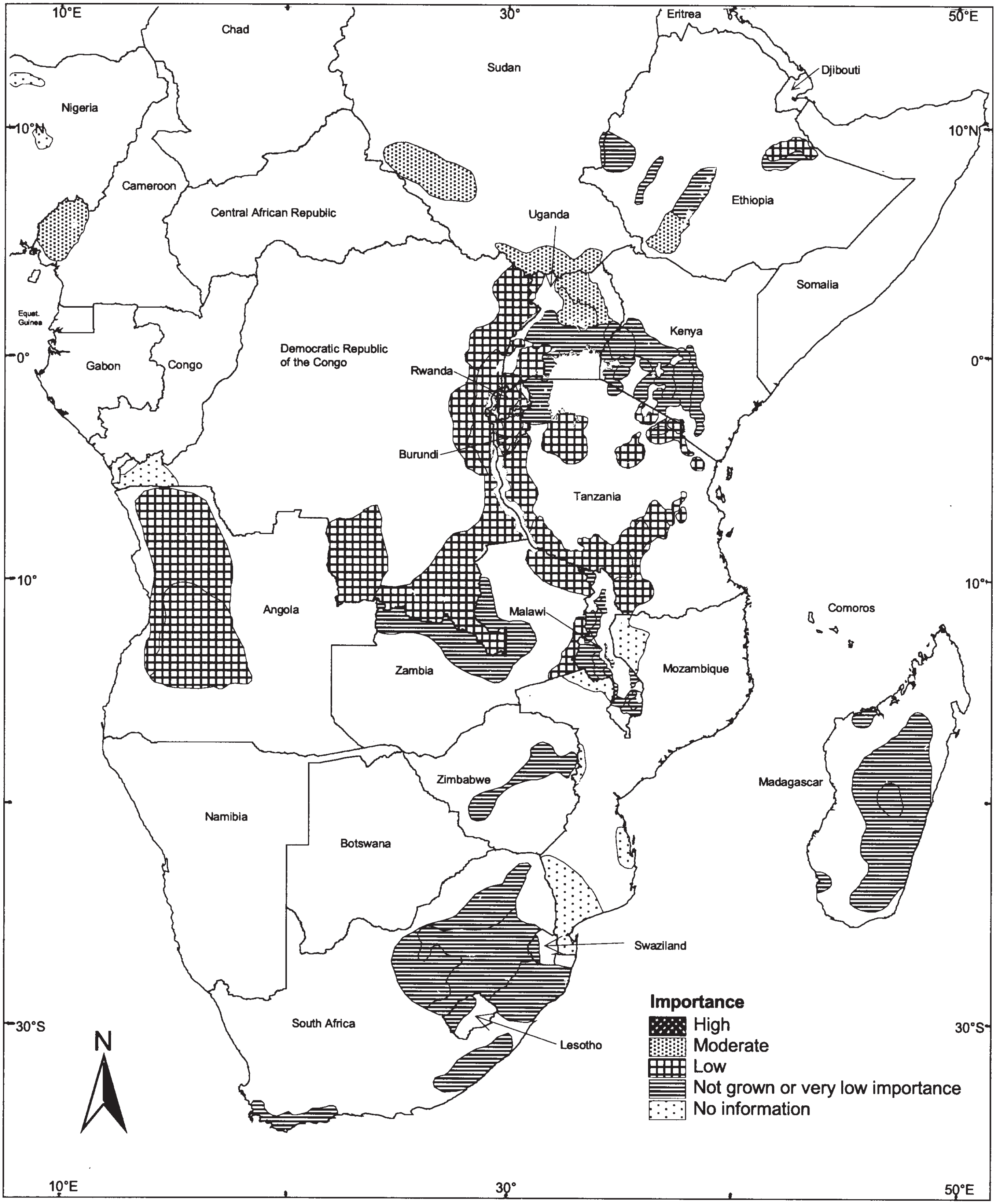
Map 18. Importance of yellow and brown bean seed types in sub-Saharan Africa.



Map 19. Importance of purple bean seed types in sub-Saharan Africa.



Map 20. Importance of medium-sized and large white bean seed types in sub-Saharan Africa.



Map 21. Importance of black bean seed types in sub-Saharan Africa.

Data table 5. Importance of major bean seed types in bean production areas of Africa.[a]

Bean production area		Seed type[b]								
		DRK	SW	WH	CAL	PUR	CRE	YEL	RED	BLK
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes									
Burundi:	Central Plateau	L	L	L	M	L	L	M	H	L
Ethiopia:	Awassa/N Sindamo	N	M	N	N	N	N	L	H	M
Kenya:	Central Highlands	M	N	N	H	N	M	N	M	N
	Western Highlands	M	L	N	H	N	L	N	M	N
	Kisii	M	L	N	H	N	L	N	M	N
Rwanda:	Central Plateau	L	L	L	M	L	L	M	L	L
	North-west	L	L	L	M	L	L	M	L	L
Tanzania:	Northern Highlands	M	L	L	M	M	L	L	M	L
Uganda:	South-west Highlands	M	L	L	M	L	L	L	H	L
	Western Highlands	L	M	L	H	L	L	L	L	L
	Mt. Elgon	L	L	L	H	L	M	L	L	N
AFBE 2:	Subhumid highlands on acid soils at low latitudes									
Burundi:	Zaire-Nile Crest	L	L	L	M	L	L	M	H	L
DR Congo:	South Kivu	L	L	L	M	L	L	L	M	L
Kenya:	Tea Zone	L	L	N	H	N	L	N	M	N
Rwanda:	Zaire-Nile Crest	L	L	L	L	L	L	M	H	L
Tanzania:	Usambara and Uluguru	M	L	L	M	M	L	M	M	L
AFBE 3:	Subhumid highlands at mid-latitudes									
Ethiopia:	Hararghe Highlands	L	M	N	N	N	N	L	M	L
	Western	L	L	N	N	L	L	L	M	N
Tanzania:	Southern Highlands	L	L	L	M	H	L	L	M	L
Zimbabwe:	High veld	M	L	L	M	L	M	L	M	N
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes									
Angola:	Central Highlands	L	L	L	A	A	H	H	L	L
Madagascar:	Antsirabe	L	L	H	N	L	L	M	L	N
Malawi:	Chitipa Highlands	M	N	L	M	N	M	M	M	N
	Livingstonia-Nyika	M	N	L	M	N	M	M	M	N
	North Viphya Hills	M	N	L	M	N	M	M	M	N
	South Viphya Hills	M	N	L	M	N	M	M	M	N
	Dedza-Ncheu Uplands	M	N	L	M	N	M	M	M	N
AFBE 5:	Semi-arid highlands at low latitudes									
Kenya:	Eastern high alt.	M	L	N	H	L	H	L	L	N
	Rift Valley	M	L	N	H	L	L	L	M	N
	Kajiado	M	L	N	H	L	M	L	M	N
Tanzania:	N semi-arid high alt.	M	L	L	M	M	L	L	M	L
AFBE 6:	Semi-arid highlands at mid-latitudes									
Ethiopia:	Rift Valley	N	H	N	N	N	N	L	L	N
Lesotho:	Foothills	L	M	L	N	L	M	M	M	N
S Af Rep:	High veld	N	H	M	N	N	H	L	N	N

(Continued)

Data table 5. (Continued.)

Bean production area		DRK	SW	WH	CAL	PUR	CRE	YEL	RED	BLK
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes									
Burundi:	Moso	L	L	L	M	L	L	L	H	L
DR Congo:	North-east	L	L	L	M	L	L	M	M	L
	West Kivu	L	L	L	M	L	L	L	M	L
Kenya:	Nyanza	L	N	N	H	N	L	H	L	N
Rwanda:	Lake Kivu Basin	L	L	L	M	L	L	M	L	L
Tanzania:	Kagera	L	M	M	M	L	L	M	M	N
	West (Kigoma)	L	L	L	L	L	L	H	M	L
	South Lake	M	L	L	M	L	L	L	M	L
Uganda:	North central	N	L	N	M	L	L	M	L	M
	NW Tall Grass Zone	L	L	L	H	L	L	M	M	L
	C and E Tall Grass Zone	L	L	L	H	L	M	L	L	N
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes									
Cameroon:	North-western	M	M	L	M	M	L	M	M	L
DR Congo:	Shaba Region	L	L	L	N	L	L	L	M	L
Malawi:	Mzimba Plains	M	M	L	M	N	L	M	M	N
	Lilongwe-Kasungu	M	M	L	M	N	L	M	M	N
	Dowa-Nchitsi Uplands	M	M	L	M	N	L	M	M	N
	Namwera Uplands	M	M	L	M	N	L	M	M	N
	Shire Highlands	M	M	L	M	N	L	M	M	N
Mozambique:	Lichinga (North)	L	L	L	L	NA	NA	NA	NA	NA
	Tete	M	L	L	L	NA	L	H	M	NA
	Manica Highlands	L	L	L	NA	NA	NA	H	NA	NA
Nigeria:	Kano	L	M	M	NA	NA	NA	NA	NA	NA
	Jos Plateau	NA	M	M	NA	NA	NA	NA	NA	NA
Sudan:	Southern	L	L	L	M	L	L	M	L	M
Tanzania:	S mid-altitudes	L	L	L	M	H	L	L	M	L
Zambia:	Eastern	L	L	M	L	L	L	L	M	L
Zimbabwe:	Mid-veld	M	L	L	M	L	H	M	M	N
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes									
Kenya:	Eastern mid-alt.	M	N	L	H	M	H	L	L	N
Rwanda:	Eastern	L	L	L	H	L	L	L	H	L
Tanzania:	N and E mid-alt.	M	L	L	M	L	L	L	L	N
Uganda:	W Short Grass Zone	N	M	L	M	H	L	L	L	L
	N Short Grass Zone	N	L	N	M	L	L	L	M	M
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes									
Angola:	Mid-altitudes	L	L	L	NA	NA	H	H	L	L
Ethiopia:	Mid-alt. Hararghe	N	H	N	N	N	L	L	M	N
S Af Rep:	Transkei	N	L	L	N	N	H	L	N	N
	Natal	N	L	L	N	N	H	L	N	N
	Mid-veld	N	H	L	N	N	H	L	N	N
Zimbabwe:	Mid-veld frindes	M	L	L	M	L	H	M	M	N

Column header "Seed type[b]" spans DRK through BLK.

(Continued)

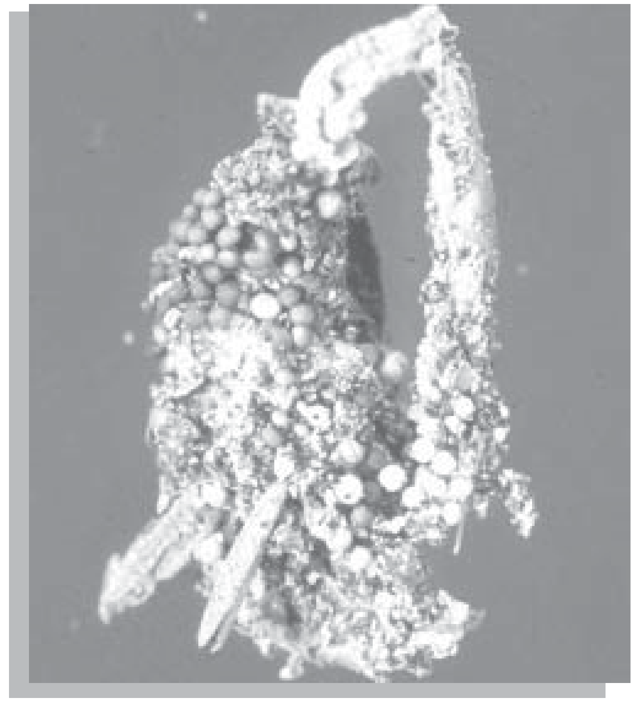
Data table 5. (Continued.)

Bean production area		Seed type[b]								
		DRK	SW	WH	CAL	PUR	CRE	YEL	RED	BLK
AFBE 11: Subhumid areas at mid-altitudes on acid soils at mid-latitudes										
DR Congo:	Kasai	L	L	L	N	N	L	L	M	L
Madagascar:	Central	L	L	M	N	M	L	M	L	N
Zambia:	North-east	L	L	M	L	M	L	M	L	L
AFBE 12: Semi-arid areas at mid-altitudes on acid soils at mid-latitudes										
Madagascar:	Following rice	L	L	H	N	N	L	L	M	N
Zambia:	N central and NW	L	L	M	N	N	M	M	L	N
Swaziland:	High and mid-veld	L	M	L	N	N	H	M	L	N
AFBE 13: Lowlands at mid-latitudes										
Algeria:	Northern	L	M	H	N	N	NA	NA	L	N
Cape Verde:		M	NA	NA	NA	NA	NA	M	M	NA
Egypt:	Nile Delta	L	M	H	N	N	N	N	L	N
Guinea:	Guinea	NA	H	NA	NA	NA	NA	NA	NA	NA
Madagascar:	Toliary	L	N	H	N	N	N	N	L	N
	Mahajanga	L	N	H	N	N	N	N	L	N
Malawi:	Lake basin (rm)	M	M	N	L	N	N	M	L	N
	Phalombe Plains	M	M	N	L	N	N	M	L	N
Mauritius:	(Irrigated)	L	L	H	N	N	L	L	L	N
Morocco:	North	L	L	H	N	N	N	N	L	N
Mozambique:	Southern (rm)	NA	NA	NA	NA	NA	NA	NA	NA	NA
S Af Rep:	Cape Province (irrig.)	N	M	L	N	N	H	N	N	N
Sudan:	Northern (irrig.)	N	L	H	N	N	L	L	L	N
Togo:	Atakpame	NA	L	L	NA	NA	NA	NA	NA	NA
Tunisia:	Northern	L	M	H	N	N	NA	NA	L	N
AFBE 14: Lowlands at low latitudes										
Burundi:	Imbo Plains	L	L	L	M	L	L	L	H	L
DR Congo:	Bas-Zaire (rm)	L	M	M	NA	NA	NA	NA	NA	NA
Tanzania:	Morogoro	L	L	L	M	H	L	L	M	L

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. DRK = large reds, dark red kidneys, and Canadian Wonder types; SW = small white and Navy; WH = other white types; CAL = Calima/Rosecoco; PUR = purple types, including 'Kablanketi' and 'Mwezi Moja'; CRE = cream types, including pinto, sugar, carioca, and other cream-beige types; YEL = yellow or brown; RED = medium and small reds, and pinks; BLK = black seed types.

H = high (>25%); M = moderate (5%-25%); L = low (<5% of the beans produced) levels of importance; N = not grown or of very low importance; NA = information not available.



Bean Diseases

Bean Diseases

Bean productivity is severely constrained by diseases (Table 3, Maps 22-35, Data tables 6 and 7). Incidence and severity of diseases vary considerably from season to season, and some diseases that are usually of little economic importance can, at times, be devastating. Conversely, diseases can be conspicuous without having any appreciable effect on seed yield (Smithson 1990). Nevertheless, diseases are widespread and may reduce yields considerably. Major diseases include angular leaf spot (*Phaeoisariopsis*

Table 3. Constraints to bean production in sub-Saharan Africa ranked in descending order of importance (production losses in thousands t/y)[a].

Constraint	Sub-Saharan Africa	Eastern Africa	Southern Africa
N deficiency	389.9	263.6	125.2
Angular leaf spot	384.2	281.3	93.5
P deficiency	355.9	234.2	120.4
Anthracnose	328.0	247.4	69.8
Bean stem maggot	297.1	194.4	96.4
Bruchid	245.6	163.0	77.6
Root rot	221.1	179.8	31.0
Common bacterial blight	220.4	145.9	69.8
Exchangeable bases	220.0	152.7	65.8
Aphids	196.9	136.3	58.9
Rust	191.4	118.7	72.4
Bean common mosaic	184.2	144.6	29.9
Halo blight	181.3	121.9	56.4
Ascochyta blight	169.2	129.4	34.2
Al/Mn toxicity[b]	163.9	97.5	60.3
Water deficit, mid-season[c]	158.0	119.8	34.7
Water deficit, late[c]	144.3	100.4	42.3
Helicoverpa spp.	135.5	90.6	41.6
Ootheca spp.	116.4	76.0	35.8
Floury leaf spot	113.7	89.7	14.5
Maruca spp.	112.6	74.9	35.3
Clavigralla spp.	102.7	64.9	36.0
Water deficit, early[c]	93.7	71.0	17.6
Thrips	87.0	55.2	29.4
Fusarium wilt	74.2	56.9	13.7
Web blight	59.5	27.4	34.1
White mould	54.4	39.2	11.7
Charcoal rot	53.2	38.6	10.1
Scab	52.9	38.6	7.6

a. Estimates assume that (1) most commercial varieties have a yield potential of 3000 kg/ha, (2) losses associated with high, moderate, and low ratings are 200, 100, and 25 kg/ha, respectively, and (3) yield potential with intercropping is reduced by 60%.

b. Independent estimates of losses from Al and Mn toxicities are 112,000 and 45,600 t/y, respectively, in eastern and southern Africa.

c. Independent estimates of losses from moisture deficits are 128,300 and 20,900 t/y in eastern and southern Africa, respectively.

griseola), anthracnose (*Colletotrichum lindemuthianum*), rust (*Uromyces appendiculatus*), common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*), and bean common mosaic (caused by a virus). Economic losses are aggravated by farmers sowing late to avoid susceptible varieties being attacked by foliar diseases.

Other diseases, including halo blight (*Pseudomonas syringae* pv. *phaseolicola)* and Ascochyta blight (*Phoma exigua* var. *diversispora* and/or *Ascochyta phaseolorum*), can also cause significant crop losses, but tend to be confined to specific environments. A third group of diseases, although widespread, tends not to cause heavy losses. Many others are recorded, but occur either sporadically or locally (Allen 1995; Beebe and Pastor-Corrales 1991).

The ratings given are based on observations made by researchers in recent years. Yield loss data to support these ratings are not readily available (Wortmann 1992). An exception is common bacterial blight for which Opio (1993) estimated yield losses in Uganda as ranging from 26.6% to 61.7%, and 6.2% to 7.8%, for a susceptible and tolerant cultivar, respectively.

Table 4. The geographic distribution[a] of races of halo blight in Africa.

Country	Races found on *Phaseolus vulgaris*[b]	Additional races found on other hosts[b]
Burundi	3, 4	
DR Congo	6	
Ethiopia	4, 6	2, 7
Kenya	4, 6, 7	
Lesotho	1, 2, 6, 8	
Madagascar		1
Malawi	2, 5, 9	
Mauritius	2	
Rwanda	1, 2, 4	
S Af Rep	1, 2, 6, 8, 9	
Swaziland	6	
Tanzania	2, 3, 4, 5, 6	7, 8
Uganda	3, 4	
Zambia	2, 3, 4	
Zimbabwe	2, 6	7

a. Only includes countries where halo blight races have been positively identified.

b. Numbers refer to race types, of which nine have so far been identified.

SOURCE: Modified from Taylor et al. (1996a).

Effective disease management is further complicated by the occurrence of pathogenic variation: races of the halo blight fungus (Taylor et al. 1996a, 1996b); pathotypes of both the common mosaic virus and common mosaic necrosis virus (Mink et al. 1994; Spence and Walkey 1995; Tables 4 and 5); and high diversity in both angular leaf spot and anthracnose (Pastor-Corrales et al. 1997). The diversity of the last two pathogens is related to the bean's centres of domestication and to the wide distribution in Africa of both Andean and Mesoamerican bean groups. Numerous pathogenic types may therefore be found at a single location with differing frequencies. Evidence shows that divergent evolution of the pathogens has occurred in Africa, giving rise to pathotypes not found in Latin America (MA Pastor-Corrales, 1996, unpublished report).

Angular leaf spot, anthracnose, and common bacterial blight are major and widespread constraints to bean production at the regional and continental levels (Maps 22-24). Angular leaf spot is the most important biotic constraint in eastern and southern Africa; it is favoured by moist, warm conditions with abundant inoculum supply (Saettler 1991). Anthracnose is relatively more important at higher altitudes than at lower latitudes. Common bacterial blight is favoured by moist conditions and, as indicated by the correlation coefficient of 0.32, higher temperatures.

A complex of root-rot species is increasing in importance in eastern and central Africa and is devastating some areas of intensive bean production and low soil fertility (CIAT 1995; Otsyula et al. 1998; Map 25). The following model explains 58% of the variation in root-rot severity (RR), when severity is rated as low (1), moderate (2), and high (3) importance.

$$RR = 1.382 + 0.000654 * PD + 0.0605 * INT + 0.191 PASOIL$$

where,

PD = human population density (per km^2).

INT = percentage of area sown to beans in a year.

Table 5. The geographic distribution[a] of the pathotypes[b] comprising bean common mosaic (BCMV) and bean common mosaic necrosis (BCMNV) viruses in Africa.

Country	Pathotypes (number of isolates)				
	BCMV			BCMNV	
	I	IVb	Va	III	VIa
Burundi	1	2		8	10
DR Congo					3
Ethiopia	1	1			
Kenya			1		7
Lesotho					2
Malawi		1			7
Rwanda		2		4	22
Swaziland		1			1
Tanzania	1			2	6
Uganda	1	2			11
Zambia		1			1
Zimbabwe		2		1	2

a. Includes only countries from where BCMV or BCMNV strains have been positively identified.

b. Strains representative of pathogenicity groups: NL-1 = I; NL-7 = II; NL-8 = III; Florida = IVa; NL-6 = IVb; NY-15 = Va; NL-2 = Vb; NL-3 = VIa; NL-5 = VIb; NL-4 = VII. BCMNV pathotypes were previously referred to as Serotype A potyvirus of BCMV, consisting of temperature-independent, necrosis-inducing strains belonging to groups III, VIa, and VIb (McKern et al. 1992; Vetten et al. 1992). BCMV pathotypes were referred to as B serotypes belonging to groups I, II, IVa, Va, and VII, which do not induce necrosis, and groups IVb and Vb, which may induce necrosis at high temperatures. BCMNV strains are now regarded as belonging to a virus distinct from BCMV (Mink et al. 1994).

SOURCE: Modified from Spence and Walkey (1995).

PASOIL = a principle component that explained 31% of the variation in seven soil properties, including (with vector values) CEC (0.15), exchangeable bases (0.51), organic carbon (0.43), pH (-0.42), and available N (0.22), P (0.48), and K (0.27).

The data also indicate that prevailing root-rot complexes tend to be worse in areas with low soil pH (r = -0.34), cooler temperatures (r = -0.22), or low K supply (r = -0.18). Usually, however, root rot is most severe where intensity of bean production is high and soil fertility is low; this observation agrees well with epidemiological information from Abawi and Pastor Corrales (1990).

The model predicts that the problem has been underestimated or will soon become more severe in:

Kisii and Nyahururu in Kenya;

Morogoro, the Usambara Mountains, and localized areas of the Kilimanjaro, Arusha, and Kagera Regions in Tanzania;

Nebbi, Apac, and parts of Ntungamo in Uganda;

The Lake Kivu Basin in Rwanda;

Localities of the Imbo Plains in Burundi;

Parts of Mbala in Zambia;

The Chitipa Highlands and Shire Highlands in Malawi;

Manica and parts of Lichinga in Mozambique;

In the north-western region of the Hararghe Highlands in Ethiopia; and

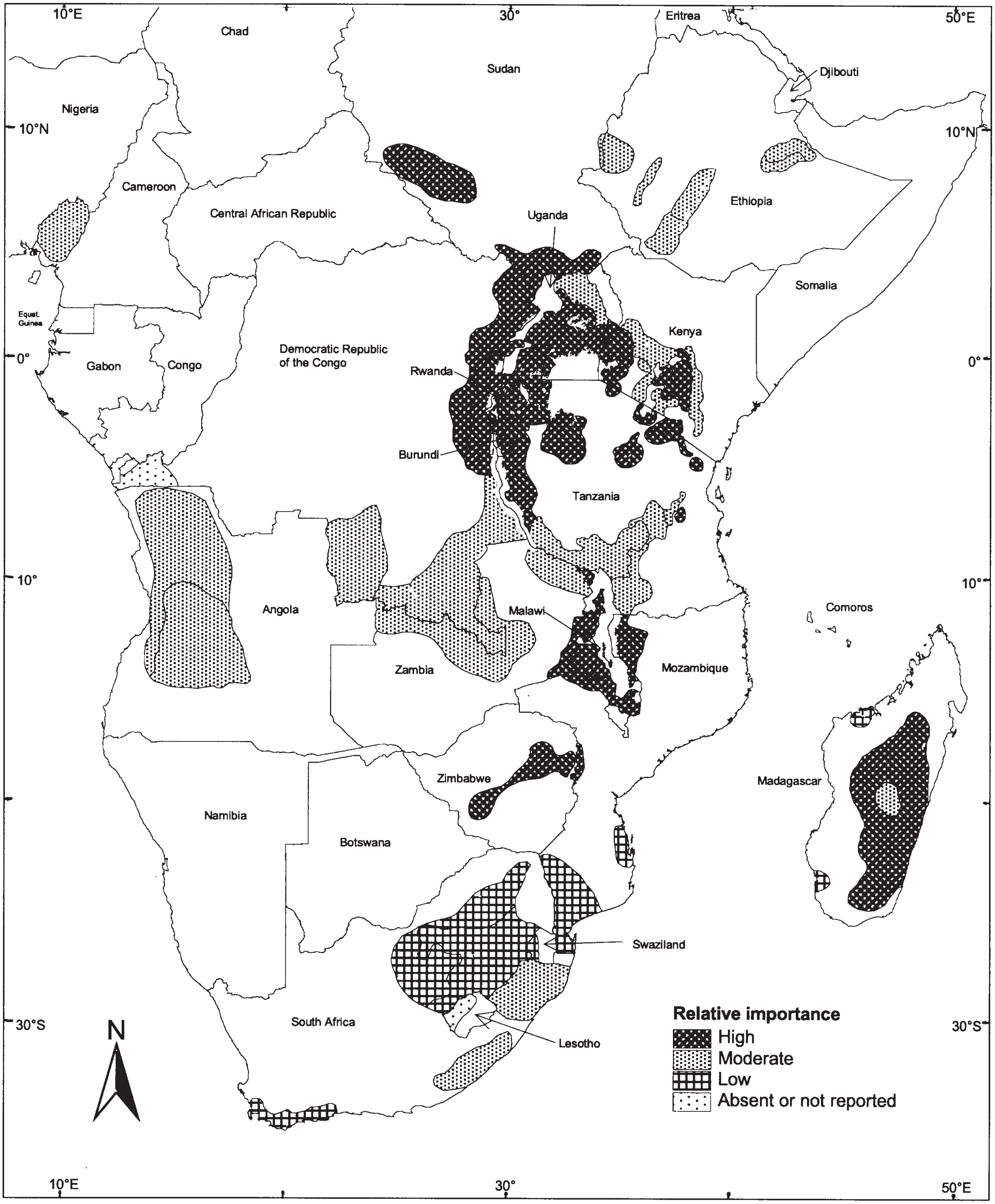
In parts of the bean production area in Cameroon.

Overall, observations agreed with predictions that areas south of latitude 20° S had no cause for alarm.

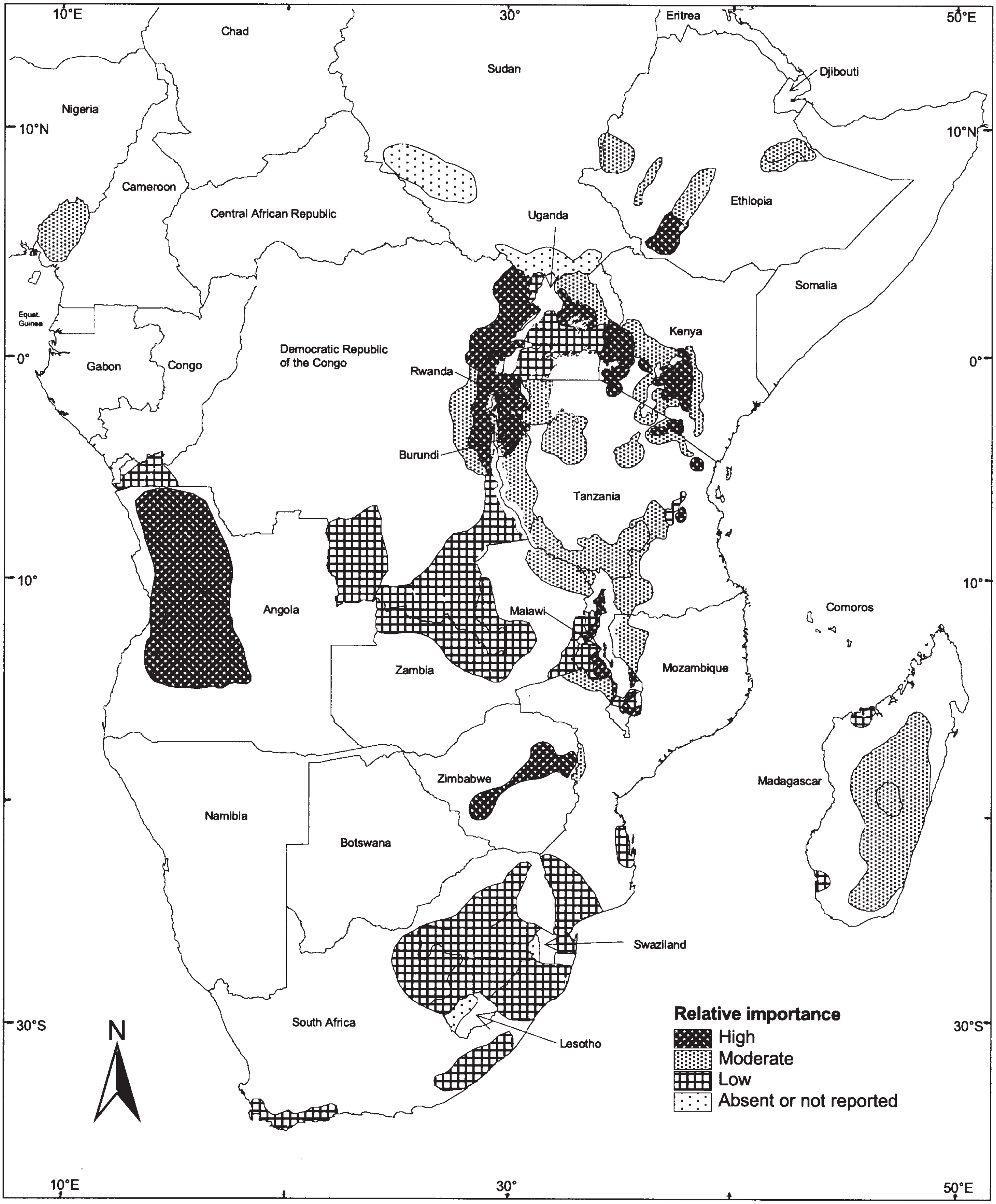
Several diseases are of moderate importance on a regional basis. Rust is more problematic in mid-latitude areas (Map 26). Severity tends to increase with soil pH

(r = 0.44), but this relationship is unexplained. Bean common mosaic (Map 27) and bean common mosaic necrosis, caused by two viruses, are more serious in eastern Africa. They are not rated of high importance wherever mean rainfall exceeds 500 mm during the season nor in southern Africa, where bean is normally grown in a single season. Halo blight (r = -0.28) and Ascochyta (r = -0.23) are important in areas of lower temperatures (Maps 28 and 29).

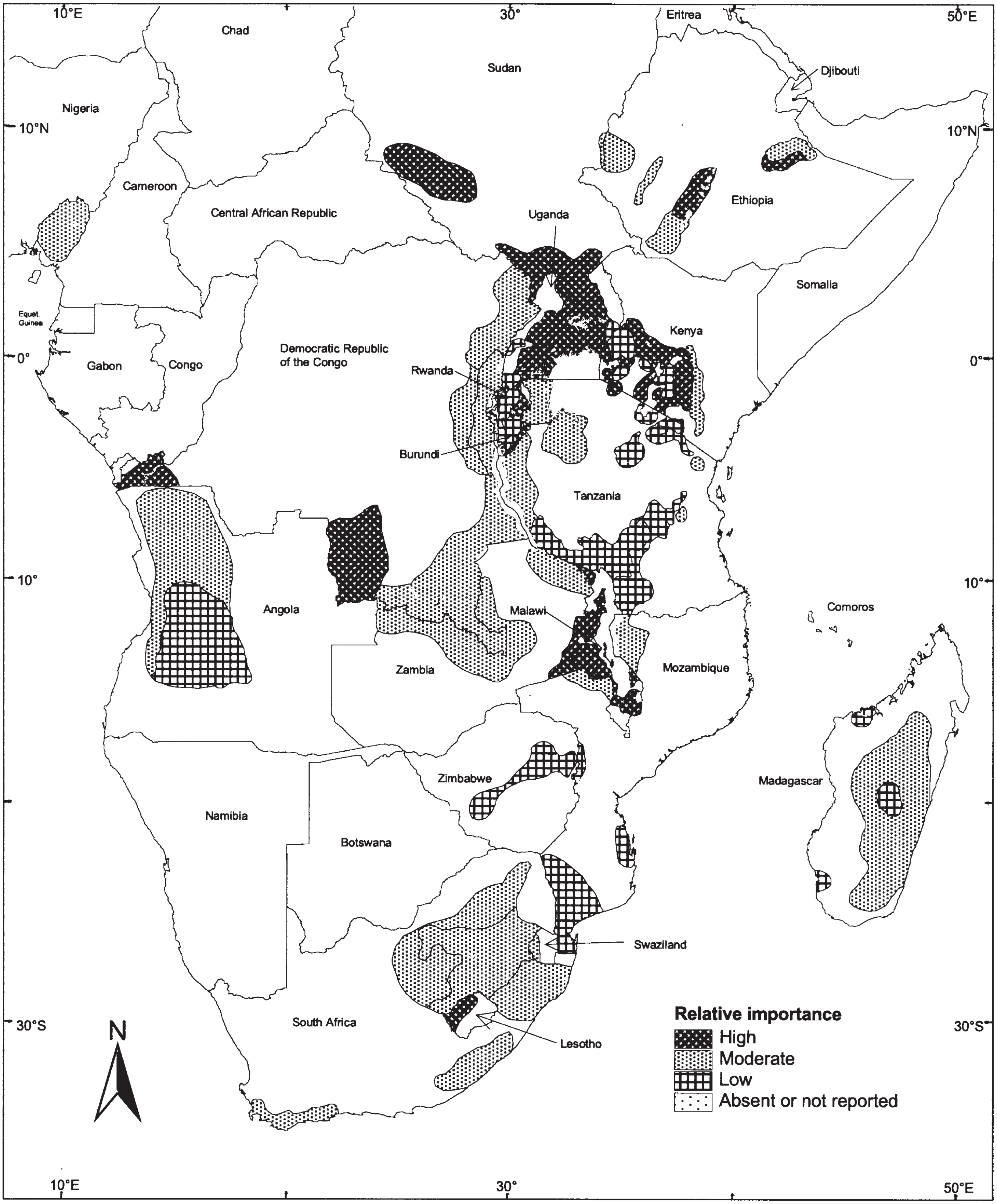
Other diseases are important only locally (Table 3). Floury leaf spot and Fusarium wilt are usually unimportant, but are more common in eastern than in southern Africa (Maps 30 and 31). Web blight incidence (Map 32) increases with rainfall (r = 0.46) and with temperature (r = 0.24). Scab is rated as highly important only in the Mbala area of north-eastern Zambia (Map 33). White mould is locally important in northern Tanzania (Map 34), and charcoal rot in the semi-arid parts of eastern Kenya (Map 35).



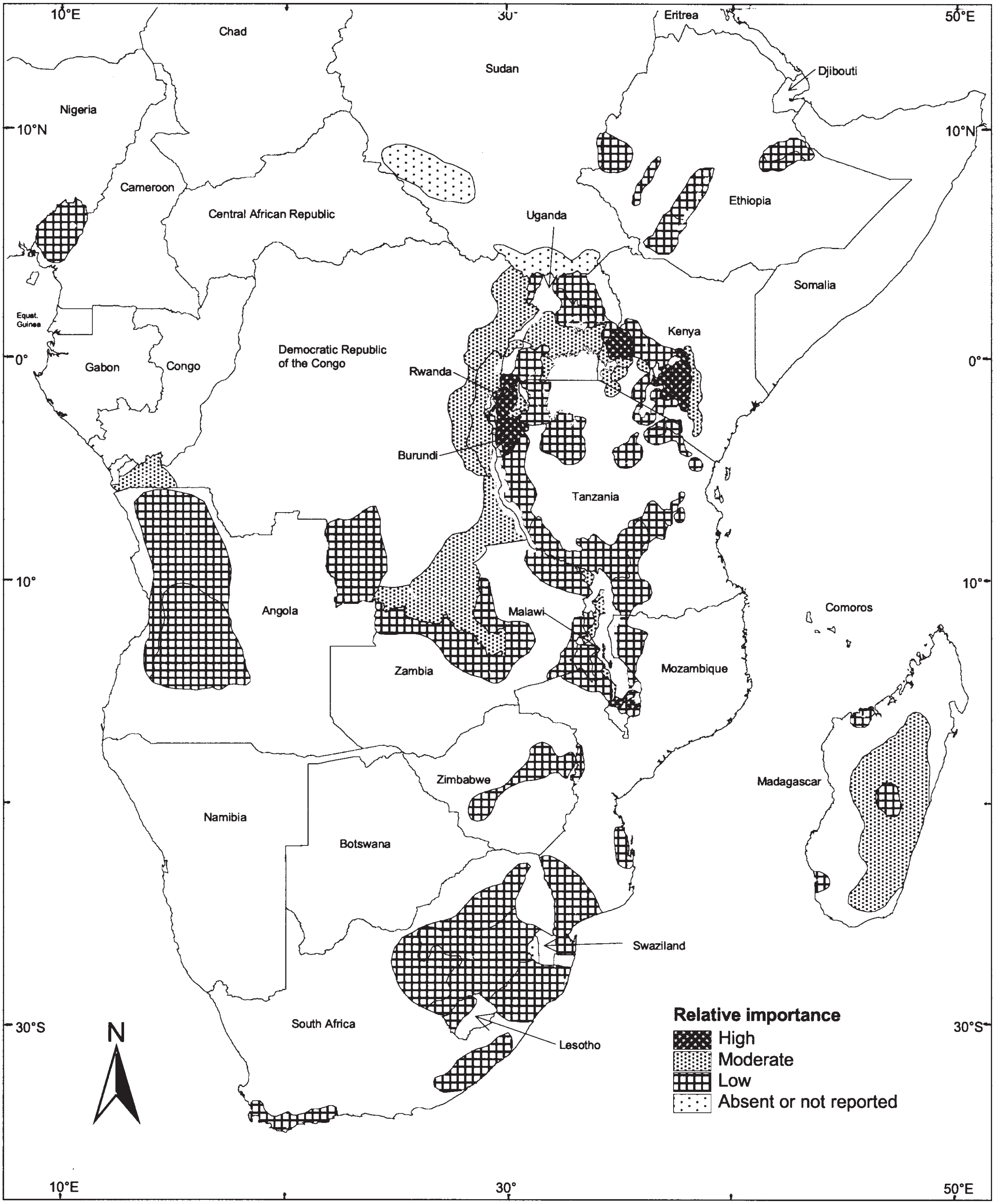
Map 22. Relative importance of angular leaf spot in bean production areas of sub-Saharan Africa.



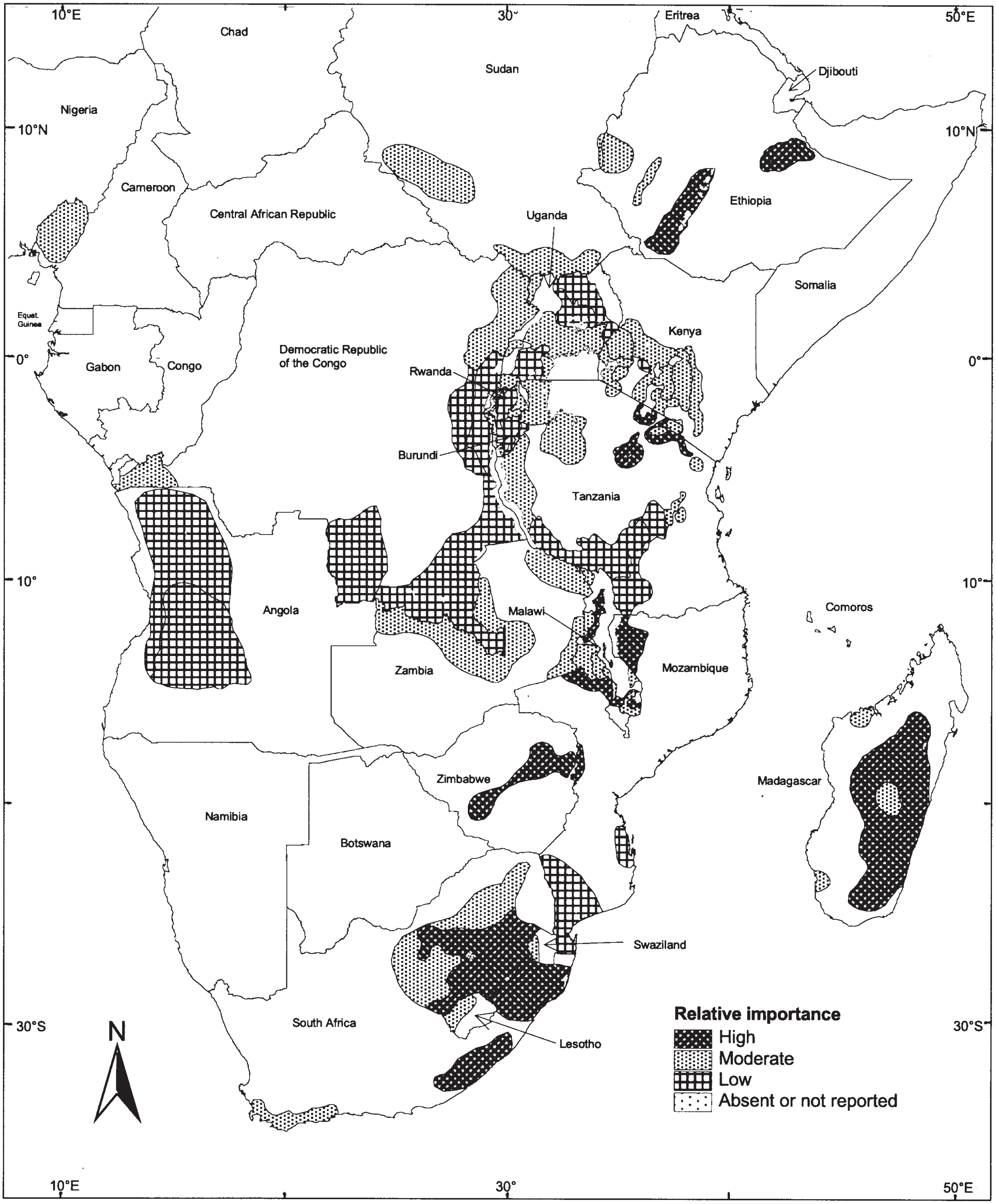
Map 23. Relative importance of anthracnose in bean production areas of sub-Saharan Africa.



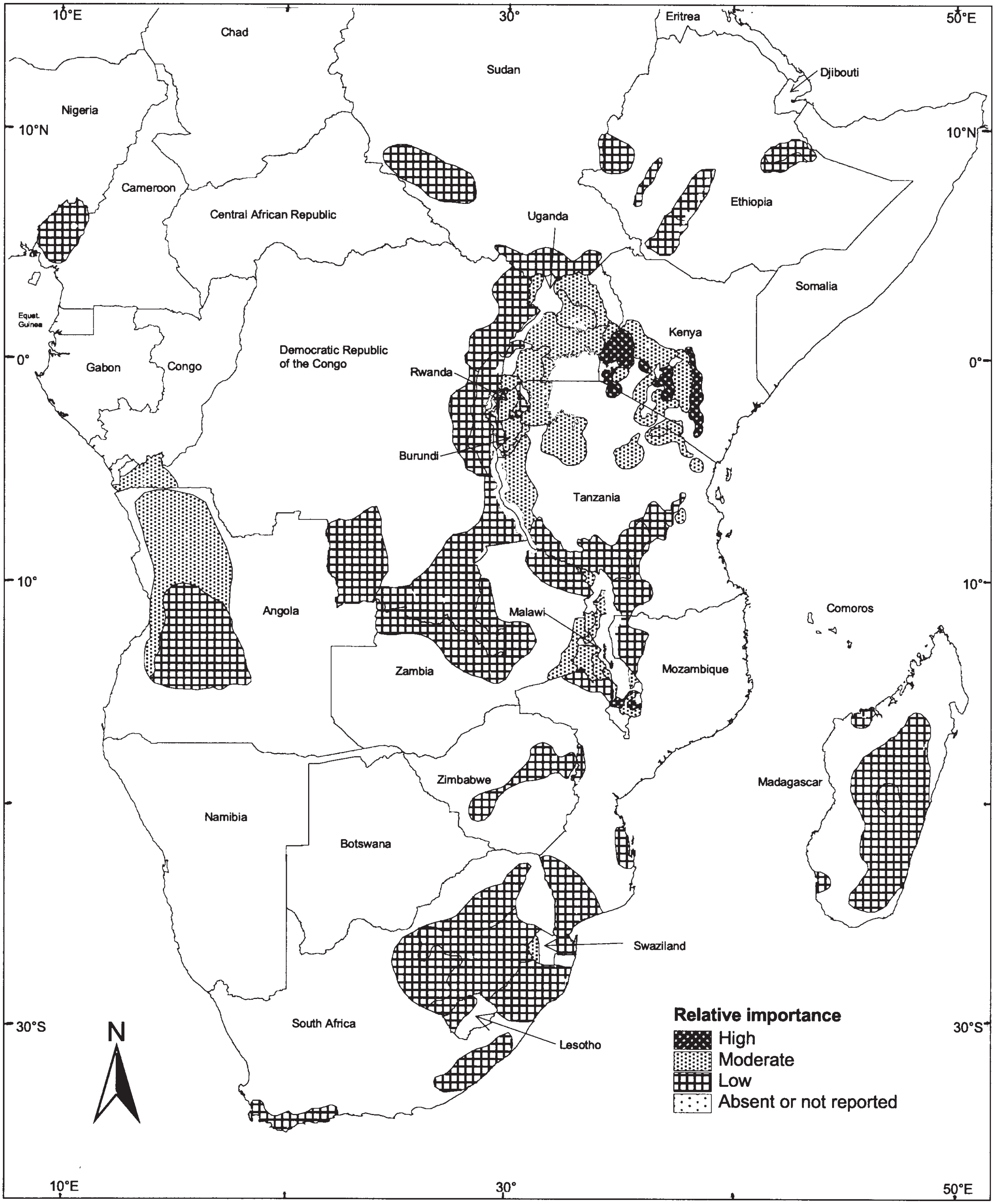
Map 24. Relative importance of common bacterial blight in bean production areas of sub-Saharan Africa.



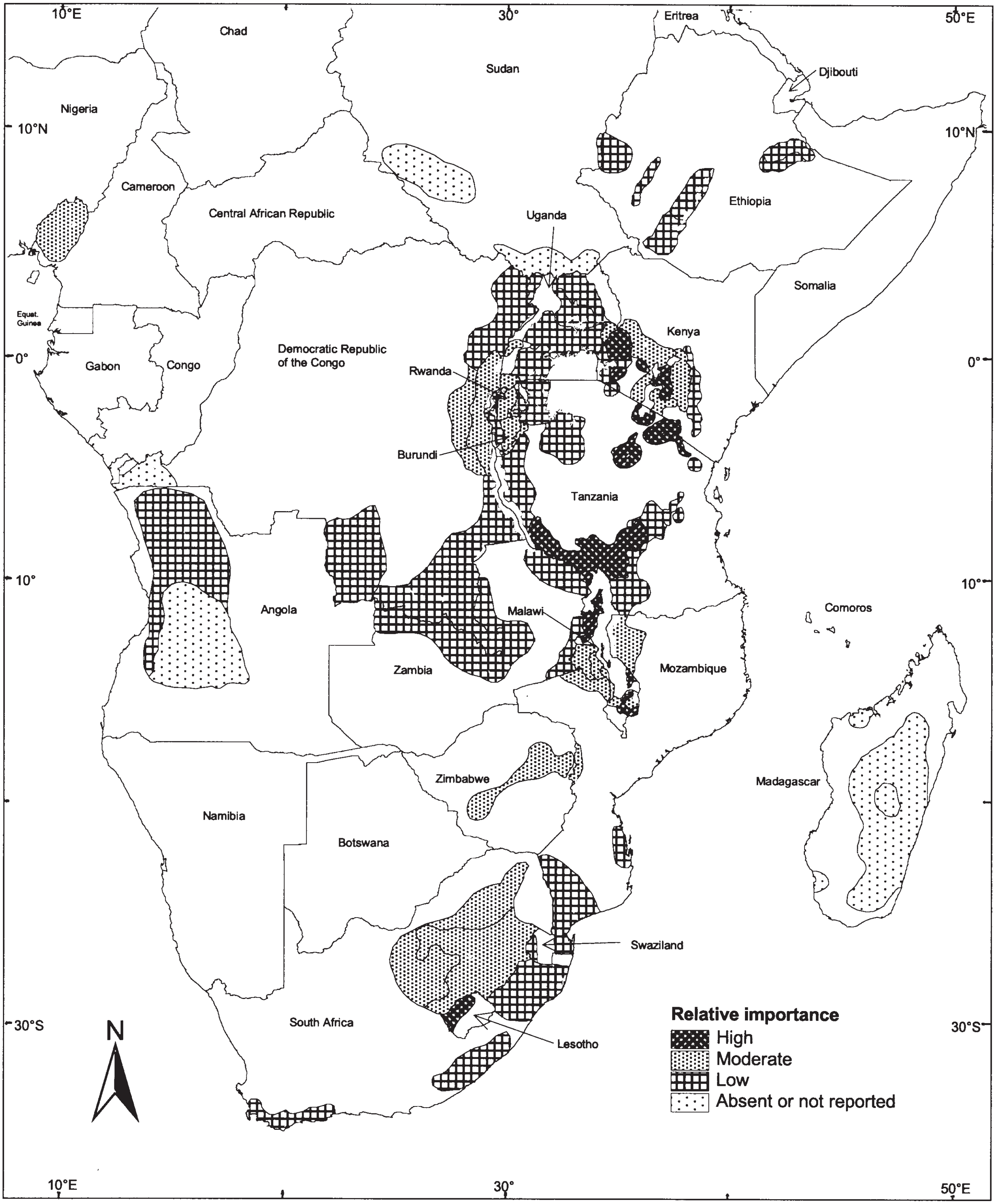
Map 25. Relative importance of root rots in bean production areas of sub-Saharan Africa.



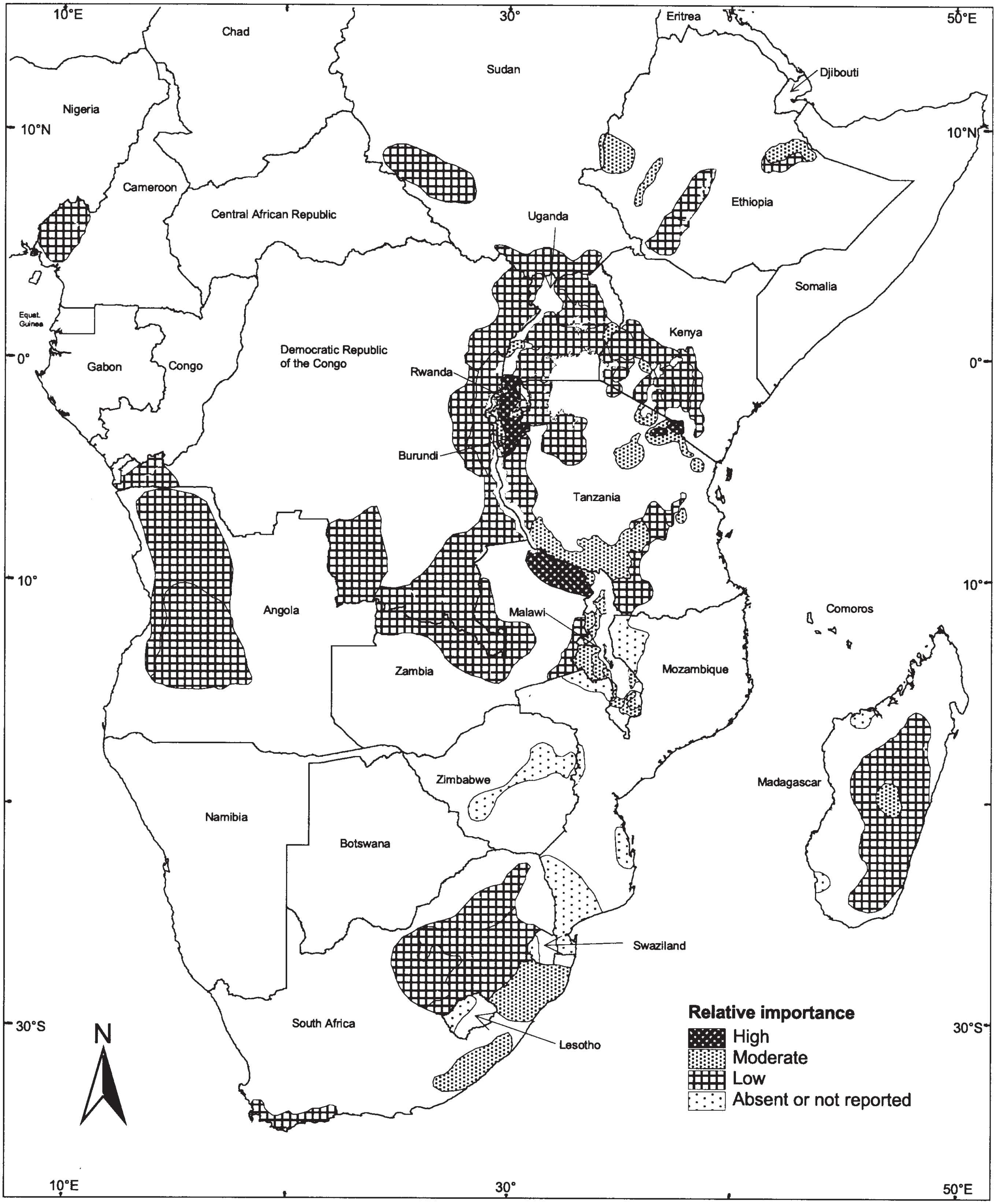
Map 26. Relative importance of rust in bean production areas of sub-Saharan Africa.



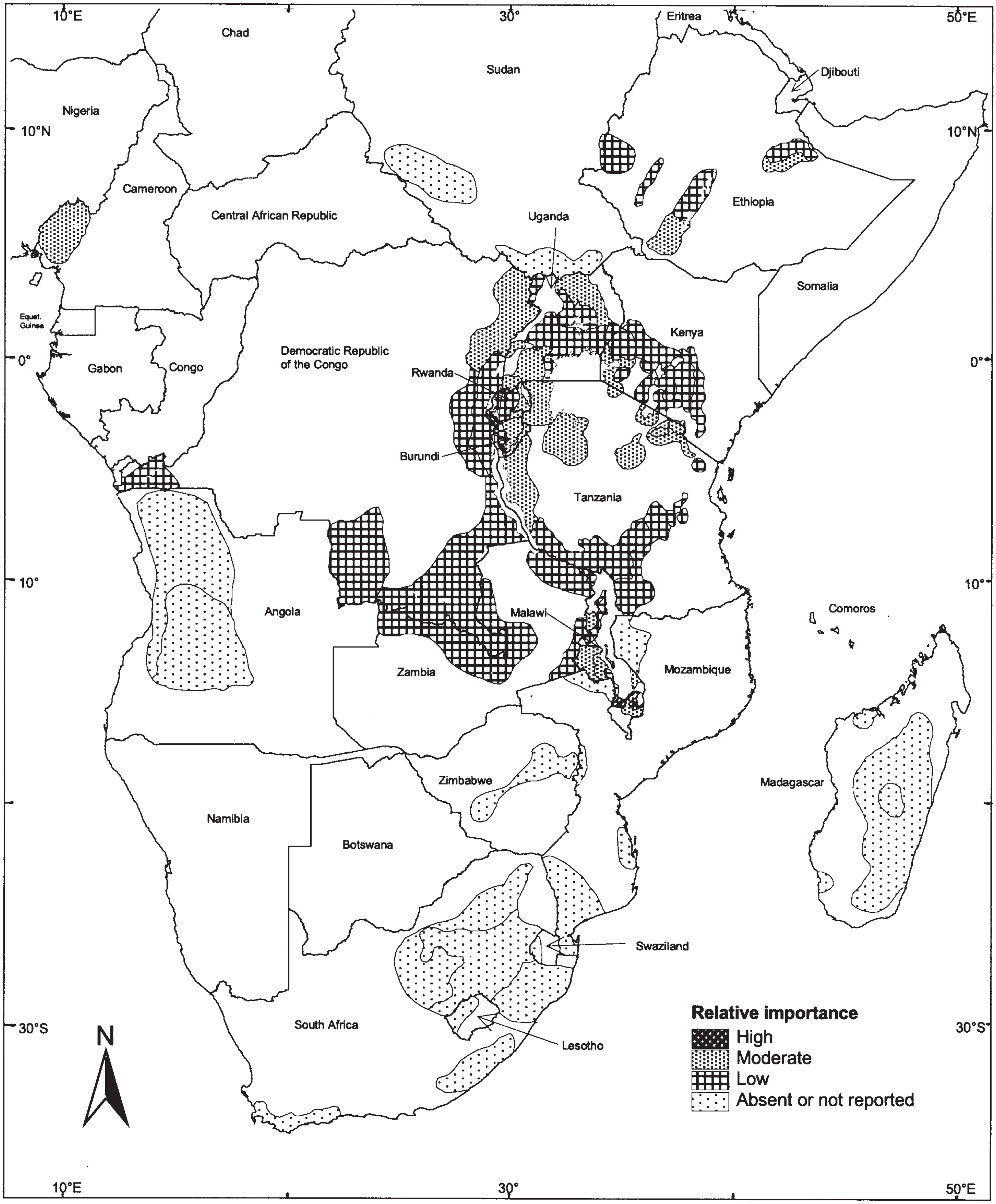
Map 27. Relative importance of bean common mosaic virus in bean production areas of sub-Saharan Africa.



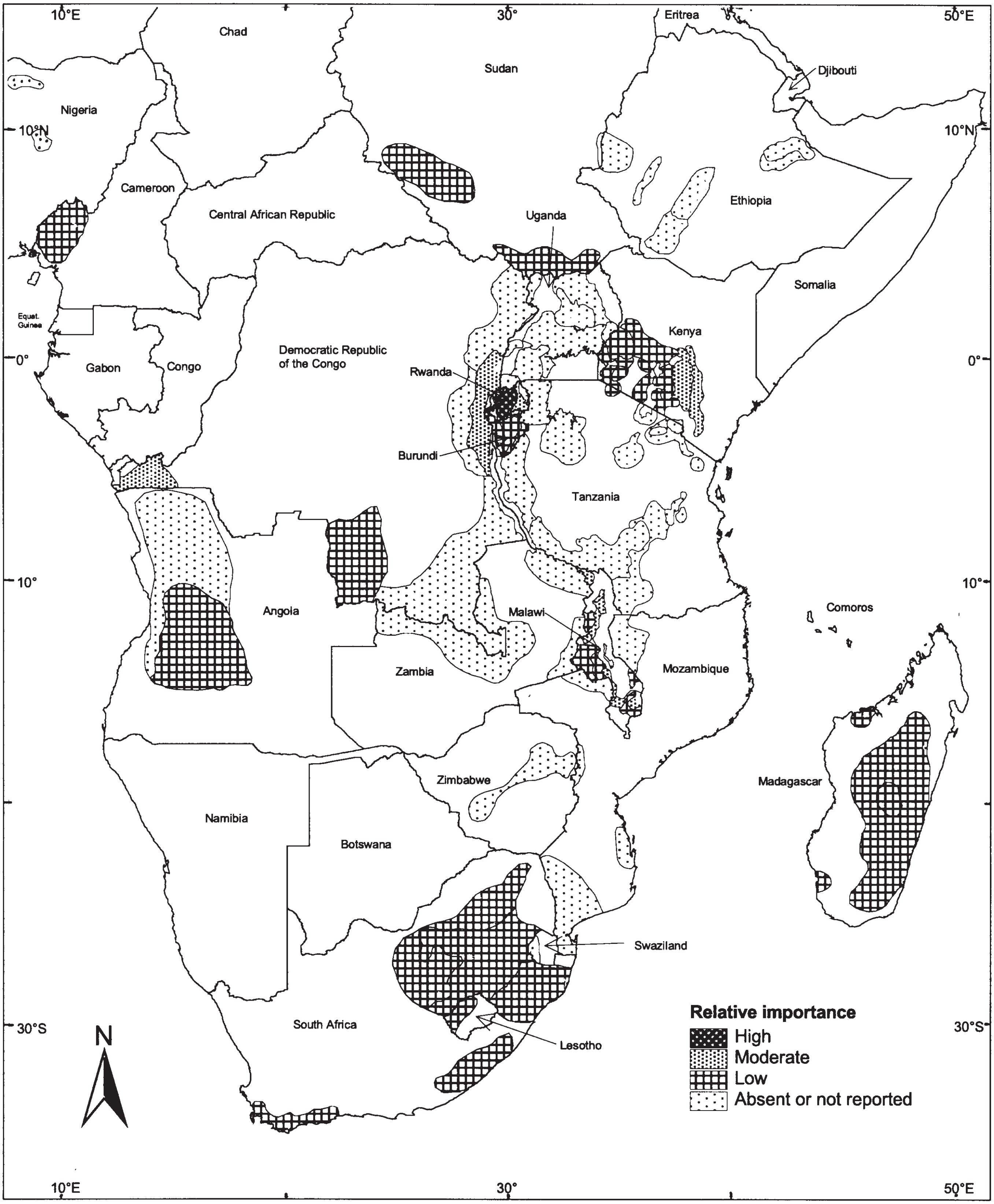
Map 28. Relative importance of halo blight in bean production areas of sub-Saharan Africa.



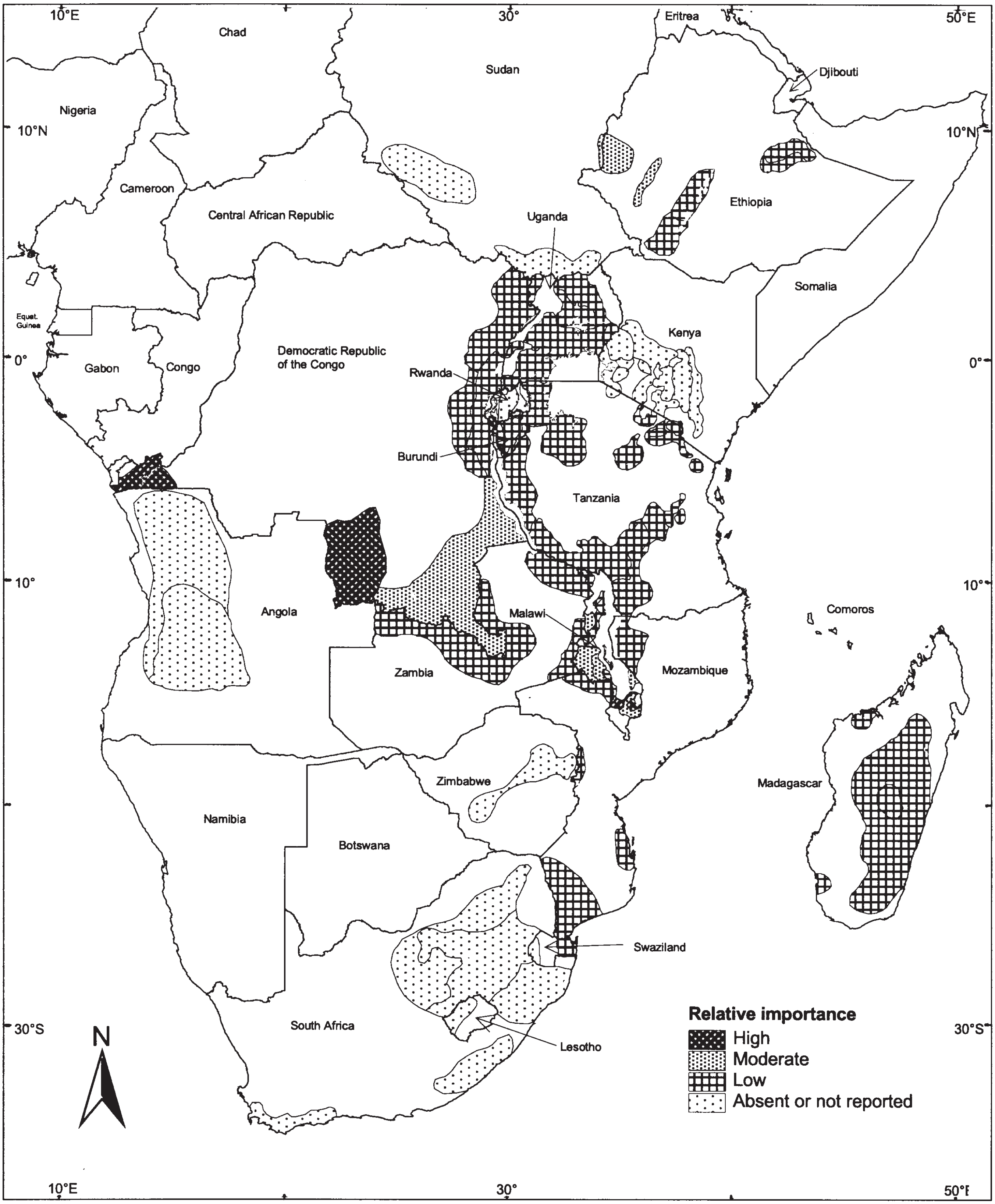
Map 29. Relative importance of Ascochyta blight in bean production areas of sub-Saharan Africa.



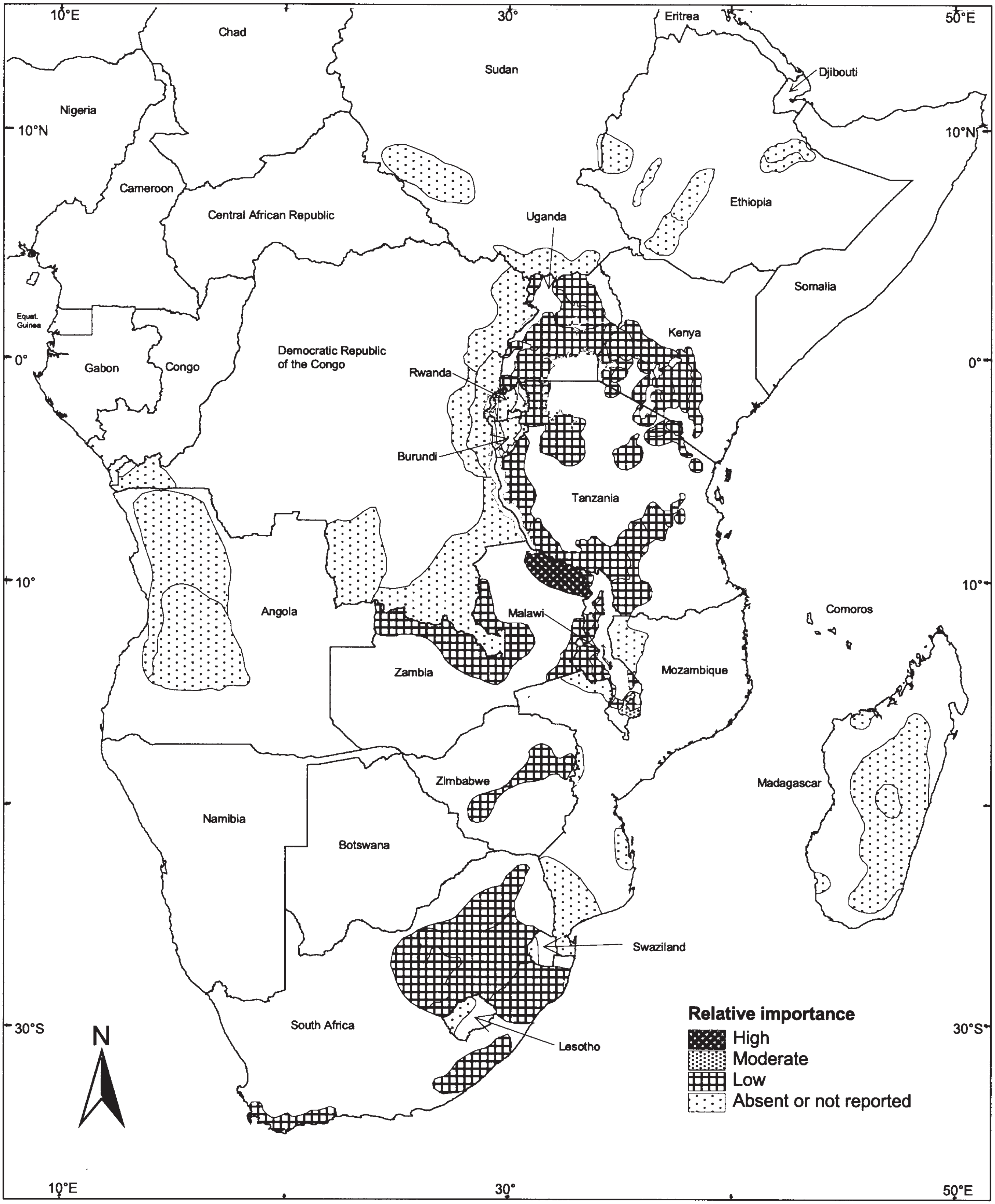
Map 30. Relative importance of floury leaf spot in bean production areas of sub-Saharan Africa.



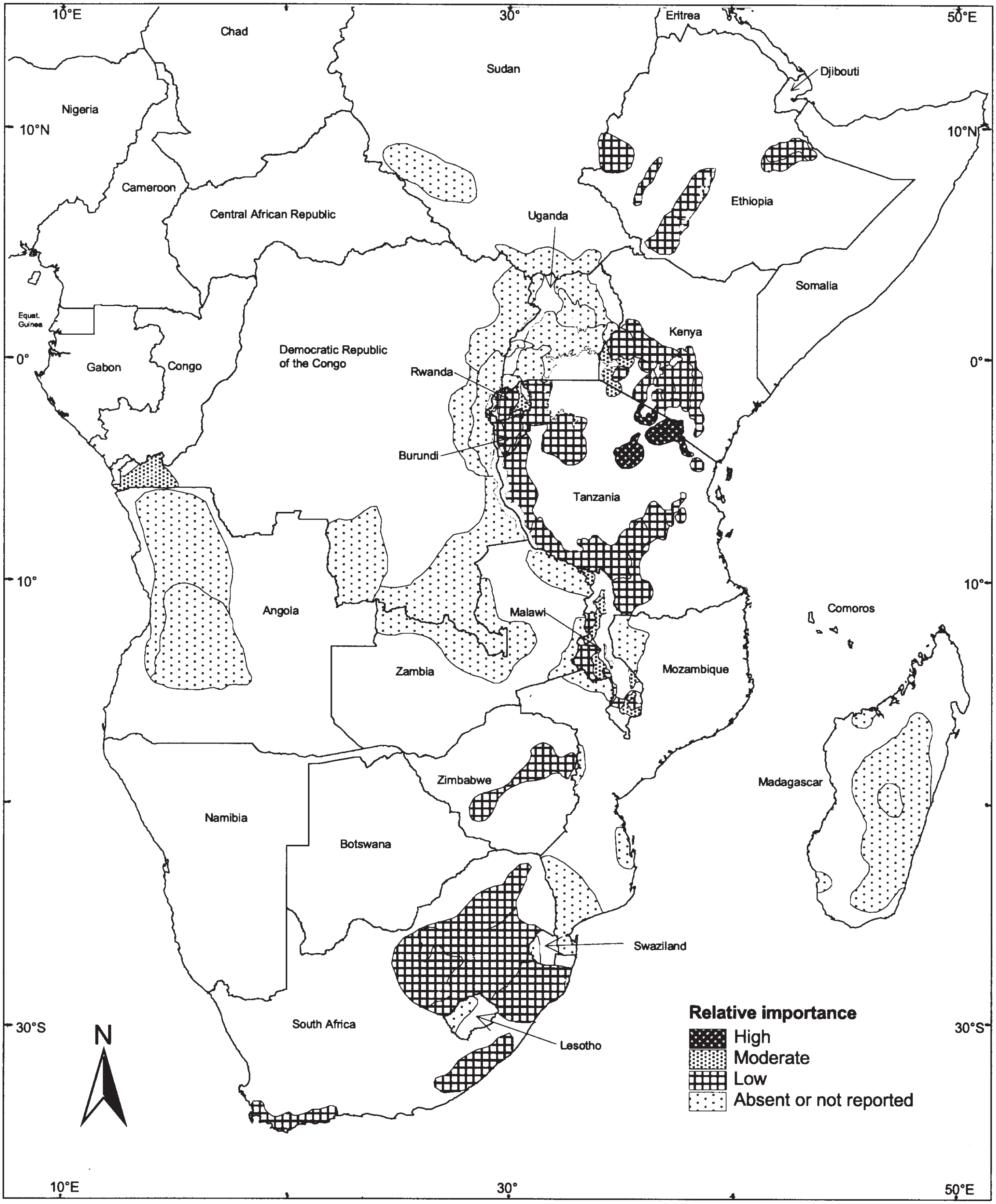
Map 31. Relative importance of Fusarium wilt in bean production areas of sub-Saharan Africa.



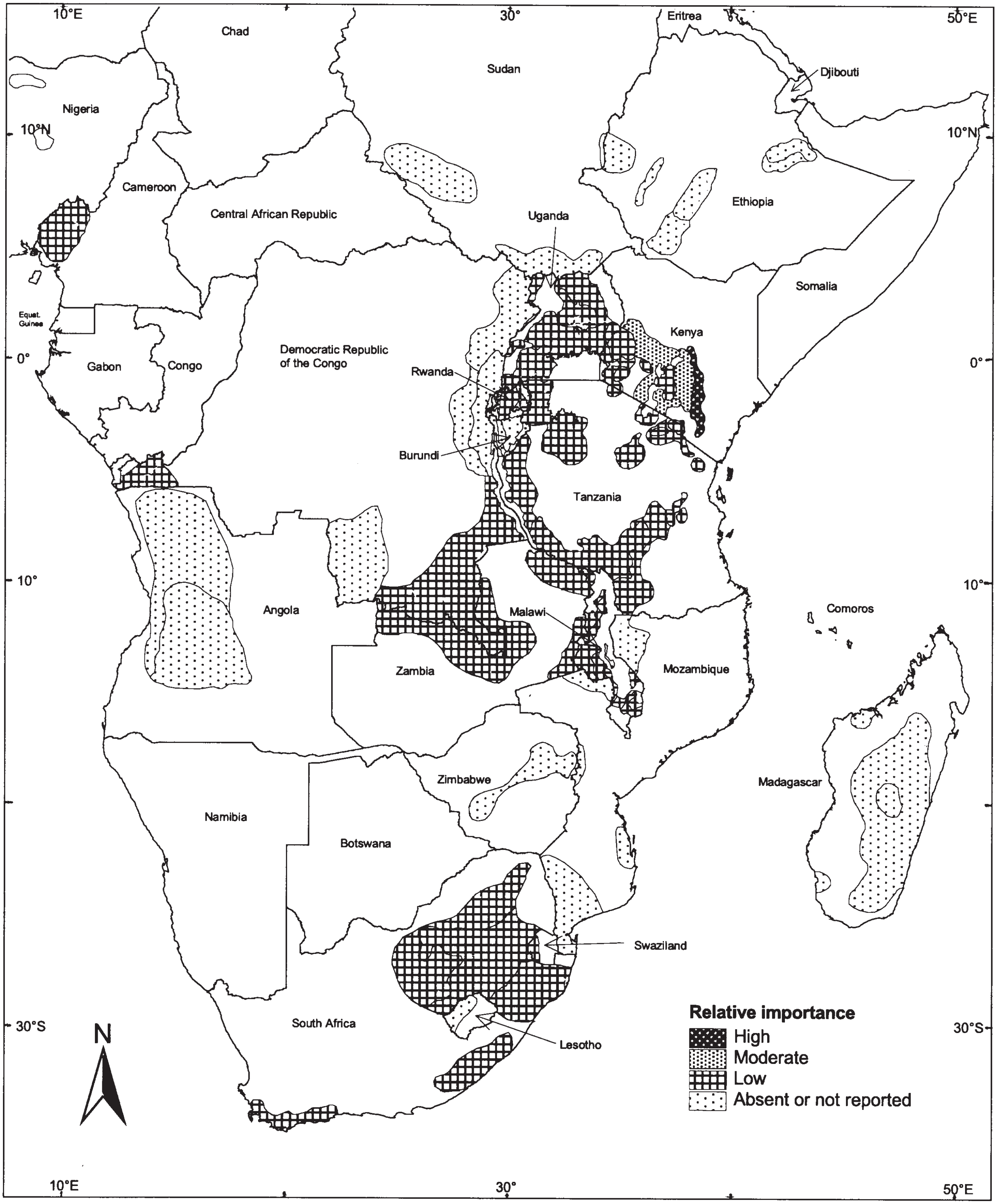
Map 32. Relative importance of web blight in bean production areas of sub-Saharan Africa.



Map 33. Relative importance of scab in bean production areas of sub-Saharan Africa.



Map 34. Relative importance of white mould in bean production areas of sub-Saharan Africa.



Map 35. Relative importance of charcoal rot in bean production areas of sub-Saharan Africa.

Data table 6. Relative importance of fungal diseases of foliage and pods in bean production areas of Africa.[a]

Bean production area		Disease[b]							
		ALS	Rust	ANT	ASC	WB	FLS	WM	Scab
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes								
Burundi:	Central Plateau	H	L	H	H	L	M	L	A
Ethiopia:	Awassa/N Sindamo	M	H	H	L	L	M	L	A
Kenya:	Central Highlands	H	M	H	L	A	L	L	L
	Western Highlands	H	M	H	L	A	L	L	L
	Kisii	H	M	H	L	A	L	L	L
Rwanda:	Central Plateau	H	L	H	H	A	L	L	A
	North-west	H	L	H	M	A	L	L	L
Tanzania:	Northern Highlands	H	M	H	H	L	M	H	L
Uganda:	South-west Highlands	H	M	H	H	L	M	A	L
	Western Highlands	H	M	H	M	L	M	A	L
	Mt. Elgon	H	L	H	M	L	L	A	L
AFBE 2:	Subhumid highlands on acid soils at low latitudes								
Burundi:	Zaire-Nile Crest	H	L	H	M	L	L	L	A
DR Congo:	South Kivu	H	L	H	L	L	L	A	A
Kenya:	Tea Zone	M	L	H	M	A	L	L	L
Rwanda:	Zaire-Nile Crest	H	L	H	M	A	L	L	A
Tanzania:	Usambara and Uluguru	H	M	H	M	L	L	L	L
AFBE 3:	Subhumid highlands at mid-latitudes								
Ethiopia:	Hararghe Highlands	M	H	M	M	L	L	L	A
	Western	M	M	M	M	M	L	L	A
Tanzania:	Southern Highlands	M	L	M	M	L	L	L	L
Zimbabwe:	High veld	H	H	H	A	A	A	L	L
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes								
Angola:	Central Highlands	M	L	H	L	A	A	A	A
Madagascar:	Antsirabe	M	M	M	M	L	A	A	A
Malawi:	Chitipa Highlands	H	M	M	M	L	L	M	L
	Livingstonia-Nyika	H	H	H	M	L	L	M	L
	North Viphya Hills	H	H	H	M	L	L	M	L
	South Viphya Hills	H	H	H	M	L	L	M	L
	Dedza-Ncheu Uplands	H	M	H	M	L	L	L	L
AFBE 5:	Semi-arid highlands at low latitudes								
Kenya:	Eastern high alt.	H	M	H	L	A	L	L	L
	Rift Valley	M	M	M	L	A	L	L	L
	Kajiado	M	M	M	L	A	L	L	L
Tanzania[c]:	N semi-arid high alt.	H	M	M	L	M	H	L	
AFBE 6:	Semi-arid highlands at mid-latitudes								
Ethiopia:	Rift Valley	M	H	M	L	L	L	L	A
Lesotho:	Foothills	A	M	A	A	A	A	A	A
S Af Rep:	High veld	L	H	L	L	A	A	L	L

(Continued)

Data table 6. (Continued.)

Bean production area		ALS	Rust	ANT	ASC	WB	FLS	WM	Scab
		Disease[b]							
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes								
Burundi:	Moso	H	M	H	M	L	M	L	A
DR Congo:	North-east	H	M	H	L	L	M	A	A
	West Kivu	H	L	M	L	L	L	A	A
Kenya:	Nyanza	H	M	H	L	A	M	M	L
Rwanda:	Lake Kivu Basin	H	L	H	M	A	L	L	L
Tanzania:	Kagera	H	M	M	L	L	M	L	L
	West (Kigoma)	H	M	M	L	L	M	L	L
	South Lake	H	M	M	L	L	M	L	L
Uganda:	North central	H	L	H	L	L	L	A	L
	NW Tall Grass Zone	H	M	L	L	L	L	A	L
	C and E Tall Grass Zone	H	M	L	L	L	L	A	L
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes								
Cameroon[c]:	North-western	M	M	M	L		M		
DR Congo:	Shaba Region	M	L	L	L	M	L	A	A
Malawi:	Mzimba Plains	H	M	L	M	M	M	L	L
	Lilongwe-Kasungu	H	M	L	M	M	M	L	L
	Dowa-Nchitsi Uplands	H	M	H	M	M	M	M	L
	Namwera Uplands	H	M	H	M	M	M	M	L
	Shire Highlands	H	M	H	M	M	M	M	M
Mozambique:	Lichinga (North)	H	H	M	A	L	A	A	A
	Tete	H	H	M	A	L	A	A	A
	Manica Highlands	H	H	M	A	L	A	A	A
Nigeria[c]:	Kano								
	Jos Plateau								
Sudan:	Southern	H	M	A	L	A	A	A	A
Tanzania:	S mid-altitudes	M	L	M	L	L	L	L	L
Zambia:	Eastern	H	M	L	L	L	L	A	L
Zimbabwe:	Mid-veld	M	L	L	A	A	A	L	L
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes								
Kenya:	Eastern mid-alt.	M	M	M	L	A	L	L	L
Rwanda:	Eastern	H	M	H	L	A	M	M	A
Tanzania:	N and E mid-alt.	H	M	M	L	L	L	L	L
Uganda:	W Short Grass Zone	H	L	L	L	L	M	A	L
	N Short Grass Zone	M	L	M	L	L	M	A	L
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes								
Angola:	Mid-altitudes	M	L	H	L	A	A	A	A
Ethiopia:	Mid-alt. Hararghe	M	H	M	L	L	M	L	A
S Af Rep:	Transkei	M	H	L	M	A	A	L	L
	Natal	M	H	L	M	A	A	L	L
	Mid-veld	L	M	L	L	A	A	L	L
Zimbabwe:	Mid-veld fringes	L	L	L	A	A	A	L	L

(Continued)

Data table 6. (Continued.)

Bean production area		Disease[b]							
		ALS	Rust	ANT	ASC	WB	FLS	WM	Scab
AFBE 11: Subhumid areas at mid-altitudes on acid soils at mid-latitudes									
DR Congo:	Kasai	M	L	L	L	H	L	A	A
Madagascar:	Central	H	H	M	L	L	A	A	A
Zambia:	North-east	M	M	M	H	L	L	A	H
AFBE 12: Semi-arid areas at mid-altitudes on acid soils at mid-latitudes									
Madagascar:	Following rice	M	M	M	L	L	A	A	A
Zambia:	N central and NW	M	M	L	L	L	L	A	L
Swaziland:	High and mid-veld	L	M	A	A	A	A	A	A
AFBE 13: Lowlands at mid-latitudes									
Algeria:	Northern	L	M	L					
Cape Verde[c]:									
Egypt[c]:	Nile Delta		L						
Guinea[c]:	Guinea								
Madagascar:	Toliary	L	M	L	A	L	A	A	A
	Mahajanga	L	M	L	A	L	A	A	A
Malawi:	Lake basin (rm)	L	L	L	L	L	L	A	L
	Phalombe Plains	H	H	L	M	H	H	L	L
Mauritius:	(Irrigated)	L	H	L	A	A	A	L	A
Morocco[c]:	North		L						
Mozambique:	Southern (rm)	L	L	L	A	L	A	A	A
S Af Rep:	Cape Province (irrig.)	L	M	L	L	A	A	L	L
Sudan:	Northern (irrig.)	L	L	A	L	A	A	A	A
Togo:	Atakpame	M	M	L	A	H	A	A	A
Tunisia[c]:	Northern	L	M	L					
AFBE 14: Lowlands at low latitudes									
Burundi:	Imbo Plains	H	M	M	L	H	H	L	A
DR Congo:	Bas-Zaire (rm)	A	M	L	L	H	L	M	A
Tanzania:	Morogoro	M	M	L	L	L	L	L	L

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. ALS = angular leaf spot, caused by *Phaeoisariopsis griseola*; ANT = anthracnose, caused by *Colletotrichum lindemuthianum*; ASC = Ascochyta blight, caused by *Phoma exigua* var. *diversispora* and/or *Ascochyta phaseolorum*; FLS = floury leaf spot, caused by *Mycovellosiella phaseoli*; rust, caused by *Uromyces appendiculatus*; scab, caused by the *Sphaceloma* state of *Elsinoe phaseoli*; WB = web blight, caused by *Thanatephorus cucumeris* or, in the imperfect state, by *Rhizoctonia solani*; WM = white mould, caused by *Sclerotinia sclerotiorum.*

The relative importance of stresses: H = high; M = moderate; L = low, associated with mean losses of 200, 100, and 25 kg/ha, respectively, assuming that yield potential is 3000 kg/ha and that intercrop yield is 40% of sole crop yield. A = absent or not reported.

c. Blank spaces = information available was insufficient at the time.

MAIN SOURCES: Allen (1995); Buruchara (1993).

Data table 7. Relative importance of various fungal, bacterial, and viral diseases in bean production areas of Africa.[a]

Bean production area		Disease[b] Charcoal rot	Root rots	Fusarium wilt	CBB	Halo blight	BCM
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes						
Burundi:	Central Plateau	A	H	L	L	M	M
Ethiopia:	Awassa/N Sindamo	A	L	A	M	L	L
Kenya:	Central Highlands	L	H	L	L	H	H
	Western Highlands	L	H	L	L	H	H
	Kisii	L	M	L	L	H	M
Rwanda:	Central Plateau	L	H	H	L	M	M
	North-west	L	L	L	L	M	L
Tanzania:	Northern Highlands	L	L	A	L	H	M
Uganda:	South-west Highlands	L	H	A	L	M	M
	Western Highlands	L	M	A	L	M	L
	Mt. Elgon	L	L	A	L	M	M
AFBE 2:	Subhumid highlands on acid soils at low latitudes						
Burundi:	Zaire-Nile Crest	A	H	L	L	L	L
DR Congo:	South Kivu	A	M	M	M	M	L
Kenya:	Tea Zone	L	M	L	L	H	H
Rwanda:	Zaire-Nile Crest	M	H	H	L	L	L
Tanzania:	Usambara and Uluguru	L	L	A	M	L	M
AFBE 3:	Subhumid highlands at mid-latitudes						
Ethiopia:	Hararghe Highlands	A	L	A	M	L	L
	Western	A	L	A	M	L	L
Tanzania:	Southern Highlands	L	L	A	L	H	L
Zimbabwe:	High veld	L	L		L	M	L
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes						
Angola:	Central Highlands	A	L	L	L	A	L
Madagascar:	Antsirabe	A	L	L	L	A	L
Malawi:	Chitipa Highlands	L	M	M	H	H	M
	Livingstonia-Nyika	L	M	M	H	H	M
	North Viphya Hills	L	M	M	H	H	M
	South Viphya Hills	L	M	M	H	H	M
	Dedza-Ncheu Uplands	L	M	M	H	H	M
AFBE 5:	Semi-arid highlands at low latitudes						
Kenya:	Eastern high alt.	M	H	M	H	M	M
	Rift Valley	M	L	L	H	M	M
	Kajiado	M	L	L	H	M	M
Tanzania:	N semi-arid high alt.	L	L	A	L	H	M
AFBE 6:	Semi-arid highlands at mid-latitudes						
Ethiopia:	Rift Valley	A	L	A	H	L	L
Lesotho:	Foothills	A	L	L	H	H	L
S Af Rep:	High veld	L	L	L	M	M	L

(Continued)

Data table 7. (Continued.)

Bean production area		Disease[b]					
		Charcoal rot	Root rots	Fusarium wilt	CBB	Halo blight	BCM
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes						
Burundi:	Moso	A	M	L	H	L	H
DR Congo:	North-east	A	M	A	M	L	L
	West Kivu	A	M	A	M	M	L
Kenya:	Nyanza	L	M	L	H	L	H
Rwanda:	Lake Kivu Basin	L	L	L	L	M	L
Tanzania:	Kagera	L	L	A	M	L	M
	West (Kigoma)	L	L	A	M	L	M
	South Lake	L	L	A	M	L	M
Uganda:	North central	L	L	A	H	L	M
	NW Tall Grass Zone	L	L	A	H	L	M
	C and E Tall Grass Zone	L	M	A	H	L	M
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes						
Cameroon:	North-western	L	L	L	M	M	L
DR Congo:	Shaba Region	L	M	A	M	L	L
Malawi:	Mzimba Plains	L	L	L	H	H	M
	Lilongwe-Kasungu	L	L	L	H	H	M
	Dowa-Nchitsi Uplands	L	L	L	H	H	M
	Namwera Uplands	L	L	L	H	H	M
	Shire Highlands	L	L	L	H	H	M
Mozambique:	Lichinga (North)	A	L	A	M	M	L
	Tete	A	L	A	M	M	L
	Manica Highlands	A	L	A	L	M	L
Nigeria[c]:	Kano						
	Jos Plateau						
Sudan:	Southern	A	A	L	H	A	L
Tanzania:	S mid-altitudes	L	L	A	L	L	L
Zambia:	Eastern	L	L	A	H	L	M
Zimbabwe[c]:	Mid-veld	L	L		H		
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes						
Kenya:	Eastern mid-alt.	H	M	M	M	L	H
Rwanda:	Eastern	L	M	M	H	L	L
Tanzania:	N and E mid-alt.	L	L	A	H	L	M
Uganda:	W Short Grass Zone	L	L	A	H	L	M
	N Short Grass Zone	L	L	A	H	L	M
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes						
Angola:	Mid-altitudes	A	L	A	M	L	M
Ethiopia:	Mid-alt. Hararghe	A	L	A	H	L	L
S Af Rep:	Transkei	L	L	L	M	L	L
	Natal	L	L	L	M	L	L
	Mid-veld	L	L	L	M	M	L
Zimbabwe:	Mid-veld fringes	L	L	L	M	L	M

(Continued)

Data table 7. (Continued.)

Bean production area		Disease[b]					
		Charcoal rot	Root rots	Fusarium wilt	CBB	Halo blight	BCM
AFBE 11: Subhumid areas at mid-altitudes on acid soils at mid-latitudes							
DR Congo:	Kasai	A	L	L	H	L	L
Madagascar:	Central	A	M	L	M	A	L
Zambia:	North-east	L	L	A	M	L	L
AFBE 12: Semi-arid areas at mid-altitudes on acid soils at mid-latitudes							
Madagascar:	Following rice	A	H	L	L	A	L
Zambia:	N central and NW	L	L	A	M	L	L
Swaziland:	High and mid-veld	L	A	A	M	L	M
AFBE 13: Lowlands at mid-latitudes							
Algeria[c]:	Northern						
Cape Verde[c]:							
Egypt[c]:	Nile Delta	M	L		L		M
Guinea[c]:	Guinea						
Madagascar:	Toliary	A	L	L	L	A	L
	Mahajanga	A	L	L	L	A	L
Malawi:	Lake basin (rm)	A	L	A	L	L	L
	Phalombe Plains	L	H	M	H	M	H
Mauritius:	(Irrigated)	L	L	A	L	L	L
Morocco[c]:	North						M
Mozambique:	Southern (rm)	A	L	A	L	L	L
S Af Rep:	Cape Province (irrig.)	L	L	L	M	L	L
Sudan:	Northern (irrig.)	M	A	L	L	L	L
Togo[c]:	Atakpame						
Tunisia[c]:	Northern						M
AFBE 14: Lowlands at low latitudes							
Burundi:	Imbo Plains	A	L	L	M	L	L
DR Congo:	Bas-Zaire (rm)	L	M	M	H	A	M
Tanzania:	Morogoro	L	L	A	L	L	L

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. BCM = bean common mosaic, caused by the bean common mosaic and bean common mosaic necrosis viruses; CBB = common bacterial blight, caused by *Xanthomonas campestris* pv. *phaseoli*; charcoal rot, caused by *Macrophomina phaseolina*; Fusarium wilt or vascular wilt, caused by *Fusarium oxysporum*; halo blight, caused by *Pseudomonas syringae* pv. *phaseolicola* and pv. *syringae*; root rots = a complex of root and stem rots, consisting primarily of those caused by *Phythium* spp., *Rhizoctonia solani*, and *Fusarium solani*.

The relative importance of stresses: H = high, M = moderate, L = low, associated with annual mean losses of 200, 100, and 25 kg/ha, respectively, assuming that yield potential is 3000 kg/ha and that intercrop yield is 40% of sole crop yield. A = absent or not reported.

c. Blank spaces = information available was insufficient at the time.

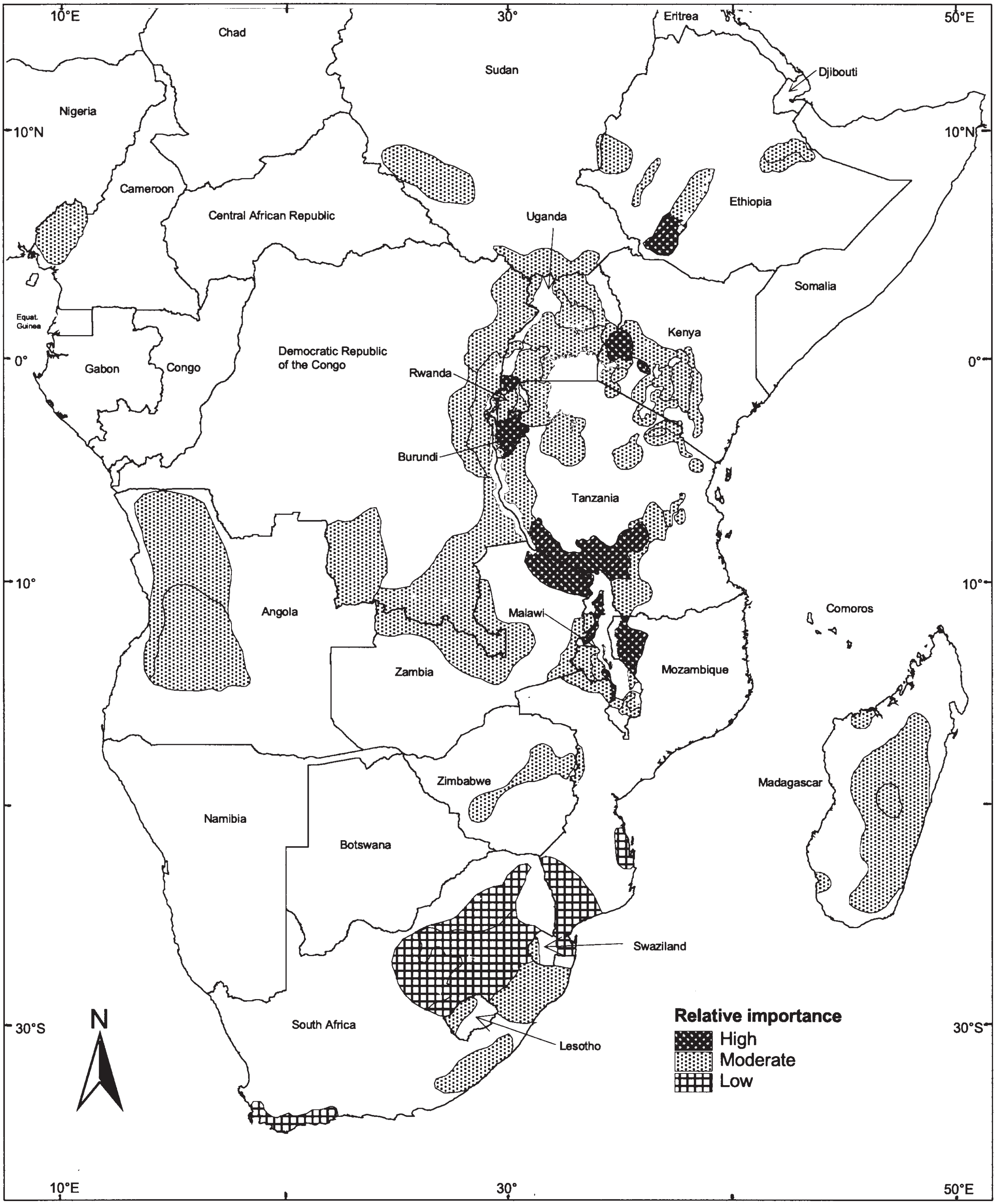
MAIN SOURCES: Allen (1995); Buruchara (1993).

Bean Insect Pests

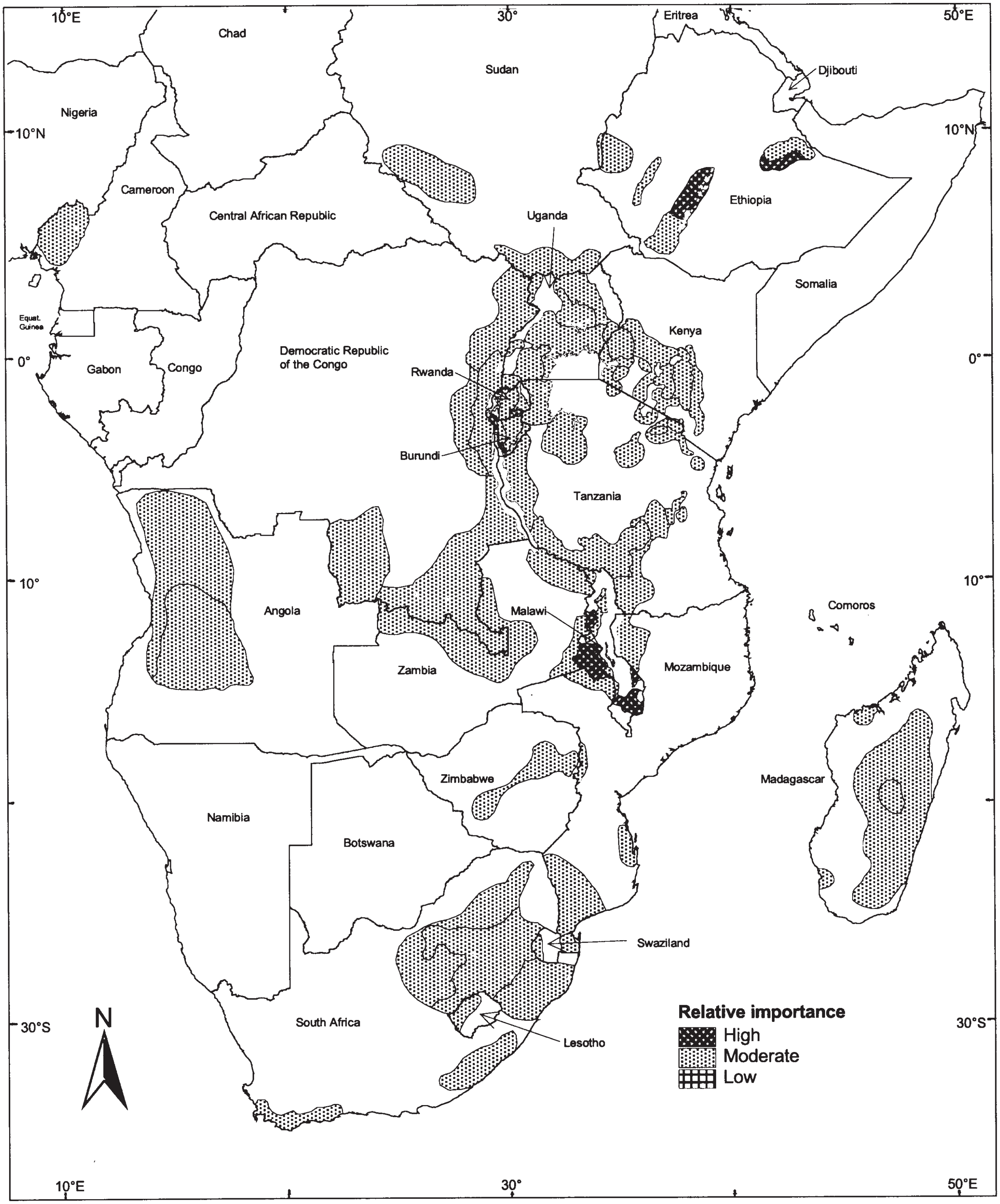
Bean Insect Pests

Several insect pests were evaluated for importance as constraints to bean production, including aphids (chiefly *Aphis fabae*); pod borers (*Helicoverpa* spp. and *Maruca testulalis*); bean stem maggot (*Ophiomyia* spp.); foliage beetles (*Ootheca* spp.); bruchids, including *Zabrotes subfasciatus* (Boheman) and *Acanthoscelides obtectus* (Say); and thrips (*Megalurothrips sjostedti*) (Data table 8). Pod bugs, mostly *Clavigralla* spp., are common pests in humid, warm environments and more problematic in southern Africa.

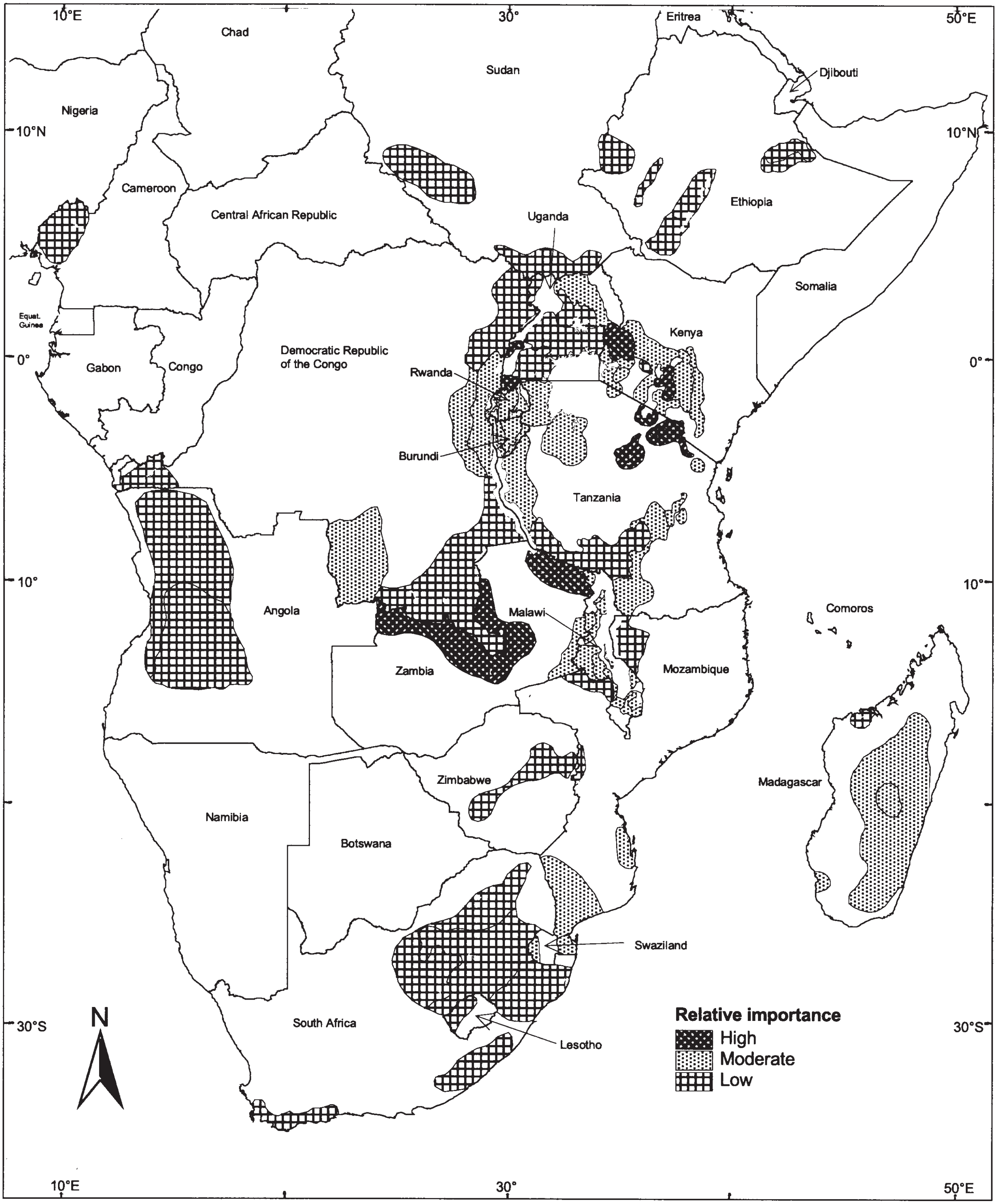
Bean stem maggot is the insect pest of greatest concern (Table 3, Map 36); it is widespread and especially serious during late planting and when conditions for seedling growth are not favourable. Bruchids cause heavy post-harvest losses and a consequent heavy loss of profit. Farmers are obliged to sell their beans immediately after harvest when prices are low. Bruchids are moderately important, at least, in all areas, and become highly important under warm conditions with a single growing season (Map 37). The importance of aphids is sometimes underestimated because their role in transmitting the bean common mosaic virus is not sufficiently recognized. Aphids are found throughout Africa (Map 38). The importance of thrips is also underestimated, because these small insects often go undetected (Map 39). Important pod and seed feeders are *Helicoverpa*, *Maruca*, and *Clavigralla*; these occur widely and usually are either unimportant or moderately important (Maps 40-42). *Ootheca* is also widespread and, occasionally, a significant pest (Map 43). Some pests are locally important, including whitefly (*Bemisia tabaci*) in northern Sudan; *Apoderus humeralis* ('le cigar', a bean leafroller) and *Pyrameis cardui* in Madagascar (Rabary 1993); and the Meloids (pollen and blister beetles, often referred to as 'CMR beetles') in Lesotho, Swaziland, and South Africa.



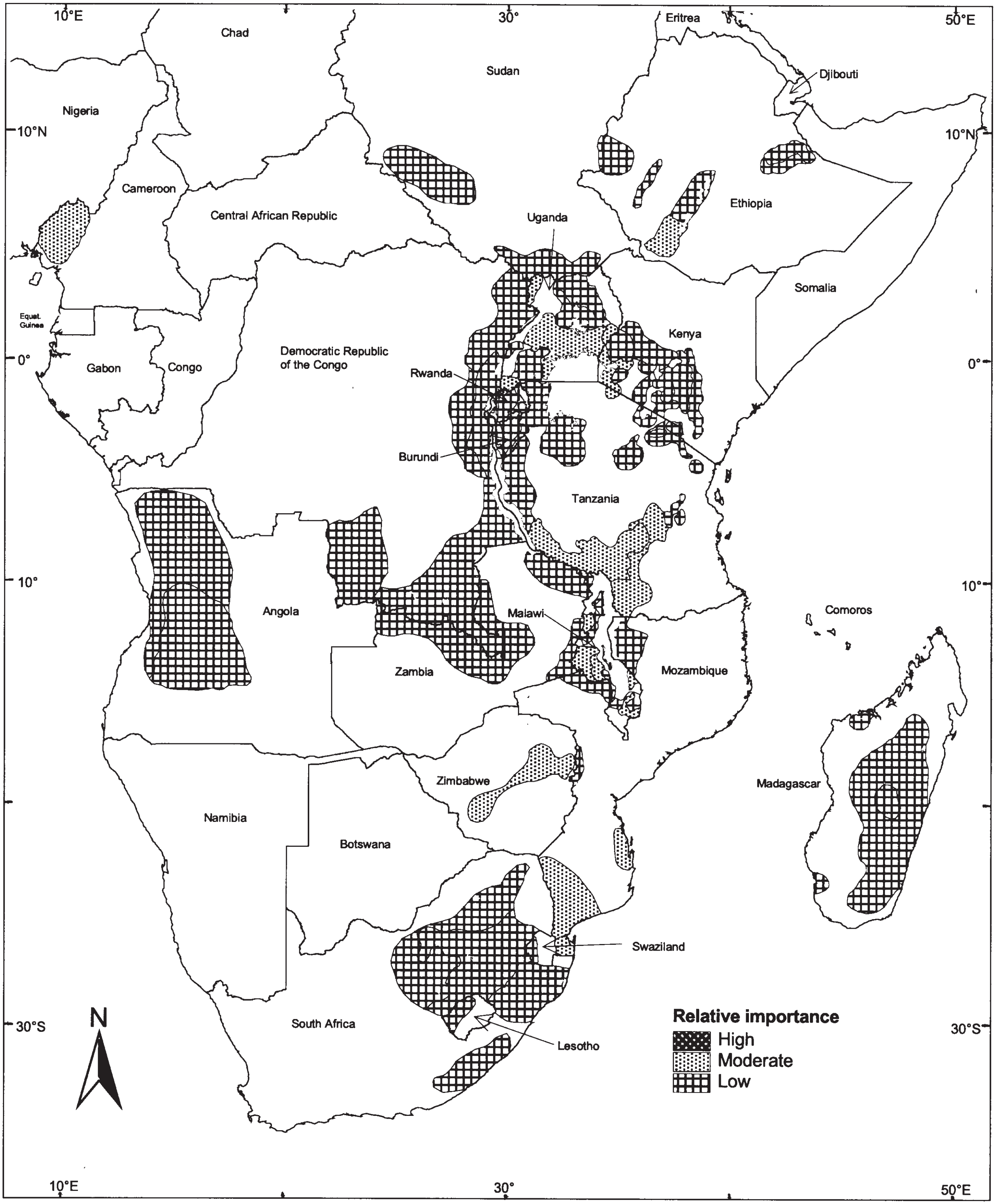
Map 36. Relative importance of the bean stem maggot in bean production areas of sub-Saharan Africa.



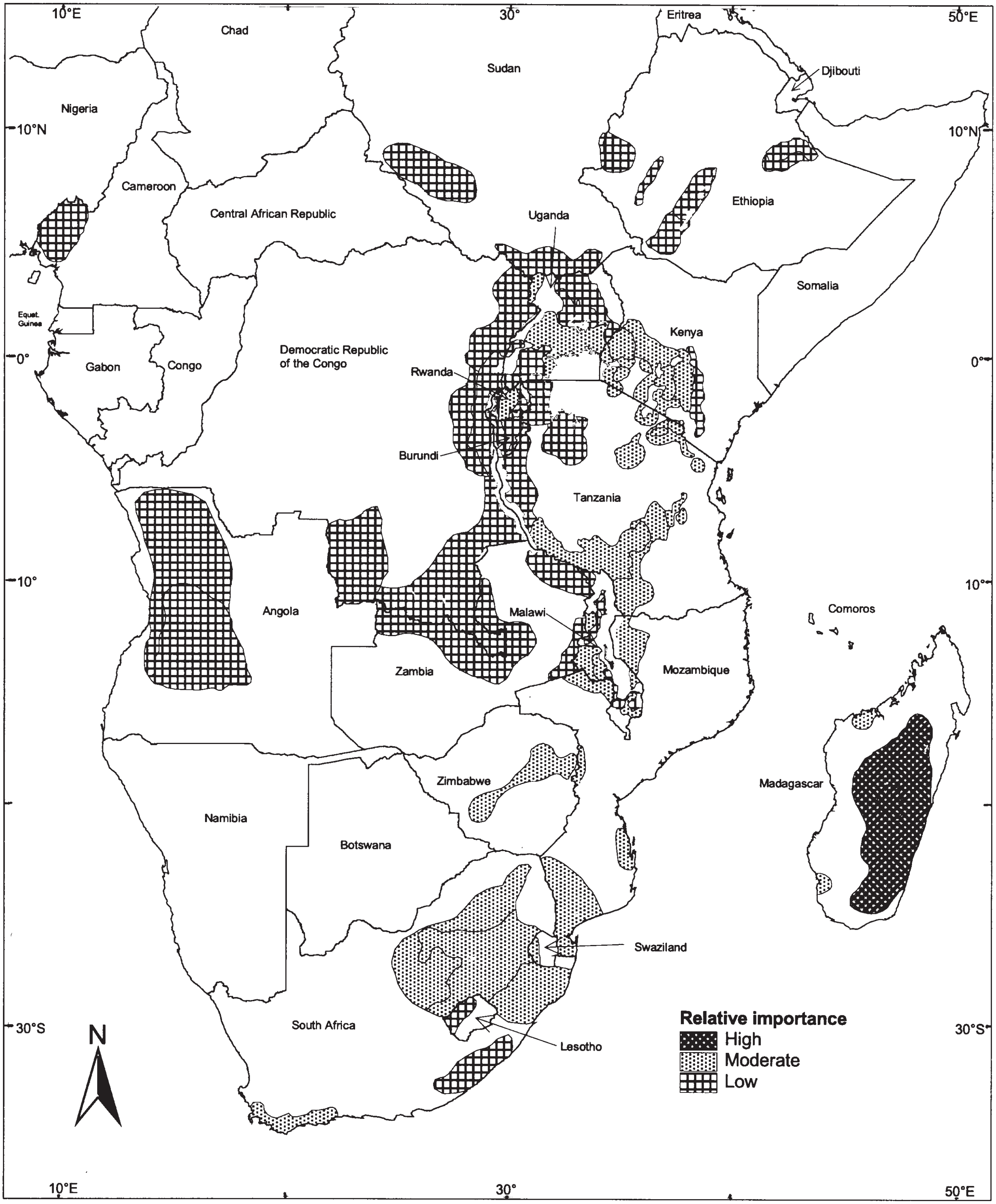
Map 37. Relative importance of bruchids in bean production areas of sub-Saharan Africa.



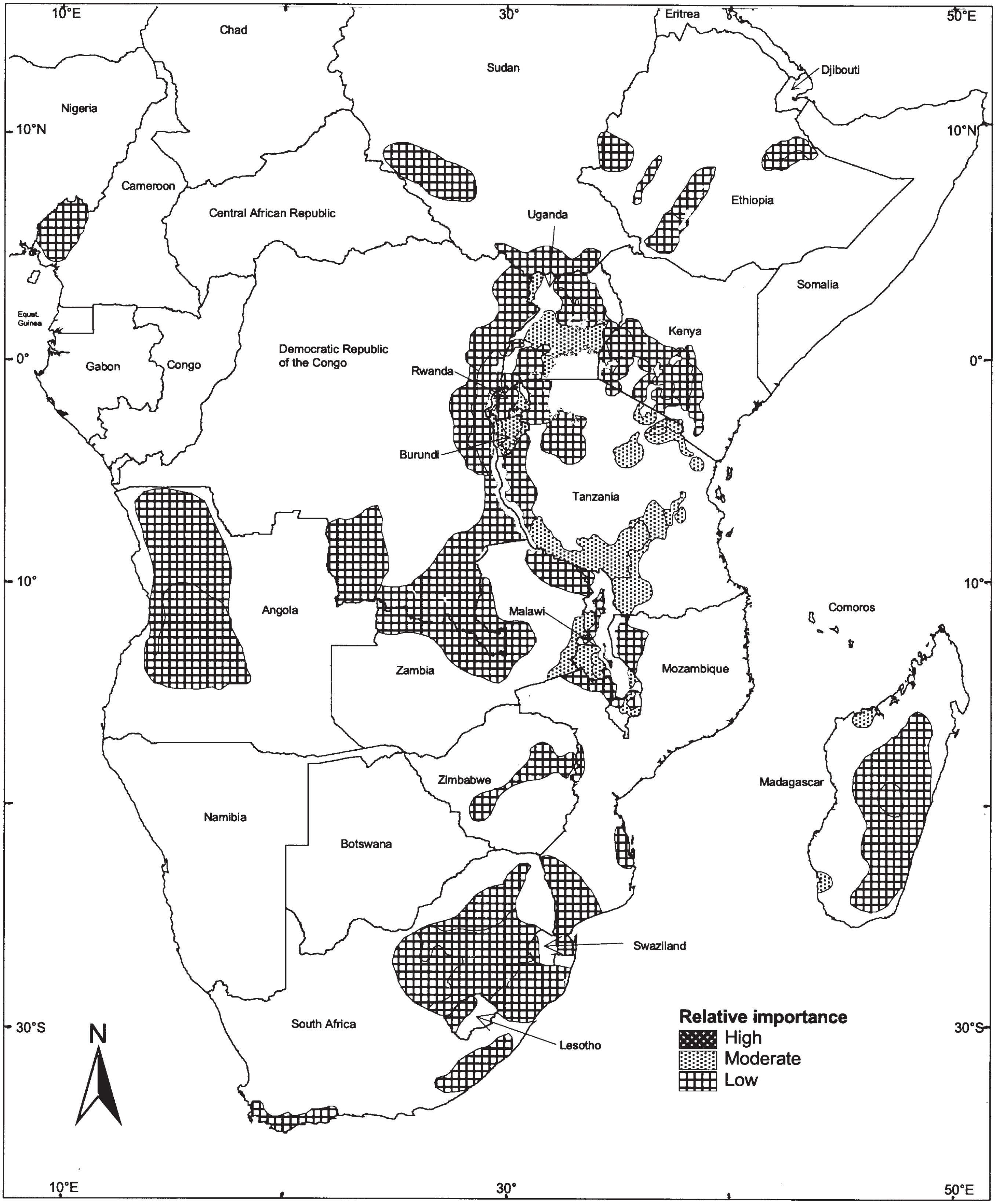
Map 38. Relative importance of aphids in bean production areas of sub-Saharan Africa.



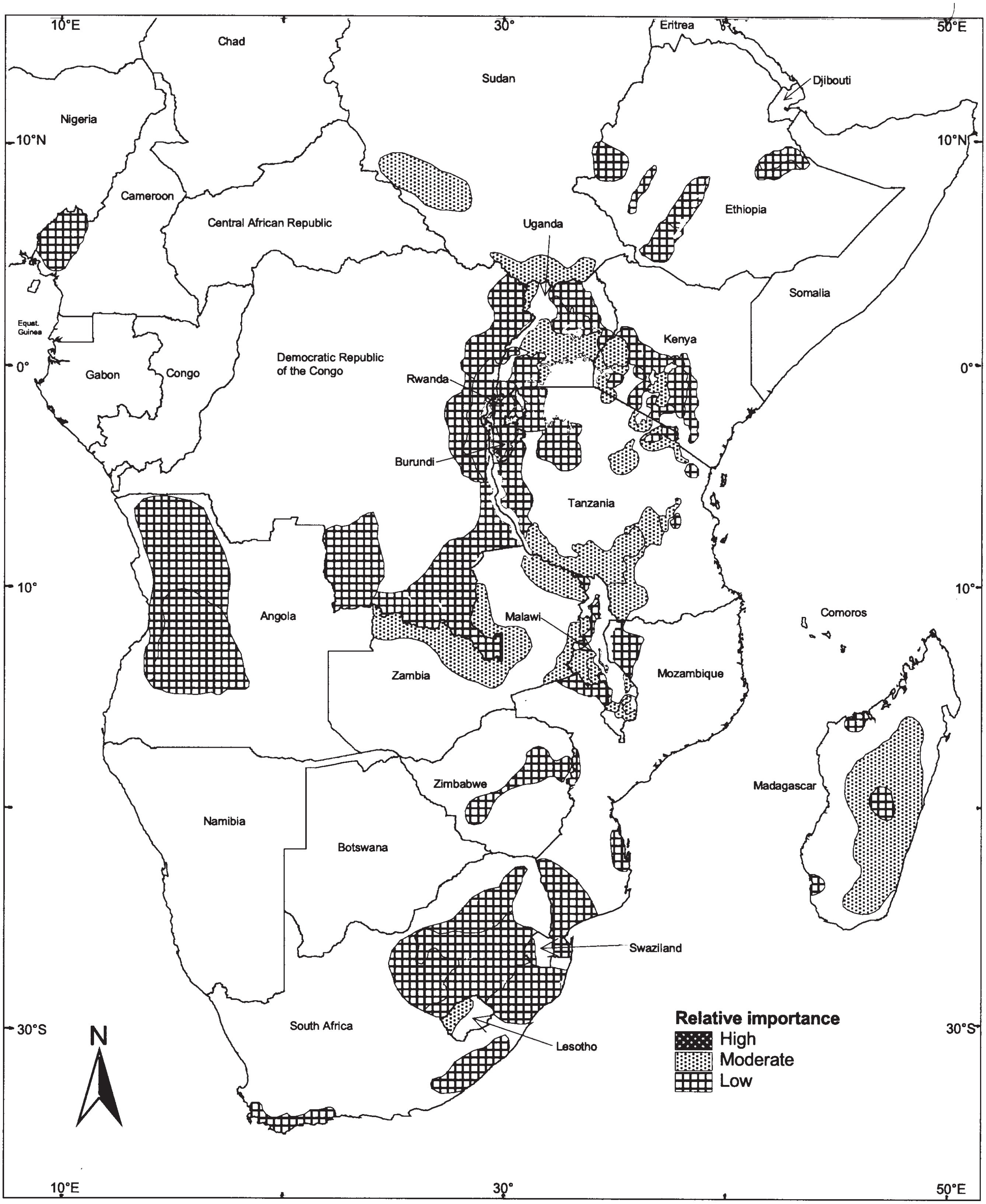
Map 39. Relative importance of thrips in bean production areas of sub-Saharan Africa.



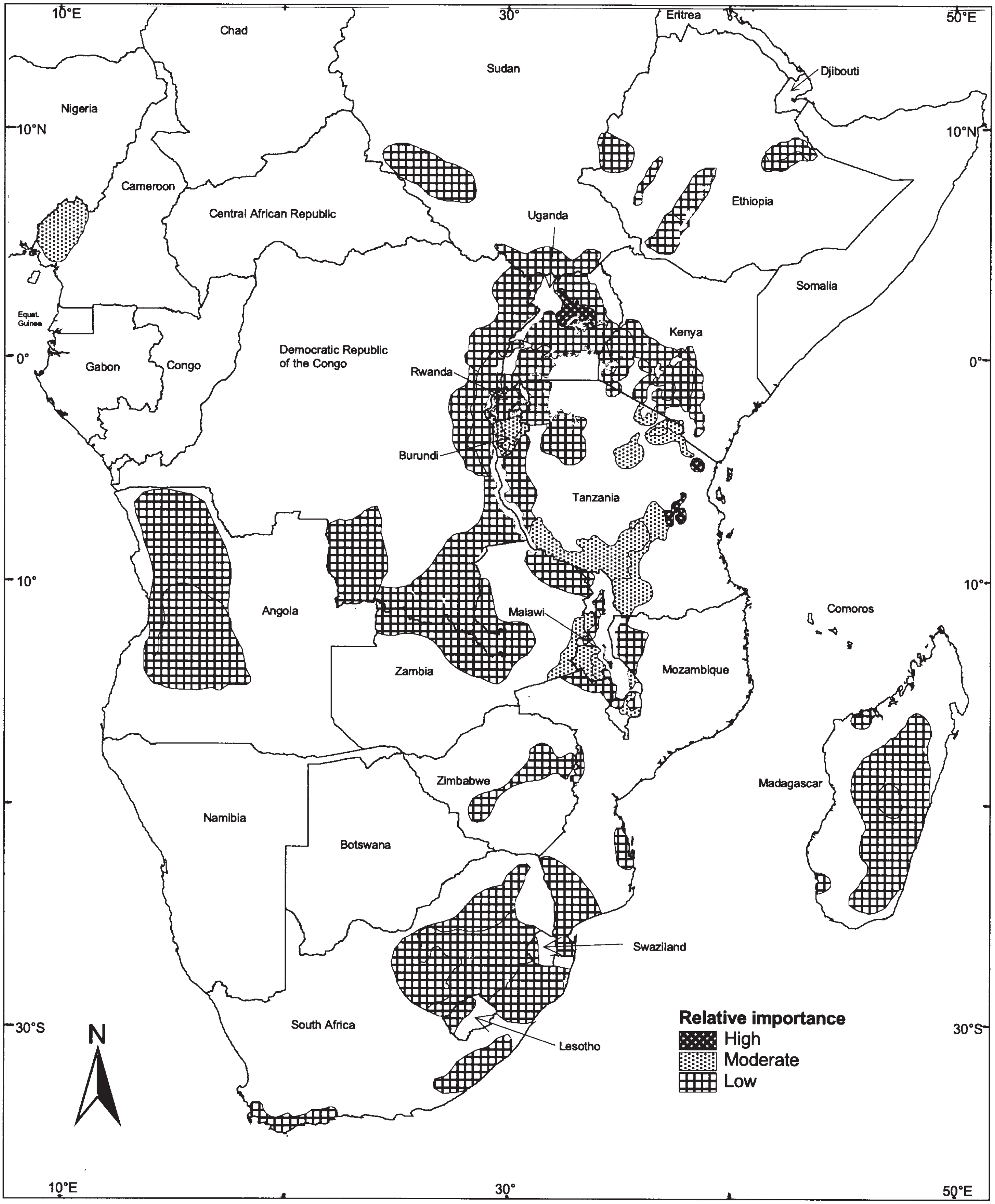
Map 40. Relative importance of *Helicoverpa* spp. in bean production areas of sub-Saharan Africa.



Map 41. Relative importance of *Maruca* spp. in bean production areas of sub-Saharan Africa.



Map 42. Relative importance of *Clavigralla* spp. in bean production areas of sub-Saharan Africa.



Map 43. Relative importance of *Ootheca* spp. in bean production areas of sub-Saharan Africa.

Data table 8. Relative importance of insect pests in bean production areas of Africa.[a]

Bean production area		Insect pest[b]							
		Aphi.	BSM	Thrip	Heli.	Mar.	Ooth.	Bru.	Cla.
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes								
Burundi:	Central Plateau	M	H	L	L	M	M	M	L
Ethiopia:	Awassa/N Sindamo	L	H	M	L	L	L	M	L
Kenya:	Central Highlands	H	M	L	M	L	L	M	M
	Western Highlands	H	H	L	M	L	L	M	M
	Kisii	M	M	L	M	L	L	M	L
Rwanda:	Central Plateau	M	M	L	M	L	L	M	L
	North-west	M	M	L	M	L	L	M	L
Tanzania:	Northern Highlands	H	M	L	M	M	M	M	L
Uganda:	South-west Highlands	H	H	M	L	L	L	M	L
	Western Highlands	H	M	L	L	L	L	M	L
	Mt. Elgon	H	M	M	L	L	L	M	L
AFBE 2:	Subhumid highlands on acid soils at low latitudes								
Burundi:	Zaire-Nile Crest	M	H	L	L	M	M	M	L
DR Congo:	South Kivu	M	M	L	L	L	L	M	L
Kenya:	Tea Zone	L	H	L	M	L	L	M	L
Rwanda:	Zaire-Nile Crest	M	H	L	L	L	L	M	L
Tanzania:	Usambara and Uluguru	M	M	L	M	M	H	M	L
AFBE 3:	Subhumid highlands at mid-latitudes								
Ethiopia:	Hararghe Highlands	L	M	L	L	L	L	M	L
	Western	L	M	L	L	L	L	M	L
Tanzania:	Southern Highlands	L	H	M	M	M	M	M	M
Zimbabwe:	High veld	L	M	M	M	L	L	M	L
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes								
Angola:	Central Highlands	L	M	L	L	L	L	M	L
Madagascar:	Antsirabe	M	M	L	H	L	L	M	L
Malawi:	Chitipa Highlands	M	H	L	L	L	L	M	L
	Livingstonia-Nyika	M	H	L	L	L	L	M	L
	North Viphya Hills	M	H	L	L	L	L	M	L
	South Viphya Hills	M	H	L	L	L	L	M	L
	Dedza-Ncheu Uplands	M	H	L	L	L	L	M	L
AFBE 5:	Semi-arid highlands at low latitudes								
Kenya:	Eastern high alt.	M	M	L	M	L	L	M	L
	Rift Valley	M	M	L	M	L	L	M	L
	Kajiado	M	M	L	M	L	L	M	L
Tanzania:	N semi-arid high alt.	H	M	L	M	M	M	M	M
AFBE 6:	Semi-arid highlands at mid-latitudes								
Ethiopia:	Rift Valley	L	M	L	L	L	L	H	L
Lesotho:	Foothills	L	M	L	L	L	L	M	M
S Af Rep:	High veld	L	L	L	M	L	L	M	L

(Continued)

Data table 8. (Continued.)

Bean production area		Insect pest[b]							
		Aphi.	BSM	Thrip	Heli.	Mar.	Ooth.	Bru.	Cla.
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes								
Burundi:	Moso	M	H	L	L	M	M	H	M
DR Congo:	North-east	L	M	L	L	L	L	M	L
	West Kivu	M	M	L	L	L	L	M	L
Kenya:	Nyanza	M	M	M	M	L	L	M	M
Rwanda:	Lake Kivu Basin	M	M	L	M	L	L	M	L
Tanzania:	Kagera	M	M	L	L	L	L	M	L
	West (Kigoma)	M	M	L	L	L	L	M	L
	South Lake	M	M	L	L	L	L	M	L
Uganda:	North central	L	M	L	L	L	H	M	L
	NW Tall Grass Zone	L	M	M	M	M	L	M	M
	C and E Tall Grass Zone	L	M	M	M	M	L	M	M
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes								
Cameroon:	North-western	L	M	M	L	L	M	M	L
DR Congo:	Shaba Region	L	M	L	L	L	L	M	L
Malawi:	Mzimba Plains	M	M	M	M	M	M	H	M
	Lilongwe-Kasungu	M	M	M	M	M	M	H	M
	Dowa-Nchitsi Uplands	M	M	M	M	M	M	H	M
	Namwera Uplands	M	M	M	M	M	M	H	M
	Shire Highlands	M	M	M	M	M	M	H	M
Mozambique:	Lichinga (North)	L	H	L	M	L	L	M	L
	Tete	L	M	L	M	L	L	M	L
	Manica Highlands	L	M	L	M	L	L	M	L
Nigeria[c]:	Kano								
	Jos Plateau								
Sudan:	Southern	L	M	L	L	L	L	M	M
Tanzania:	S mid-altitudes	M	M	M	M	M	M	M	M
Zambia:	Eastern	M	M	L	L	M	M	M	M
Zimbabwe:	Mid-veld	M	M	M	M	M	M	M	L
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes								
Kenya:	Eastern mid-alt.	M	M	L	L	L	L	M	L
Rwanda:	Eastern	M	M	L	L	M	L	M	L
Tanzania:	N and E mid-alt.	M	M	L	M	L	H	M	M
Uganda:	W Short Grass Zone	L	M	L	L	L	L	M	L
	N Short Grass Zone	M	M	L	L	L	L	M	L
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes								
Angola:	Mid-altitudes	L	M	L	L	L	L	M	L
Ethiopia:	Mid-alt. Hararghe	L	M	L	L	L	L	H	L
S Af Rep:	Transkei	L	M	L	M	L	L	M	L
	Natal	L	M	L	M	L	L	M	L
	Mid-veld	L	L	L	M	L	L	M	L
Zimbabwe:	Mid-veld fringes	M	M	L	M	L	L	M	L

(Continued)

Data table 8. (Continued.)

Bean production area		Insect pest[b]							
		Aphi.	BSM	Thrip	Heli.	Mar.	Ooth.	Bru.	Cla.
AFBE 11: Subhumid areas at mid-altitudes on acid soils at mid-latitudes									
DR Congo:	Kasai	M	M	L	L	L	L	M	L
Madagascar:	Central	M	M	L	H	L	L	M	M
Zambia:	North-east	H	H	L	L	L	L	M	M
AFBE 12: Semi-arid areas at mid-altitudes on acid soils at mid-latitudes									
Madagascar:	Following rice	M	L	L	H	L	L	M	L
Zambia:	N central and NW	H	M	L	L	L	L	M	M
Swaziland:	High and mid-veld	M	M	L	M	L	L	M	L
AFBE 13: Lowlands at mid-latitudes									
Algeria[c]:	Northern	M							
Cape Verde[c]:									
Egypt[c]:	Nile Delta	M							
Guinea[c]:	Guinea								
Madagascar:	Toliary	M	M	L	M	M	L	M	L
	Mahajanga	L	M	L	M	M	L	M	L
Malawi:	Lake basin (rm)	M	L	L	L	L	L	H	M
	Phalombe Plains	M	M	L	L	L	L	H	M
Mauritius:	(Irrigated)	M	L	H	L	L	L	M	L
Morocco[c]:	North								
Mozambique:	Southern (rm)	M	L	M	M	L	L	M	L
S Af Rep:	Cape Province (irrig.)	L	L		M	L	L	M	L
Sudan[c]:	Northern (irrig.)								
Togo:	Atakpame	M	M	M	M	M	M	M	M
Tunisia[c]:	Northern	M							
AFBE 14: Lowlands at low latitudes									
Burundi:	Imbo Plains	M	M	L	L	M	M	H	M
DR Congo[c]:	Bas-Zaire (rm)	L							
Tanzania:	Morogoro	M	M	L	M	M	H	M	M

a. Conventions used throughout the table are explained footnote a of Data table 1.

b. Aphi. = aphids (*Aphis fabae*); Bru = bruchids, including *Zabrotes subfasciatus* and *Acanthoscelides objectus;* BSM = bean stem maggot (*Ophiomyia* spp.); Cla. = *Clavigralla* spp. of pod bugs; Heli. = *Helicoverpa* complex or African bollworm; Mar. = *Maruca testulalis* or legume pod borer; Ooth. = *Ootheca* spp. or bean foliage beetle; thrip = *Megalurothrips sjostedti*.

Relative importance of stresses: H = high, M = moderate, L = low, associated with mean annual losses of 200, 100, and 25 kg/ha, respectively, assuming that yield potential is 3000 kg/ha and that intercrop yield is 40% of sole crop yield. A = absent or not reported.

c. Blank spaces = information available was insufficient at the time.

Abiotic Constraints

Abiotic Constraints

Temperature

Most (80%) bean production areas in eastern and southern Africa have a mean temperature (15-23 °C) favourable to bean growth for at least part of the year (Figure 2). Little production occurs at lower temperatures but 19% occurs at higher temperatures. Beans in the mid-altitudes of eastern Kenya are produced at above optimal temperatures. Beans are also produced at relatively high temperatures in eastern Transvaal in South Africa; south-western Sudan; the Phalombe Plains in Malawi; and Bas-Zaire, eastern Kasai, and western Kivu in DR Congo. However, data from some of these areas are poor.

Rainfall

Mean rainfall exceeds 400 mm during the 3 months following the main sowing dates for bean in 65% of production areas (Figures 3A and 3B). Moisture deficits severely constrain bean production in some other areas, frequently resulting in complete crop loss (Map 44, Data table 9). Losses attributable to moisture deficits were estimated, using two different sets of data (Table 3). One method estimated losses as follows: for rainfall ranges of <300, 300-375, 375-450, and >450 mm per season, losses for a sole crop of bean were 1000, 600, 400, and 0 kg/ha, respectively.

The two sets of estimates were similar for eastern Africa but differed greatly for southern Africa. Researchers' estimates of the severity of the problem in southern Africa are higher than those based on estimated mean rainfall during the growing season. The differences in estimates may stem from the higher temperatures during the season.

Eastern Kenya and eastern Transvaal are major areas of bean production where moisture

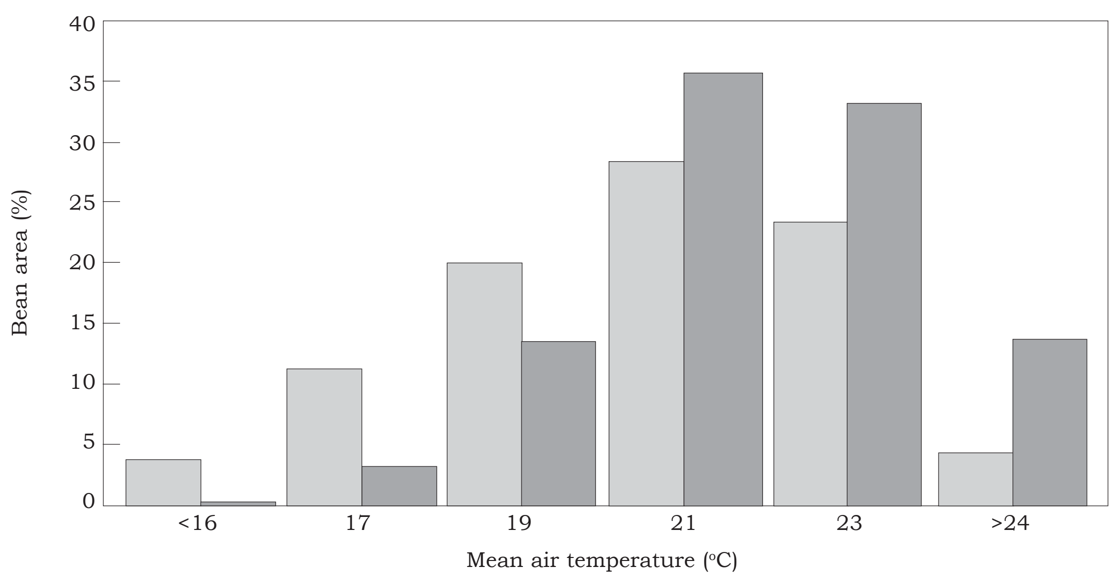


Figure 2. Distribution of bean production areas (%) in eastern (□) and southern Africa (■) in relation to mean air temperatures during the growing season.

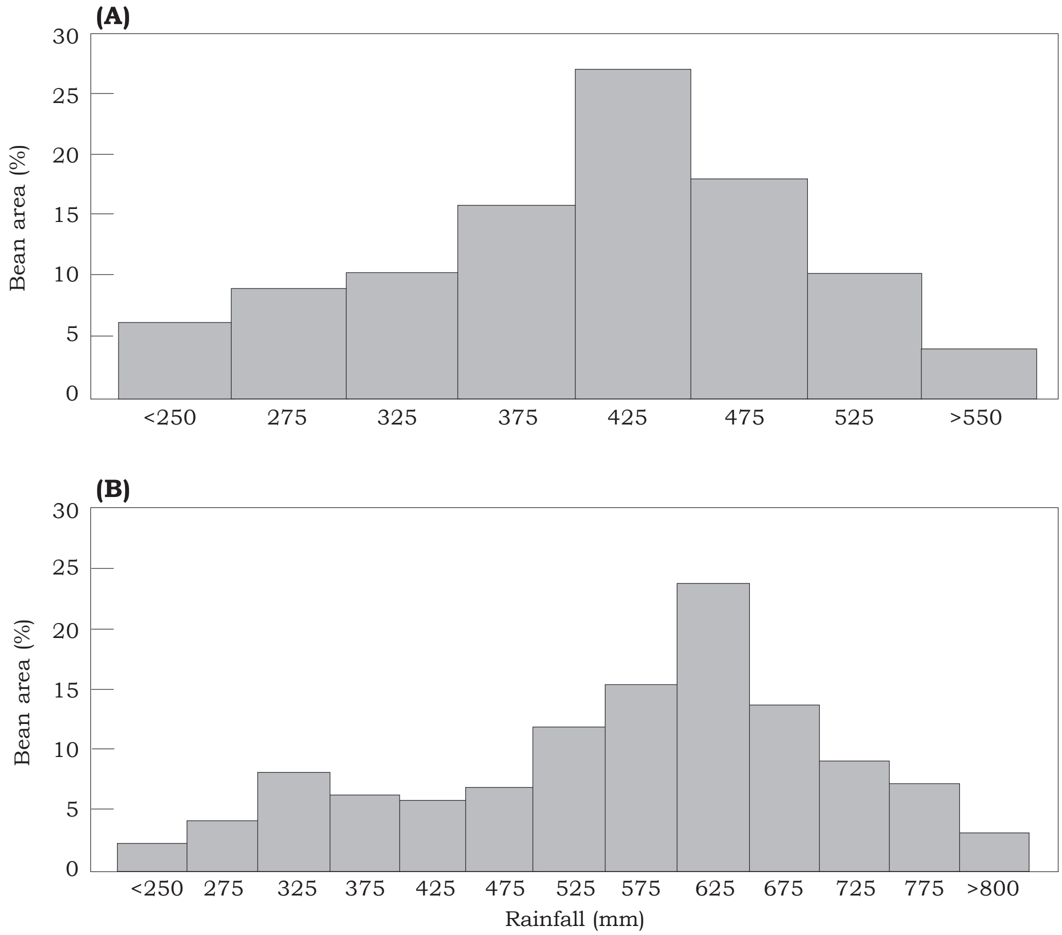


Figure 3. Distribution of bean production areas (%) in eastern (A) and southern Africa (B) in relation to mean rainfall during the 3 months associated with the main growing season.

deficits are frequent and severe. Other important areas of moisture deficit are parts of northern Tanzania, the Kasese area of Uganda, and parts of the Hararghe Highlands and the Rift Valley of Ethiopia. Rainfall is excessive during the growing season in southern Malawi, western Ethiopia, north-western Cameroon, and the Shaba Region of DR Congo.

Daylength

Photoperiod response is a major factor affecting adaptation of beans to higher latitudes (White et al. 1992). Some early and intermediate maturing varieties (e.g., GLP x 92, G 13671) mature late in Madagascar. Photoperiod sensitivity is usually greater in genotypes of Andean origin than in germplasm of Meso-American origin. Sowing and early vegetative development for the main production seasons in the mid-latitudes coincide with long daylength (e.g., 13 h), followed by decreasing daylength (Data table 1).

Soils and Soil-Related Constraints

Orthic Ferralsol is the major soil type in bean production areas of eastern and southern Africa (Table 6), but is generally low in nutrients (Data table 9). Relatively more productive histic, eutric, and dystric Nitosols are important in eastern Africa; Luvisols are important in both regions; whereas humic, orthic, and rhodic Ferralsols are important in southern Africa. Bean is produced primarily in areas where median soil pH is between 5.0 and 6.0 (Figure 4), with 23% and 20% of production in areas where soil pH is either below or equal to 5.0 in eastern and southern Africa, respectively. The low pH complex is most problematic to beans on xanthic Ferralsols in Angola and Kasai of DR Congo; on humic Ferralsols in

Table 6. Percentage of bean production areas found in association with major soil types in eastern and southern Africa.

Soil type	Eastern Africa	Southern Africa
Acrisol, ferric	2.8	3.0
Cambisol, chromic	6.9	1.1
Ferralsol, humic	3.4	8.0
Ferralsol, orthic	16.7	28.0
Ferralsol, rhodic	1.3	8.5
Lithosol[a]	3.2	7.0
Luvisol, ferric	4.5	8.3
Nitosol, dystric	7.7	2.3
Nitosol, eutric	11.7	1.8
Nitosol, humic	28.8	0.3
Andosol mollic	6.1	0.0
Other	6.7	31.7

a. Lithosols are usually interspersed with Cambisols, Luvisols, and/or other types. Bean production probably occurs on the associated soils.

eastern and north-eastern Zambia, in the Zaire-Nile Crest of Rwanda and Burundi, and in eastern DR Congo; and often on orthic Ferralsols.

Soil N, P, and K availability was estimated by considering organic carbon and pH levels for representative soil profiles using the QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils) model (Janssen et al. 1990) (Figure 5, Maps 45 and 46, Data table 9). Soil P is the most frequently deficient nutrient and supply is low in 65% and 80% of the bean production areas of eastern and southern Africa, respectively (Data table 9). Availability of soil N is lower in southern Africa, being low and moderately low on 60% and 30% of the bean production areas, respectively. In eastern Africa, it is low on 50% of the production areas.

Deficiency of bases (Map 47) is a major constraint to bean production and potassium is moderately deficient on 45%-50% of the area in both regions and moderately deficient in some of the remaining areas. Two independent, but similar, estimates indicated that Al and Mn toxicities are constraints of moderate importance (Map 48). They were assumed to cause losses of 200 and 100 kg/ha for a sole crop of bean if the typical soil pH was 4.5-5.0 or 5.0-5.5, respectively.

The importance of edaphic constraints was estimated from the predominate soil types of the area. In some cases, ratings may have overemphasized the importance of the problems for the bean crop, as farmers avoid sowing beans on soils where only low yields can be expected. Most bean production may, in fact, be on moderate to good soils, especially where pressure on the land is less. In such cases, the ratings may be more relevant for the future, as increasing pressure on the land leads to more intensive use of marginal lands.

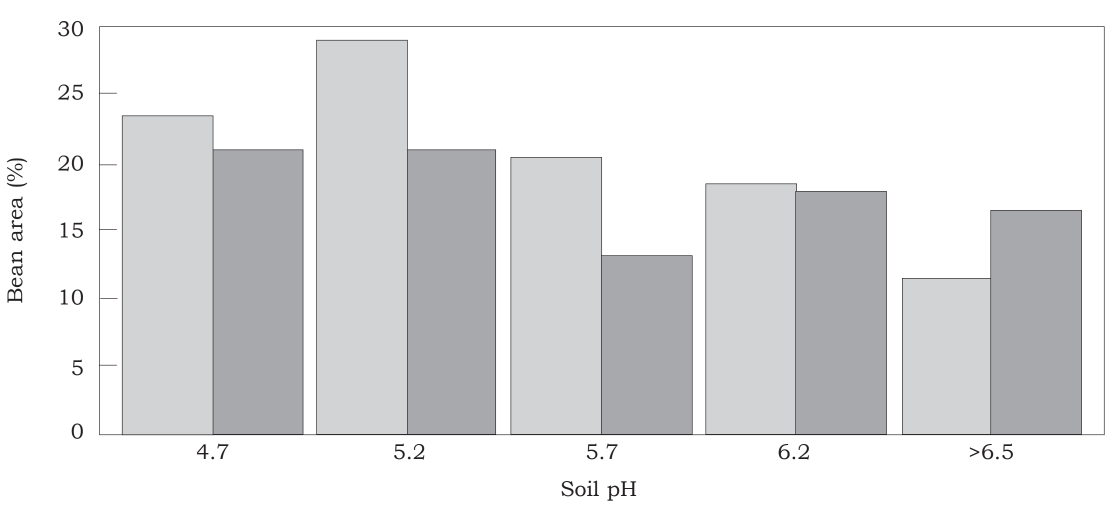


Figure 4. Distribution of bean production areas (%) in eastern (□) and southern Africa (■) in relation to soil pH.

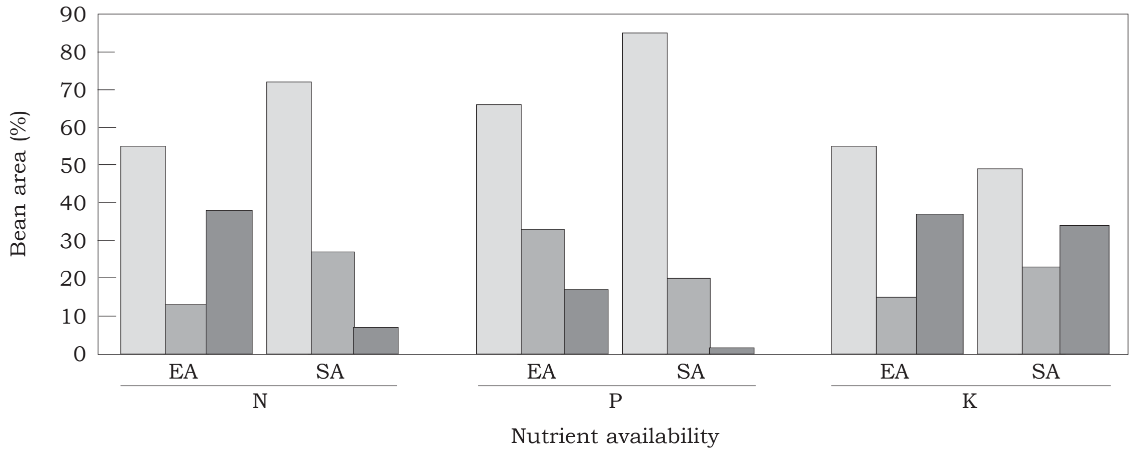


Figure 5. Distribution of bean production areas (%) in eastern (EA) and southern Africa (SA) in relation to soil nutrient availability (= low; = moderate; = adequate; N = nitrogen; P = phosphorus; K = potassium).

Information on Soil Characteristics

Soil order information was extracted from the FAO's *Soil Map of the World 1:5,000,000* for the coordinates of each production point. The soil unit given on the soil map was determined for each production point.

Typical values for pH, organic carbon (OC), Olson P, and exchangeable K were determined for each soil unit: information available with the global database for OC and pH was considered, as well as soil profile descriptions from Kenya (FURP 1987) and Ethiopia (Braun et al. 1997). Availability of N, P, and K and soil productivity values were determined, using the QUEFTS model (Janssen et al. 1990). The values used are presented in Table 7.

Table 7. Values used to determine soil nutrient availability and potential soil productivity.[a]

Soil type	pH	OC (%)	P (ppm)	K (meq 100/g)	Nq[b]	Pq[b]	Kq[b]	Yieldq[c]
Acrisol, ferric	5.5	1.2	8	1.0	51	7.7	234	2805
Acrisol, orthic	5.0	2.2	8	0.3	24	5.2	84	1250
Andosol, humic	5.2	11.0	20	0.3	75	15.0	50	3515
Andosol, mollic	6.1	4.4	12	2.0	232	21.3	115	7748
Andosol, ochric	6.0	2.5	15	0.4	127	16.0	41	3903
Andosol, vitric	6.3	1.4	4	0.4	79	6.7	60	2833
Arenosol, albic	5.9	0.9	3	0.1	44	4.6	26	1612
Arenosol, cambic	6.5	0.3	.2	0.1	18	1.9	43	724
Arenosol, luvic	6.3	0.2	2	0.1	11	1.7	58	399
Cambisol, chromic	7.6	0.4	4	0.3	27	2.7	80	1160
Cambisol, dystric	4.9	3.3	10	0.6	107	9.5	68	3880
Cambisol, eutric	6.6	2.0	14	0.6	122	13.0	57	4380
Cambisol, ferralic	5.0	2.8	10	0.6	95	9.9	77	3901
Cambisol, humic	4.9	3.8	8	0.1	122	9.3	11	1010
Ferralsol, humic	4.8	3.5	5	0.4	107	5.9	44	2685
Ferralsol, orthic	5.0/1	1.5	5	0.1	51	5.1	16	1385
Ferralsol, plinthic	4.8	1.4	5	0.1	43	3.9	25	1443
Ferralsol, rhodic	5.5	1.3	5	0.5	55	6.5	109	2771
Ferralsol, xanthic	4.8	1.2	5	0.2				
Fluvisol, calcaric	7.3	0.5	3	1.0	34	2.4	231	1099
Fluvisol, eutric	6.6	1.3	20	2.1	80	13.7	291	4670
Gleysol	6.1	2.0	15	2.0	105	14.5	240	5827
Gleysol, eutric	6.4	1.3	15	2.0	75	11.8	306	4295
Gleysol, humic	5.0	6.6	20	2.0	280	30.2	98	8363
Gleysol, plinthic	5.2	2.7	15	2.0	101	14.0	251	5857
Lithosol[d]	6.5	1.0	23	1.2	59	14.6	218	3631
Luvisol, chromic	6.2	1.2	10	0.4	65	9.1	72	3106
Luvisol, ferric	6.5	1.1	4	0.1	65	5.4	25	1929
Luvisol, gleyic	6.5	1.0	4	2.0	63	5.4	25	1929
Luvisol, orthic	6.4	2.5	8	0.6	144	12.0	51	4301
Nitosol, dystric	5.2	1.8	5	0.2	67	6.8	44	2543
Nitosol, eutric	6.3	2.0	10	0.3	112	12.0	60	3177
Planosol, eutric	5.5	3.3	6	1.1	98	10.0	145	4489
Planosol, solodic	6.9	0.7	3	0.2	46	3.0	39	1337
Podosol, humic	4.3	3.2	3	1.0	82	2.0	180	720
Regosol, calcaric[e]	7.6	0.8	2	0.2	54	2.4	33	1120
Regosol, dystric	7.0	0.3	2	0.2	20	1.5	64	618
Regosol, eutric	6.4	0.5	2	0.2	29	2.6	65	1150
Vertisol, chromic	6.0	1.0	10	0.5	51	8.5	113	2803
Vertisol, pellic	6.5	2.0	10	2.0	119	11.1	200	4206
Xerosol, calcic	8.2	0.6	5	0.3	34	3.3	51	1499
Xerosol, haplic	7.7	0.5	5	0.3	32	3.3	51	1499
Xerosol	7.2	0.4	4	0.2	27	2.7	54	1155
Yermosol, haplic	6.6	0.3	3	0.2	18	2.6	65	1150

a. QUEFTS = Quantitative Evaluation of the Fertility of Tropical Soils; a model developed by Janssen et al. (1990). The values for nutrient availability were grouped as follows:

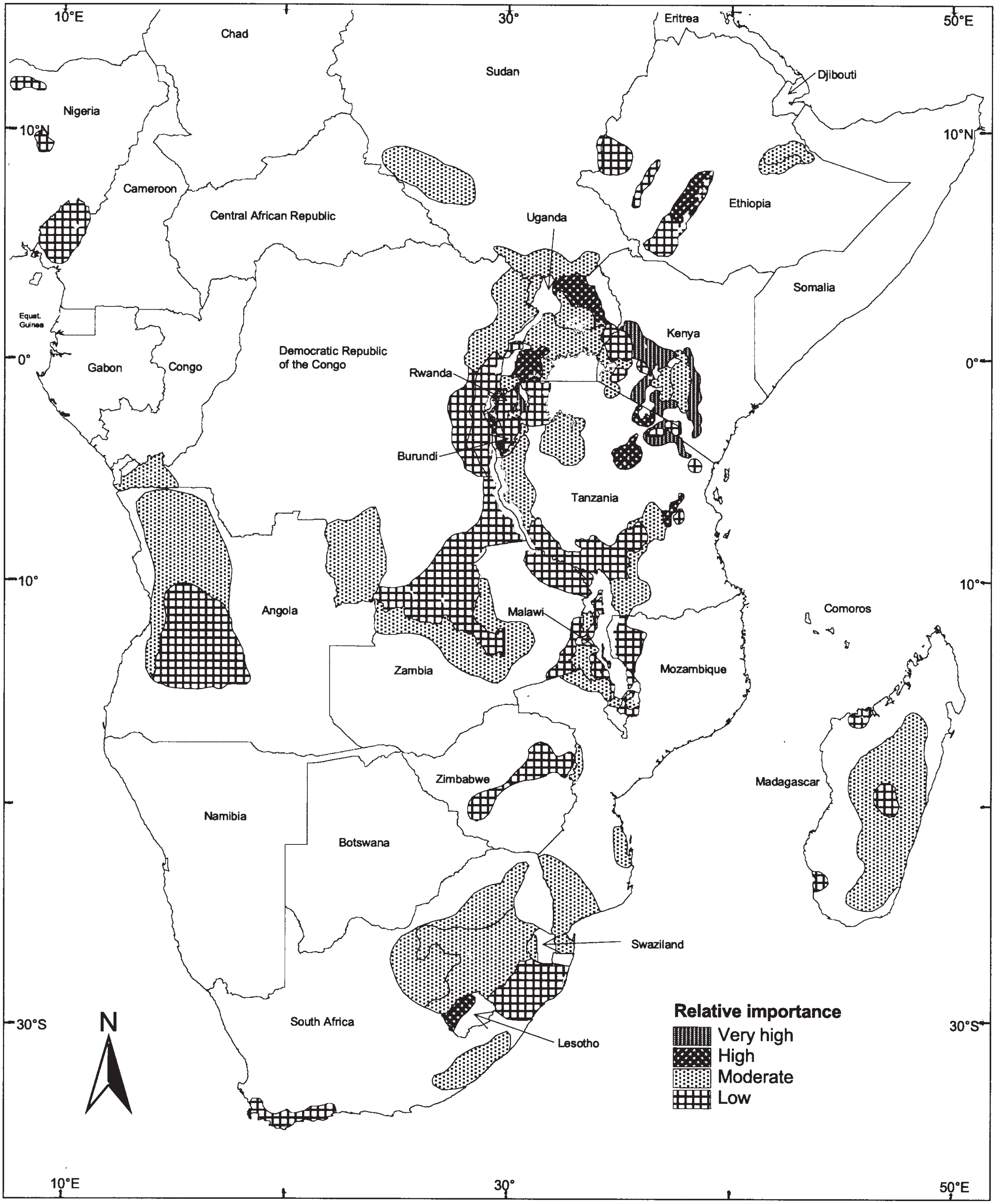
	N	P	K
Low	<40	<8	<40
Moderate	40-90	8-16	40-80
High	>90	>16	>80

b. Nq, Pq, and Kq are the QUEFTS estimates of N, P, and K available during a 6-month growing period (kg/ha).

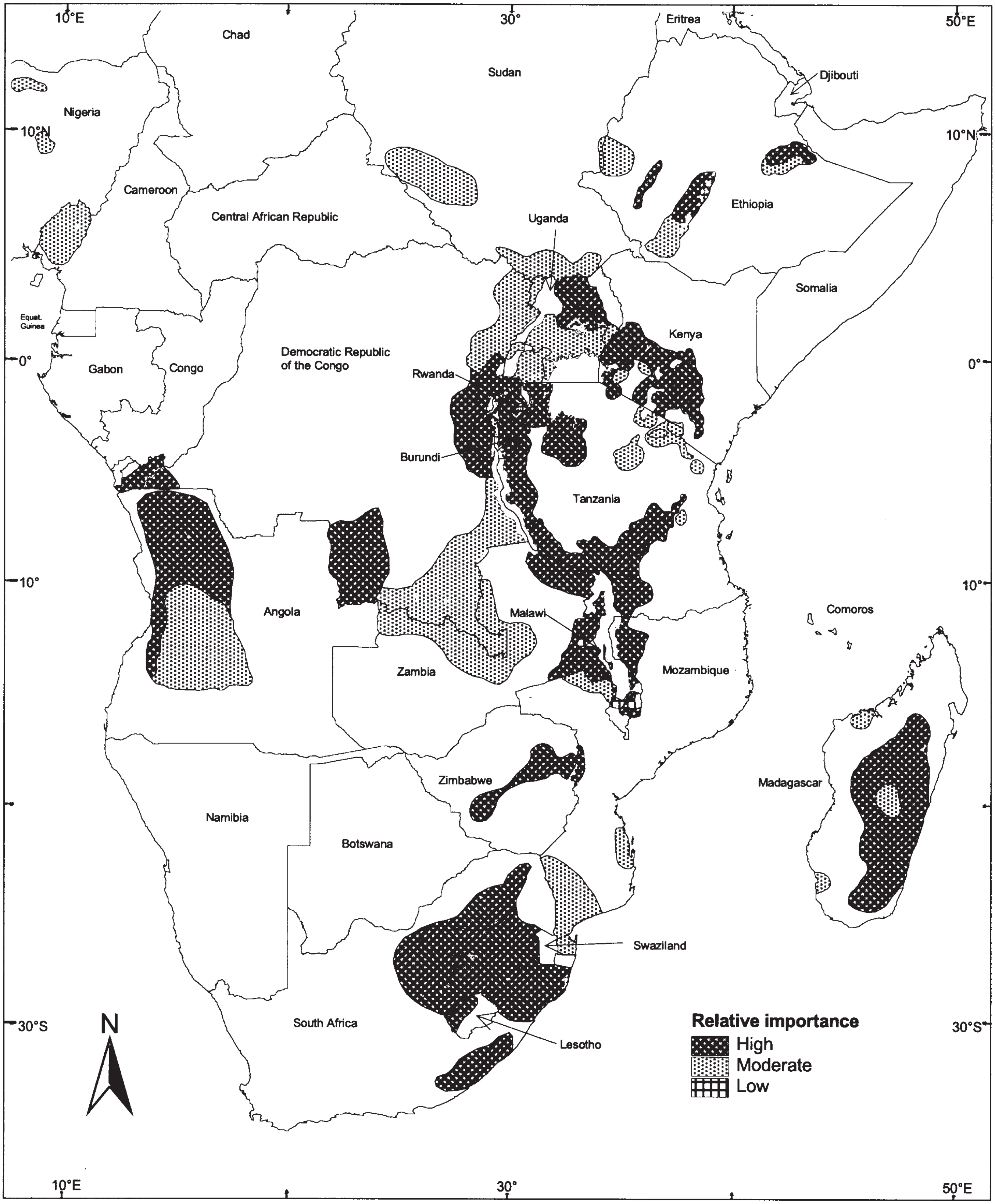
c. Yieldq is a measure of productivity estimated by using QUEFTS and expressed as the equivalent of maize yield per season (kg/ha).

d. Lithosols are usually interspersed with Cambisols and/or Luvisols in southern Africa.

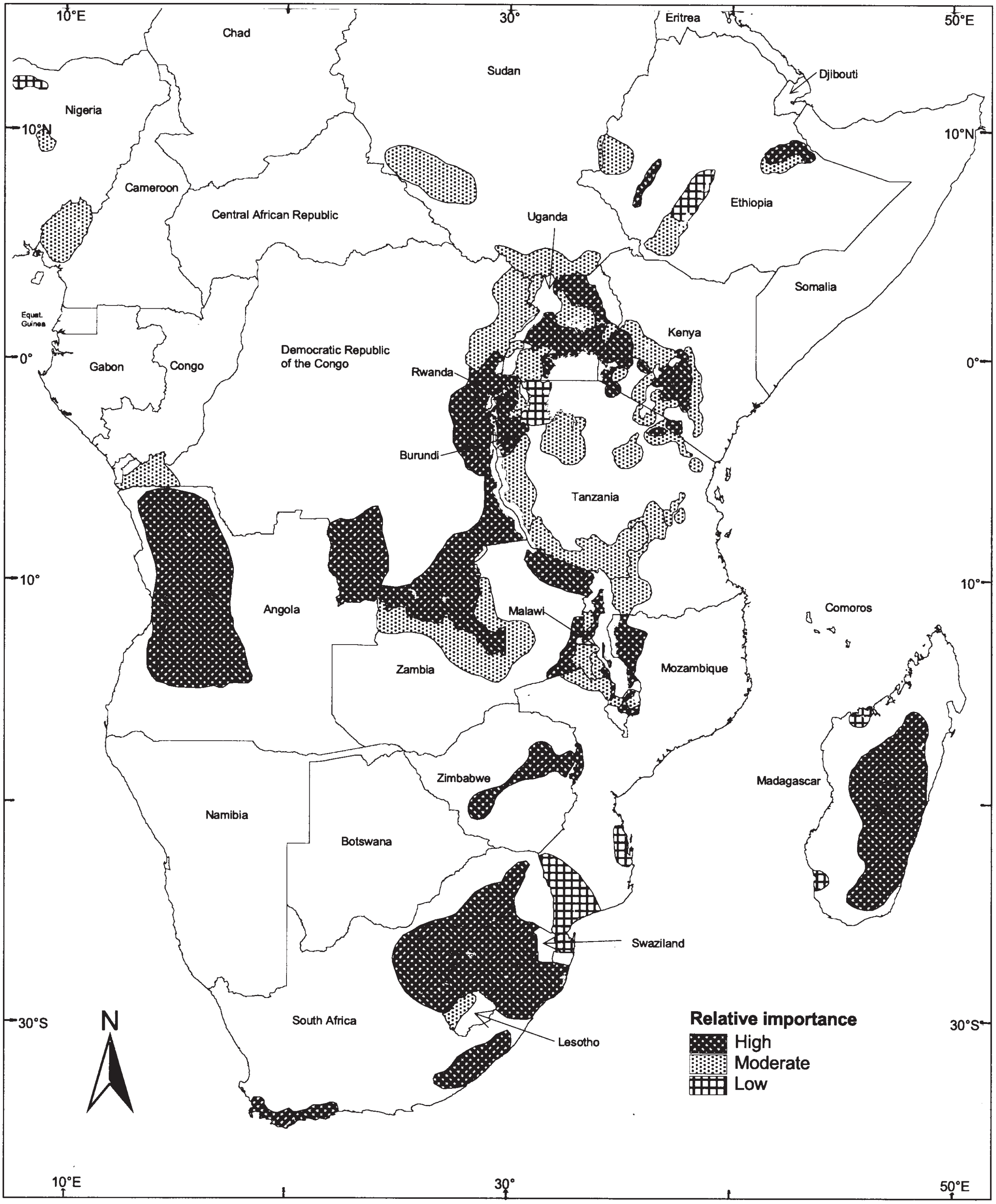
e. Significant bean production rarely occurs on Regosols, which are usually interspersed with other soil types.



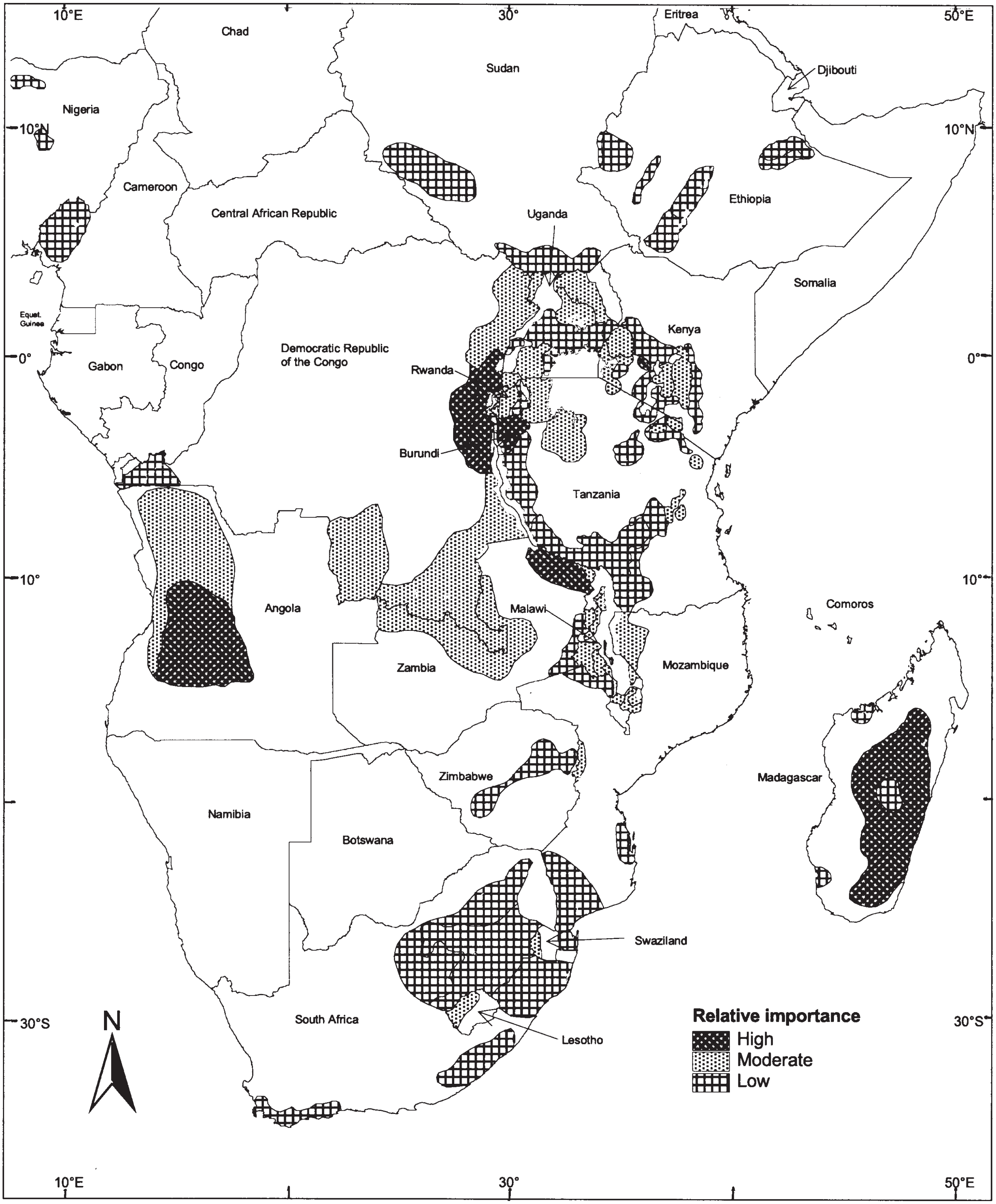
Map 44. Relative importance of soil moisture deficits in bean production areas of sub-Saharan Africa.



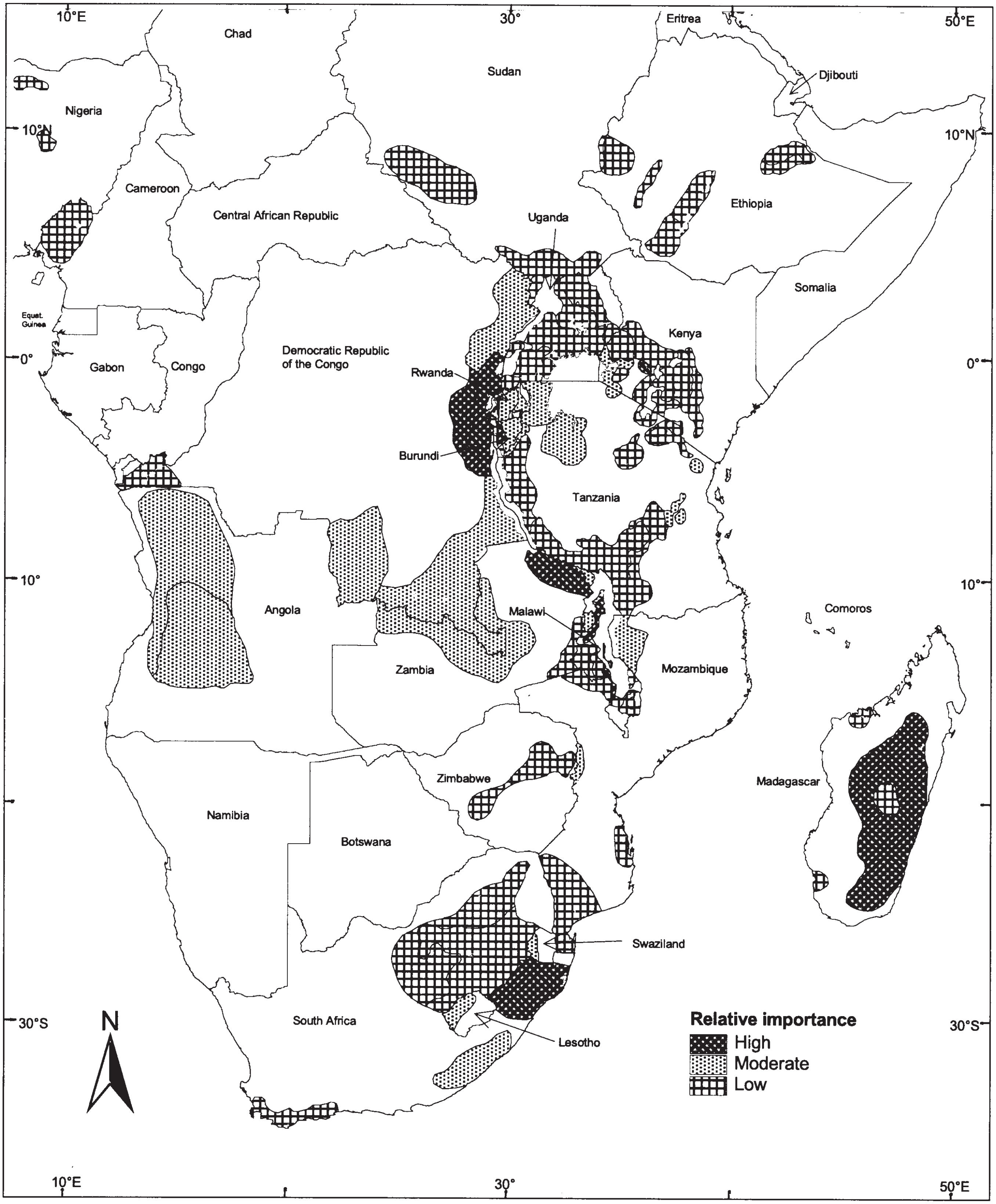
Map 45. Relative importance of low soil-nitrogen availability in bean production areas of sub-Saharan Africa.



Map 46. Relative importance of low soil-phosphorus availability in bean production areas of sub-Saharan Africa.



Map 47. Relative importance of low soil-base availability in bean production areas of sub-Saharan Africa.



Map 48. Relative importance of aluminium and manganese toxicities in bean production areas of sub-Saharan Africa.

Data table 9. Relative importance of edaphic and drought stresses in bean production areas of Africa.[a, b]

Bean production area		Low soil nutrient supply				Al or Mn	Water deficits[c]		
		N	P	K	Bases	toxicity	E	M	L
AFBE 1:	Subhumid eastern African highlands of high potential at low latitudes								
Burundi:	Central Plateau	H	H	L	H	M	L	L	L
Ethiopia:	Awassa/N Sindamo	M	M	L	L	L	L	L	M
Kenya:	Central Highlands	H	H	L	M	L	L	M	M
	Western Highlands	H	H	L	M	L	L	L	L
	Kisii	M	M	L	L	L	L	L	L
Rwanda:	Central Plateau	H	H	L	M	M	L	L	L
	North-west	M	M	L	M	M	L	L	L
Tanzania:	Northern Highlands	M	H	L	M	L	L	L	L
Uganda:	South-west Highlands	H	H	M	M	L	L	M	M
	Western Highlands	M	M	L	L	L	L	L	L
	Mt. Elgon	M	M	L	L	L	L	L	L
AFBE 2:	Subhumid highlands on acid soils at low latitudes								
Burundi:	Zaire-Nile Crest	H	H	M	H	H	L	L	L
DR Congo:	South Kivu	H	H	M	H	H	L	L	L
Kenya:	Tea Zone	M	H	M	H	H	L	L	L
Rwanda:	Zaire-Nile Crest	H	H	M	M	H	L	L	L
Tanzania:	Usambara and Uluguru	M	M	H	M	M	L	L	L
AFBE 3:	Subhumid highlands at mid-latitudes								
Ethiopia:	Hararghe Highlands	H	H	L	L	L	L	M	M
	Western	M	M	L	L	L	L	L	L
Tanzania:	Southern Highlands	H	M	L	L	L	L	L	M
Zimbabwe:	High veld	H	H	L	L	L	L	L	L
AFBE 4:	Subhumid highlands on acid soils at mid-latitudes								
Angola:	Central Highlands	M	H	M	H	M	L	L	L
Madagascar:	Antsirabe	M	H	L	L	L	L	L	L
Malawi:	Chitipa Highlands	H	H	M	M	M	L	L	L
	Livingstonia-Nyika	H	H	M	M	M	L	L	L
	North Viphya Hills	H	H	M	M	H	L	L	L
	South Viphya Hills	H	H	M	M	H	L	L	L
	Dedza-Ncheu Uplands	H	H	M	M	H	L	L	L
AFBE 5:	Semi-arid highlands at low latitudes								
Kenya:	Eastern high alt.	H	H	M	M	L	M	M	M
	Rift Valley	H	M	L	L	L	H	H	H
	Kajiado	H	M	L	L	L	H	H	H
Tanzania:	N semi-arid high alt.	M	M	L	L	L	H	H	H
AFBE 6:	Semi-arid highlands at mid-latitudes								
Ethiopia:	Rift Valley	H	L	L	L	L	L	M	H
Lesotho:	Foothills	H	M	M	M	M	M	H	H
S Af Rep:	High veld	H	H	L	L	L	L	M	L

(Continued)

Data table 9. (Continued.)

Bean production area		Low soil nutrient supply N	P	K	Bases	Al or Mn toxicity	Water deficits[c] E	M	L
AFBE 7:	Subhumid areas at mid-altitudes and low latitudes								
Burundi:	Moso	H	M	M	L	L	L	M	L
DR Congo:	North-east	M	M	M	M	M	L	M	L
	West Kivu	H	H	M	H	H	L	L	L
Kenya:	Nyanza	H	H	M	M	M	L	M	M
Rwanda:	Lake Kivu Basin	M	M	L	M	M	L	L	L
Tanzania:	Kagera	H	L	L	M	M	L	L	L
	West (Kigoma)	H	M	L	L	L	L	M	L
	South Lake	H	M	M	M	M	L	M	M
Uganda:	North central	H	M	M	M	L	M	H	M
	NW Tall Grass Zone	M	M	M	M	L	L	M	L
	C and E Tall Grass Zone	M	H	M	L	L	L	M	L
AFBE 8:	Subhumid areas at mid-altitudes and mid-latitudes								
Cameroon:	North-western	M	M	L	L	L	L	L	L
DR Congo:	Shaba Region	M	H	M	M	M	L	L	L
Malawi:	Mzimba Plains	H	M	M	M	M	L	L	M
	Lilongwe-Kasungu	H	M	M	M	L	L	L	M
	Dowa-Nchitsi Uplands	H	M	M	M	L	L	L	L
	Namwera Uplands	H	H	M	M	L	L	L	L
	Shire Highlands	H	H	M	M	L	L	L	L
Mozambique:	Lichinga (North)	H	H	M	M	M	L	L	L
	Tete	M	M	L	L	L	L	L	M
	Manica Highlands	H	H	M	M	M	L	L	M
Nigeria:	Kano	M	L	L	L	L	L	L	L
	Jos Plateau	M	M	L	L	L	L	L	L
Sudan:	Southern	M	M	L	L	L	M	M	L
Tanzania:	S mid-altitudes	H	M	L	L	L	L	L	M
Zambia:	Eastern	H	H	L	L	L	L	L	L
Zimbabwe:	Mid-veld	H	H	H	L	L	L	H	M
AFBE 9:	Semi-arid areas at mid-altitudes and low latitudes								
Kenya:	Eastern mid-alt.	H	M	L	L	L	M	H	H
Rwanda:	Eastern	H	M	M	L	M	M	H	H
Tanzania:	N and E mid-alt.	M	L	L	L	L	M	H	M
Uganda:	W Short Grass Zone	M	M	M	M	L	M	H	M
	N Short Grass Zone	H	H	M	M	L	M	H	H
AFBE 10:	Semi-arid areas at mid-altitudes and mid-latitudes								
Angola:	Mid-altitudes	H	H	M	M	M	L	M	M
Ethiopia:	Mid-alt. Hararghe	M	M	L	L	L	L	M	M
S Af Rep:	Transkei	H	H	L	L	M	L	M	L
	Natal	H	H	L	L	H	L	L	L
	Mid-veld	H	H	L	L	L	L	M	L
Zimbabwe:	Mid-veld fringes	H	H	L	L	L	L	H	H

(Continued)

Data table 9. (Continued.)

Bean production area		Low soil nutrient supply N	P	K	Bases	Al or Mn toxicity	Water deficits[c] E	M	L
AFBE 11:	Subhumid areas at mid-altitudes on acid soils at mid-latitudes								
DR Congo:	Kasai	H	H	M	M	M	L	L	L
Madagascar:	Central	H	H	M	H	H	L	M	L
Zambia:	North-east	H	H	M	H	H	L	L	L
AFBE 12:	Semi-arid areas at mid-altitudes on acid soils at mid-latitudes								
Madagascar:	Following rice	M	M	M	L	M	L	M	H
Zambia:	N central and NW	M	M	M	M	M	L	M	H
Swaziland:	High and mid-veld	H	H	M	M	M	L	M	H
AFBE 13:	Lowlands at mid-latitudes								
Algeria:	Northern	M	L	L	L	L	L	M	M
Cape Verde[d]:									
Egypt:	Nile Delta	M	L	L	L	L	L	L	L
Guinea:	Guinea	M	M	L	L	L	L	L	L
Madagascar:	Toliary	M	L	L	L	L	L	L	L
	Mahajanga	M	L	L	L	L	L	L	L
Malawi:	Lake basin (rm)	L	L	L	L	L	M	H	H
	Phalombe Plains	L	M	M	M	L	L	M	H
Mauritius:	(Irrigated)	H	M	L	L	M	L	L	L
Morocco:	North	M	L	L	L	L	L	M	M
Mozambique:	Southern (rm)	M	L	L	L	L	L	M	H
S Af Rep:	Cape Province (irrig.)	H	H	L	L	L	L	L	L
Sudan:	Northern (irrig.)	M	L	L	L	L	L	L	L
Togo:	Atakpame	M	M	L	L	L	L	L	L
Tunisia:	Northern	M	L	L	L	L	L	M	M
AFBE 14:	Lowlands at low latitudes								
Burundi:	Imbo Plains	M	M	L	L	L	M	H	H
DR Congo:	Bas-Zaire (rm)	H	M	L	L	L	L	M	H
Tanzania:	Morogoro	H	M	L	M	M	M	H	H

a. Conventions used throughout the table are explained in footnote a of Data table 1.

b. Relative importance of stresses: H = high, M = moderate, L = low, associated with annual mean losses of 200, 100, and 25 kg/ha, assuming that yield potential to be 3000 kg/ha and that intercrop yield is 40% of sole crop yield.

c. Water deficits refer to soil moisture deficits during the vegetative (E); early reproductive, or R5 and R6 (M); and late (L) stages of growth.

d. Blank spaces = information available was insufficient at the time.

Summary

Summary

Every year about 4,025,000 ha of beans are planted in 14 African bean environments. Two of these environments account for 43% of the production, another two have less than 100,000 ha of annual production, and the remaining 10 environments fall between the two extremes. Three major African bean environments (AFBEs 1, 3, and 7, Data table 1) are favourable for bean production. These have moderate to very high rural population densities (Data table 2).

Major biotic constraints in these favourable environments are, in order of descending importance, angular leaf spot, anthracnose, bean stem maggot, bruchids, and root rots. The severity of some biotic constraints, especially root rots and the bean stem maggot, is enhanced by certain abiotic stresses. Soil moisture deficits are less important in these more favourable areas but can cause serious losses in some seasons. Low soil N and P availability are major constraints, but are potentially manageable with applications of organic and inorganic fertilizer, accompanied by newly available cultivars that efficiently use nutrients and are resistant to or tolerant of major biotic stresses.

Bean production is primarily small scale, with little use of inputs. As demand for beans increases and varieties with resistance to or tolerance of the major biotic stresses become increasingly available, both double-cropping with beans and input use are likely to increase, leading to substantial increases in productivity.

Increases in production will be more difficult to achieve in those environments where productivity is constrained by difficult-to-manage abiotic constraints, particularly low soil pH and inadequate soil moisture. In addition to improved varietal resistance to or tolerance of biotic stresses, tolerance of the low pH complex and of soil moisture deficits will be needed to improve both productivity and stability of production. Only then will inputs be adopted and the varietal yield potential achieved in these less favourable environments. Returns to research are lower from these less favoured environments than from the more favoured areas, but their problems need to be addressed as dependence on these environments is increasing as bean crops extend more to marginal soils in response to growing land pressure and urban demands.

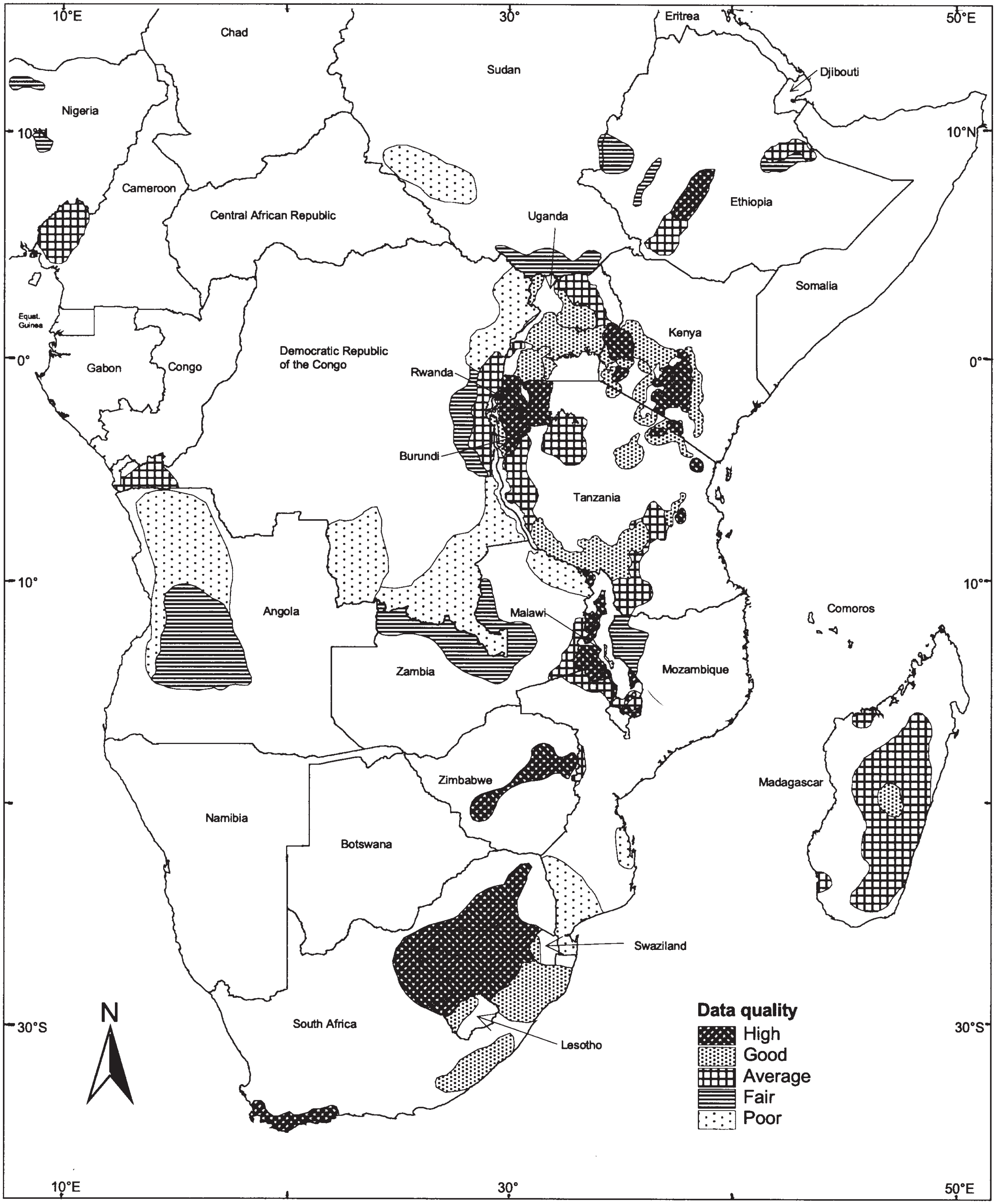
Sources of Information for the *Atlas*

Sources of Information for the *Atlas*

Information on bean production in Africa varies in quality (Map 49) and comes from a variety of sources. Much of the information used in this document comprised observations of bean researchers made over the last 15 years, including results from at least 20 diagnostic surveys, numerous on-farm trials, the Pan-Africa Bean Research Alliance (of more than 150 researchers at over 40 research institutes in 18 countries), and a series of national and regional planning workshops for bean research. National production statistics were used when available and current. In some cases, FAO production statistics were used. Reliable statistics on bean production are generally lacking for DR Congo and Mozambique, and the estimates given are a consensus of data from researchers with varying familiarity with those bean production areas.

Digital databases were valuable sources of information. *Africa: A Topographic and Climatic Database V 1.0* (5' grid) of the Centre for Resource and Environmental Studies, Australian National University, was the source of rainfall and temperature data to determine mean rainfall and temperature during the 3-month growing season. Soil information was obtained from the *Digital Soil Map of the World and Derived Soil Properties V 3.5, 1995* (1:5,000,000) of the Food and Agriculture Organization of the United Nations (FAO).

The primary source of data for the bean distribution map (Map 1) were Gray (1990) and Wortmann and Allen (1994). Gray's sources for the first approximation are given below, together with our sources used to make revisions. Because of inadequacies in the statistics, revisions were often made, based on expert opinions of bean researchers working in Africa.



Map 49. Quality of data for bean production in sub-Saharan Africa.

List of sources for the *Atlas*.

Country	First approximation		Revision	
	Source	Total area mapped (ha)	Source	Area added (ha)
Algeria	None.	0	Agrostat PC files, FAO (1990-1993).	3,000 ha in coastal areas.
Angola	1. Area by district from *Estatísticas Agrícolas Correntes de Angola* (1969/70). 2. FAO production estimate (1988).	110,000	Expert opinion.	Area was not changed, but points were moved from south and north to increase the density around Huambo.
Burundi	Area by province from *Cellule Planification Regionale et Amenàgement du Territoire*, Burundi (1987).	388,105	No revisions were made.	
Cape Verde	1. Area by island from *Agricultural Statistics*, Praia (1969). 2. FAO production estimate (1988).	29,000	No revisions were made.	
DR Congo	Area by region from the Service d'Etude et Planification du Departement de l'Agriculture et du Développement Rural (1989).	121,720	1. Agrostat PC files, FAO (1990-1993). 2. Dessert KC; Chibinga A; Mukishi P. *Zaire, Southern Kivu: Bean diagnostic research in the zone of Kabare.* (Typescript.) (1987.) 3. Expert opinion: previous estimates were very low. Even so, the quality of information is considered poor, except for Kivu and Bas-Zaire.	Points were added for several production areas to map a total of 440,000 ha.
Egypt	Not reported.	0	*Potential for Field Beans in West Asia and North Africa*, CIAT (1983).	20,000 ha mapped in the Nile Valley.
Ethiopia	Not reported.	34,000	1. Various farming systems survey reports. 2. Expert opinion.	The number of hectares mapped was greatly increased, especially in the Hararghe Highlands where beans are produced in association with sorghum and maize, and been estimated.

(Continued)

List of sources . . . (Continued.)

Country	First approximation		Revision	
	Source	Total area mapped (ha)	Source	Area added (ha)
Ghana	1. Breakdown of bean hectarage by region (source and date unknown). 2. *Atlas for African Agriculture* (1986). 3. FAO production estimate (1988).	67,000	Expert opinion: former estimates apparently include other pulses.	Area was reduced to 1,500 ha.
Guinea	No beans were mapped.	0	Country profile by Roger Kirkby (1988).	30,000
Guinea-Bissau	1. Area by zone from the *Agricultural Census*, Guinea-Bissau (1960/61). 2. FAO production estimate (1988).	3,000	No revisions were made.	
Kenya	Area by district from Gutu W; Ngalyuke CAK. *Agriculture and Livestock Data Compendium*. Kenya Ministry of Planning and National Development, Nairobi (1989).	540,533	Gitu KW. *Agricultural Data Compendium.* Technical Paper no. 92-10 (1992).	
Lesotho	Area by district from *Lesotho Agricultural Situation Report* (1986/87).	18,456	1. Agrostat PC files, FAO (1990-1993). 2. Expert opinion.	Mapped area reduced to 10,000 ha.
Madagascar	Area by district from *Statistique 'Mpara'*, Madagascar (1981-1984).	90,000	Area by district (nd).	5,000 and 8,000 ha added for Mahajanga and Toliary, respectively.
Malawi	Area by administrative district from National Rural Development Programme, Malawi Ministry of Agriculture (1988/89).	92,318	1. Agrostat PC files, FAO (1990-1993). 2. Expert opinion.	28,000 ha added and points redistributed.
Mauritius	1. Total island area from the Mauritius Chamber of Agriculture (1979). 2. FAO production estimate (1988).	2,000	No revisions were made.	
Morocco	Not reported.	0	*Potential for Field Beans in West Asia and North Africa*, CIAT (1983).	7,000 ha were mapped.

(Continued)

List of sources . . . (Continued.)

Country	First approximation		Revision	
	Source	Total area mapped (ha)	Source	Area added (ha)
Mozambique	1. Area by district for 1970 from *Annuario Estatístico*, Mozambique (1972). 2. FAO production estimate (1988).	125,000	Expert opinion.	10,000 ha added, and points moved to decrease the points in the south-central region and to increase the intensity around Lichinga, NE Tete, and the western (Manica) highlands.
Nigeria	Not reported.	0	Expert opinion.	5,000 ha were mapped for each of the Kano area and the Jos Plateau.
Rwanda	Area by district from *Resultats de l'enquête nationale agricole,* vol. 1, Rwanda (1984).	463,658	1. Agrostat PC files, FAO (1990-1993). 2. Expert opinion.	Total area was reduced to 320,000 ha and points moved from areas of national parks.
S Af Rep	FAO production estimate (1988).	87,000	1. *Dry Beans in Natal*, Department of Agricultural Development for Natal Region (1991). 2. Expert opinion.	Area increased to 107,000 ha, and points moved.
Sudan	Area by province from trip report by Roger Kirkby (1990).	30,000	1. IGADD database. 2. Expert opinion: the original estimate accounts for production in the Nile Valley, but excludes production in southern and south-western Sudan.	40,000 ha were added in the southern and south-western regions.
Tanzania	Area by district from *Basic Data: Agricultural and Livestock Sector 1982/3-1986/7.* United Republic of Tanzania, Planning and Marketing Division, Ministry of Agriculture and Livestock Development (1987).	375,790	1. Farming systems research reports. 2. Expert opinion.	Points moved from south-east and central Tanzania to W, N, and S. 15,000 ha added in the Southern Highlands.
Togo	Area by region from *Enquêtes et Statistiques Agricoles*, Togo (1984).	123,800	Expert opinion: the previous estimate apparently includes other pulses.	The mapped area was reduced to 5,000 ha.

(Continued)

List of sources . . . (Continued.)

Country	First approximation		Revision	
	Source	Total area mapped (ha)	Source	Area added (ha)
Tunisia	Not reported.	0	*Potential for Field Beans in West Asia and North Africa*, CIAT (1983).	3,000 ha were mapped.
Uganda	Area by district from data provided by Bill Grisley (1988).	455,065	1. *Production zones and targets, 1992-1995*. Ministry of Agriculture, Animal Industries and Fisheries, Uganda (1992). 2. Expert opinion.	Area increased to 475,000 ha. Some points moved.
Zambia	Area by district from data provided by Bill Grisley (1986/87).	23,637	1. Central Statistics Office (1996/97). 2. *Agricultural Census Reports*, 1989/90 and 1990/91.	
Zimbabwe	Area by province for communal farming areas; data provided by Bill Grisley (1987).	16,869	1. Agrostat PC files, FAO (1990-1993). 2. Expert opinion.	7,000 ha were added.

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Acronyms and Abbreviations Used in the Text

AFBE	African bean environment
AFBYAN	African Bean Yield and Adaptation Nursery
AHI	Africa Highlands Initiative of the CGIAR
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BCMNV	Bean common mosaic necrosis virus
BCMV	Bean common mosaic virus
BPA	Bean production area
CAB International	Centre for Agriculture and Biosciences International, UK
CGIAR	Consultative Group on International Agricultural Research, Italy
CIDA	Canadian International Development Agency
DfID	Department for International Development (*formerly* ODA), United Kingdom
DR Congo	Democratic Republic of the Congo
ECABREN	Eastern and Central Africa Bean Research Network
FAO	Food and Agriculture Organization of the United Nations, Italy
FSR	Farming systems research
FURP	Fertilizer Use Research Project, Kenya
IBP	Intensity of bean production
ICZ	Intertropical convergence zone (climate)
IGADD	Inter-Governmental Authority on Drought and Development
masl	Metres above sea level
MISP	Maintenance and Improvement of Soil Productivity of the AHI
NARO	National Agricultural Research Organization, Uganda
nd	No date
OC	Organic carbon
PD	Population density
PP+	Photoperiod (probable effects on bean plants)
PPN	Photoperiod (neutral effects on bean plants)
QUEFTS	Quantitative Evaluation of the Fertility of Tropical Soils (model)
rm	Residual moisture
S Af Rep	Republic of South Africa
SABRN	Southern Africa Bean Research Network
SACCAR	Southern Africa Centre for Cooperation in Agricultural Research and Training
SADC	Southern Africa Development Cooperation
SDC	Swiss Development Cooperation
UNESCO	United Nations Educational, Scientific, and Cultural Organization, France
USAID	United States Agency for International Development

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