Appendix 1
Regional Biological Surveys for CWD in Uganda, Ethiopia, Tanzania and Rwanda

A1.1 CWD Country Surveys

As the disease resurged in the 1990s, it became urgent to carry out detailed surveys to determine its true distribution, severity and the ways in which farmers were coming to terms with it. These surveys were conducted between March 2002 and January 2003. A total of 8505 coffee farms were sampled as follows: Uganda 1374; Tanzania 964; Democratic Republic of Congo (DRC) 1000; Rwanda 1560; Ethiopia 1607; Cameroon 1000 and Côte d'Ivoire 1000.

The dates of the surveys were; Uganda (March–April 2002), Ethiopia (July–August 2002), Tanzania (October 2002–January 2003) and Rwanda (July–August, 2002). The surveys were coordinated by CAB International Africa Regional Centre, and undertaken in collaboration with the respective National Coffee Research Systems (NCRSs) of each participating country, with assistance from CIRAD. In Uganda, the administrative units from which coffee farms were sampled are (in decreasing hierarchical order) district, county, sub-county, parish and village. In Ethiopia, they are region, zone, wereda (district) and kebele (division). In Tanzania, they are region, district and division; while in Rwanda they are province, district, sector and cell. The number of farms to be sampled in each unit was then determined, using coffee production, coffee variety, agro-ecological zone and accessibility as the main criteria.

Coffee farms, both Arabica and Robusta, were located and sampled with staff from the local district agricultural offices. A clustered sampling procedure was carried out, whereby three to four coffee farms were sampled at every stop. At each farm, 30 randomly selected trees on a diagonal transect across the farm were assessed for the incidence and severity of coffee wilt disease (CWD), together with the presence of other diseases and insect pests. Visual examination of cut stems confirmed whether observed dieback or any other symptoms were due to CWD or other causes. A diagnostic symptom of CWD is the presence of a characteristic blue-black staining when the bark is scraped (Figure A.1).

A1.2 Locations

A1.2.1 Uganda

The surveyed farms were situated between 0° 46.025' south and 0° 59.385' north, and 30° 02.628' and 33° 57.226' east, and between 829 and 1650 m above sea level.

A1.2.2 Ethiopia

The farms surveyed were located between 5° 54.993' and 9° 59.124' north and 35° 03.085' and 40°48.653' east, and between 1053 and 2420 m above sea level.

Figure A.1: Coffee stem showing the characteristic blue-black coloration typical of the infection by coffee wilt disease (CWD).

Characteristic blue-black coloration on a stem of a CWD-infected coffee tree

A1.2.3 Tanzania

The coffee farms visited were located between 1° 00.059' and 11° 23.267' south and 30° 06.468' and 38° 34.460' east, and at altitudes of between 308 and 2165 m above sea level.

A1.3 Survey methods

As the disease is systemic and causes the death of the tree, a simple scoring system for the presence or absence of CWD per tree is a robust and an appropriate means of quantifying the disease. Thus, data for two disease variables were collected:

- Disease incidence – presence or absence of CWD per farm;
- Disease severity – percentage of coffee trees infected with CWD per farm.

In addition, information on the extent of infection per tree was collected, using a score of 1 to 6 to quantify the extent of infection per tree, as this could provide information on the period of time a tree has been infected. Farm characteristics recorded included: farm size, production system, topography of farm, agronomic practices (coffee variety and type, coffee age, use of intercropping, use of mulching, use of fertilizer, shading of crop and pruning of trees) and environmental characteristics (altitude, annual mean rainfall, temperature and soil type). In countries where information on diseases other than CWD and insect pests were recorded, these were also summarized at the level of the administrative unit, and correlations between other diseases or insect pests and CWD were investigated.

In order to identify possible factors that influence the occurrence of CWD, additional biophysical data were collected from the local government departments in each country, i.e. soil type, mean rainfall and temperature for the entire area covered by the survey.

Impact of the spread of CWD was assessed on approximately 100 farms sampled during the first survey, which were subsequently revisited during a follow-up survey conducted 6 months after the initial survey. Using the same data sheets as those used in

the initial survey, the incidence and severity of the disease on all the marked trees was scored. The follow-up surveys were conducted in Uganda and Ethiopia only and the analyses for these countries are described below. Similar follow-up surveys could not be undertaken in Tanzania as technical problems led to the delays in the implementation of the first surveys.

A1.3.1 Data analysis

Data from the Biological Survey were entered into, and summarized in, a spreadsheet form. Data for the extent of infection were also summarized, but as the disease is systemic and inevitably leads to tree death, they were not found to add any additional information over and above the data for incidence and severity, and were, therefore, not analysed further. Analysis was carried out in the GenStat Statistical Package (Genstat, 2000) to answer each objective of the survey. Data from each country were analysed identically and details of each analysis are described below.

1. *Quantify the incidence and severity of CWD*: Summaries of data for the incidence and severity of CWD were calculated at the appropriate administrative unit levels in each country. The summaries were then mapped to show the distribution of CWD in each country. Analysis of data for the incidence of CWD was carried out using logistic modelling for binary responses. The model was used to predict the probability of infection on a farm, depending on the explanatory factors, i.e. administrative units. Analysis of data for the severity of CWD on farms was carried out using binomial modelling with percentage response (percentage of trees infected on farm). This model was used to predict the level of CWD infection on a particular farm, depending on the explanatory factors, i.e. administrative units.

2. *Identify the factors influencing the incidence and severity of CWD*: Summaries of the possible explanatory factors were obtained from: farm characteristics (farm size, production system and topography of farm); agronomic practices (coffee variety and type, coffee age, use of intercropping, use of mulching, use of fertilizer, shading of crop and pruning of trees) and; environmental characteristics (altitude, annual mean rainfall, temperature and soil type). In countries where information on diseases other than CWD and insect pests were recorded, these were also summarized at the level of administrative unit, and correlations between other diseases or insect pests and CWD were investigated.

Cross-tabulations and correlations of each possible explanatory factor with data for the incidence and severity of CWD were calculated. Also, cross-tabulations and correlations of explanatory factors with each other were calculated to investigate whether one factor could entirely explain another. Chi-square tests were performed on cross-tabulations of factors with the incidence of CWD to investigate possible associations. Linear correlations were calculated for explanatory factors consisting of continuous data (e.g. farm size) with CWD severity.

Binary logistic regression was used to regress the possible explanatory factors on CWD incidence, and binomial modelling was used to regress the possible explanatory factors on CWD severity.

3. *Assess the impact of the spread of CWD on coffee production*: Summaries of changes in the incidence and severity of CWD between the first and second surveys in

Uganda and Ethiopia were used to quantify the spread of CWD, and calculate the reduction in coffee yield caused by the disease. Possible explanatory factors (defined above) influencing the rate of spread were investigated using the increase in severity in a binomial model.

A1.4   Number of Farms Surveyed in Each Administrative Unit

A1.5   Biological Survey

Biological surveys were undertaken on >5500 coffee farms in different agro-ecological zones in the key coffee-producing areas of the four participating countries, Uganda (March–April 2002), Ethiopia (July–August 2002), Tanzania (October 2002–January 2003) and Rwanda (July–August 2002). The surveys were coordinated by CAB International – Africa Regional Centre, and undertaken in collaboration with the respective NCRSs of each participating country, with assistance from CIRAD.

At each farm, 30 randomly selected trees on a diagonal transect across the farm were assessed for the incidence and severity of CWD, together with the presence of other diseases and insect pests. Penknives were used to confirm whether observed dieback or any other symptoms were due to the CWD or other causes. A diagnostic symptom of CWD is the presence of characteristic blue-black staining when the bark is scraped (Figure A.1). Sampled trees were physically numbered from 1 to 30, using white paint.

These data, together with information describing the location of each farm and farming system including agronomic practices, were recorded in a data sheet developed and agreed upon at a workshop at which the sampling procedure was developed, held in Mukono, Uganda (Appendix 2).

Table A1.1: Uganda.

District	County	Number of farms surveyed	District	County	Number of farms surveyed
Bugiri	Bukoli	18	Mayuge	Bunya	18
Bundibugyo	Bwamba	18		Butambala	27
Bushenyi	Sheema	18	Mpigi	Gomba	45
Hoima	Bugahya	9		Mawokota	78
	Buhaguzi	9	Mubende	Busujju	27
Iganga	Kigulu	18		Buwekula	42
Jinja	Butembe	9		Kasanda	64
	Kagoma	9		Mityana	17

Continued

Table A1.1: Continued

District	County	Number of farms surveyed	District	County	Number of farms surveyed
Kamuli	Bugabula	9	Mukono	Buikwe	54
	Buzaya	9		Mukono	45
Kayunga	Ntenjeru	63		Nakifuma	70
Kibaale	Bugangaizi	18	Rakai	Kakuuto	36
Kiboga	Kiboga	55		Kooki	27
Kyenjojo	Mwenge	18		Kyotera	72
Luwero	Bamunanika	32	Rukungiri	Rubabo	18
	Katikamu	36	Sembabule	Mawogola	36
	Nakaseke	72	Wakiso	Busiro	98
Masaka	Bukomasimbi	44		Kyadondo	45
	Bukoto	45			
	Kalungu	46	**Grand total**		**1374**

Table A1.2: Ethiopia.

Region	Zone	Number of farms surveyed	Region	Zone	Number of farms surveyed
Amhara	Awi	18	SNNP	Bench Maji	53
	East Gojam	22		Gedeo	100
	North Wollo	22		Hadiya	20
	North Shewa	13		KAT	75
	Oromiya	11		Kefa	46
	South Wello	15		Sheka	38
	West Gojam	40		Sidama	196
Oromiya	Bale	66		South Omo	28
	Illubabor	157		Amaro	24
	Jima	228		Burji	11
	West Hararghe	173		Konso	20
	West Wellega	150		Walaita	63
			Gambela	Abobo	18
Grand total					**1607**

Table A1.3: Tanzania.

Region	District	Number of farms surveyed	Region	District	Number of farms surveyed
Southern Highlands	Ileje	28		Karagwe	58
	Iringa	19		Muleba	54
	Ludewa	16		Ngara	34
	Lushoto	34		Tarime	35
	Makete	5		Ukerewe	13
	Mbeya	31		Musoma	7
	Mbinga	38	Northern Zone	Arumeru	41
	Mbozi	42		Babati	19
	Morogoro	27		Hai	40
	Mufindi	31		Karatu	28
	Njombe	18		Monduli	12
	Rungwe	36		Moshi (V)	43
	Songea	18		Mwanga	40
Lake Zone	Biharamulo	23		Rombo	42
	Bukoba (V)	71		Same	61
			Grand total		**964**

Table A1.4: Rwanda.

Province	District	Number of farms	Province	District	Number of farms
Butare	Gikonko	25		Nyarubuye	22
	Kibingo	25		Rukira	22
	Kiruhura	25		Ville de Kibungo	22
	Maraba	25	Kibuye	Gisunzu	27
	Mugombwa	22		Rusenyi	28
	Nyakizu	25		Rutsiro	27
	Nyamure	25		Ville de Kibuye	28

Continued

Table A1.4: Continued

Province	District	Number of farms	Province	District	Number of farms
Byumba	Humure	23	Kigali Ngari	Bicumbi	27
	Kinihira	22		Buliza	27
	Kisaro	23		Gasabo	27
	Rwamiko	23		Ngenda	27
Cyangugu	Bugarama	40		Nyamata	27
	Bukunzi	40		Rulindo	25
	Gashonga	40		Rushashi	27 (R) + 27 (A)
	Gatare	40		Shyorongi	27
	Impala	40		Ville de Kabuga	26
	Nyamasheke	40	Ruhengeri	Buhoma	10
	Ville de Cyangugu	37		Bukonya	12
Gikongoro	Kaduha	23	Umutara	Murambi	9
	Karaba	25	Gitarama	Kamonyi	34
	Nyaruguru	23		Kayumbu	20 (R) + 34 (A)
	Ville de Gikongoro	23		Muhanga	34
Gisenyi	Kageyo	26		Ndiza	34
	Kayove	26		Ntenyo	34
	Nyagisagara	24		Ntongwe	34
	Nyamyumba	26		Ruyumba	34
Kibungo	Kigarama	23		Ville de Ruhango	33
	Mirenge	23			
Grand total: 1547 (47 Robusta and 1500 Arabica)					

A1.6 An Example of a Data Sheet Used in the Regional Biological Survey

DATA INPUT FORM FOR COFFEE WILT DISEASE SURVEY

Date_____ Recorder_____

District _____County_____ Subcounty_____ Farmer_____

Parish_____Villlage_____ No. fields_____

No. lost trees if abandoned _____ Intercropping _____

Soil (**B**)_____ Production system (**C**)_____ Crop _____

Shade if any_____ Coffee age _____ Weeding (**D**)_____

Coffee variety: Seedling____ or Clone_____ Mulching: Yes____No._____

Pruning: Yes_____No _____ Physiological stage (**E**)_____ Annual yield: (before_____ or

Fertilizer/manure_____ No. trees uprooted _____ (after)_____

Initial number of trees _____ Field size (acres)_____

Coordinates N/S_____W/E _____ Altitude(m) _____ Topography (**F**)_____

Tree	Healthy	Wilt (CWD)	Wilt (A) score	Dead tree	Stump L/D	Missing tree	Other diseases	Insect pests	Remarks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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25									
26									
27									
28									
29									
30									

Notes: A. CWD score used: **1**=absent/no symptoms; **2**=leaves curl inwards; **3**=dieback and defoliation (1-24%);
4=dieback and defoliation (25-50%); **5**=dieback and defoliation (50-75%); **6**=dieback and defoliation/tree death (76-100%).
B. Soil: **1**=sandy; **2**=sandy clay; **3**=clay; **4**=loam; **5**=others (specify).
C. Production system: **1**=forest; **2**=semi forest coffee; **3**=garden/cottage coffee; **4**=plantation coffee.
D. Weeding; **1**=unweeded; **2**=slashing; **3**=hoeing; **4**=herbicide; **5**=others (specify).
E. Physiological stage: **1**=vegetative; **2**=flowering; **3**=pinhead; **4**=expansion; **5**=hard green; **6**=ripening.
F.Topography: **1**=slope; **2**=valley; **3**=hill top; **4**=flat/level ground; **5**=other (specify).

Dead=dead tree from causes other than F. xylarioides   **Stumps**: L=Live stumps. D=Dead stumps