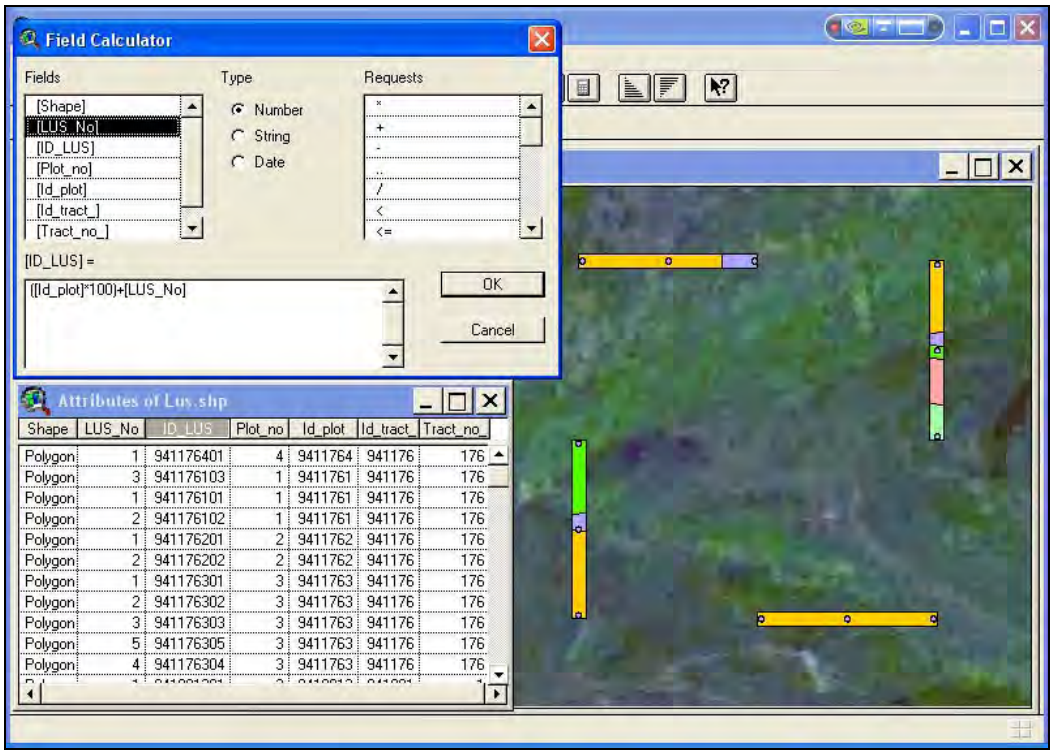
Forestry Department

Food and Agriculture Organization of the United Nations

A GIS PRIMER ON HOW TO ILLUSTRATE SPATIAL DATA AND INFORMATION GENERATED THROUGH NATIONAL FOREST INVENTORIES



PREPARED BY CECILIA ALARCÓN SALINAS
ROME, MARCH 2007

STRENGTHENING MONITORING, ASSESSMENT AND REPORTING ON SUSTAINABLE FOREST MANAGEMENT IN ASIA (GCP/INT/988/JPN)

Strengthening Monitoring, Assessment and Reporting (MAR) on Sustainable Forest Management (SFM) in Asia (GCP/INT/988/JPN)

FAO initiated the project "Strengthening Monitoring, Assessment and Reporting on Sustainable Forest Management in Asia" (GCP/INT/988/JPN) in January 2006. The five-year project is funded by the Government of Japan.

The main objective of this project is to facilitate development of harmonized forest related national monitoring, assessment and reporting (MAR) systems in the Asia-Pacific region to contribute directly to the improvement of sustainable forest management (SFM) regimes. An allied objective of the project is to enhance the use of the MAR information in national decision-making, formulation of effective forest policies, and sustainable forest management and planning.

The project accomplishes its objectives in two phases. The first two years, the Development Phase, the project would focus on: (a) international activities like the establishment of linkages with forest-related processes; (b) facilitating development of a globally harmonized framework, guidelines and database structure, including pilot testing in some countries; (c) use of MAR information in forest planning and development of forest policies at the national level; (d) establishment of a country-level network of national focal points to various forest-related processes; and (e) initiate a set of national activities that facilitate the implementation of the harmonized MAR.

The Implementation Phase spreads over the remaining three years of the project period and focuses on the implementation of the harmonized MAR, including facilitation in the establishment of database at the national level in selected project countries within the Asia-Pacific region through studies, reviews, training, workshops and expert consultations. The detailed design of this phase will be finalized on the basis of a review of the activities and the outputs of the first phase.

All countries in the Asia-Pacific region can participate in the project, although the actual level and intensity of their involvement may vary among them. Forestry departments in respective countries have been requested to nominate their national focal points for this project.

The project is organized under the Forest Resources Development Service (FOMR) in the Forest Resources Division (FOM) of FAO Forestry Department. The contact persons are:

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Monitoring Assessment and Reporting

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Views of participants in a workshop reported in the proceeding may be considered as their personal views. These may be same or different from the official view of their country.

The MAR-SFM Working Paper Series provides an important forum for the rapid release of preliminary findings needed for validation and to facilitate the final development of official quality-controlled publications. Should users find any errors in the documents or have comments for improving their quality they should contact Kailash.Govil@fao.org.

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1 Introduction

The application of GIS as an integral tool to manage data and information in National Forest Inventories (NFI) represents a dynamic and powerful instrument to policy makers, facilitating decision making for local developments according to the regional or national forest priorities.

This study shows an example of application of GIS[1] to illustrate how data and information generated in NFIs can be managed and displayed to decision makers to better understand the outcomes of NFIs. Current study is based on data and information from the NFI of Lebanon[2].

Many definitions of GIS have been developed during the last decades, but essentially, constitutes *"An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information"*[3]

The GIS functionality provides the possibility to manage, maintain and visualized many kinds of data and information. Furthermore, this information can be processed and linked to the different data sets, querying and displaying the results on a map. Each geographic data represent a feature that is stored as a series of geographic coordinates representing points, lines or polygons, which are organized in data sets or themes. These layers of information can present maps where the attributes of the different datasets can be combined with their specific information. However, to explain the GIS concept is not the objectives of this study.

2 Building a GIS pilot data model based on existing NFI data and information

The GIS includes links between map features and tabular data, which provide descriptive information to the maps features. To build a GIS data model a GIS project is created and connection to a database is established to link to the data tables that are needed for the GIS data model. When the NFI tabular data are accessible in the GIS model the map features can be generated and the links between the map features and the tabular data can be created.

To build a GIS pilot model based on existing NFI data and information the NFI in Lebanon is employed.

The NFI methodology of Lebanon included a systematic sampling for field data collection. The sample grid located a sample site every 4 x 4 minutes latitude and longitude (a tract every 7.4 x 6.1 Km throughout Lebanon) resulting in a total of 226 sample sites.

The sample site is a Tract of the size 1 km x 1 km, in which there are 4 perpendicular Plots, each 20 x 250 meter, which further contain 3 circular subplots with the radius 3.99m, as illustrated in Figure 1.

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[1] Further information on examples of the application of GIS is listed in the Bibliography

[2] FAO -Republic of Lebanon, Ministry of Agriculture. 2005 *National Forest and Tree Assessment and Inventory TCP/LEB/2903 (T)*, Lebanon

[3] Environmental Systems Research Institute (ESRI), 1990. Understanding GIS The Arc/Info Method. USA.

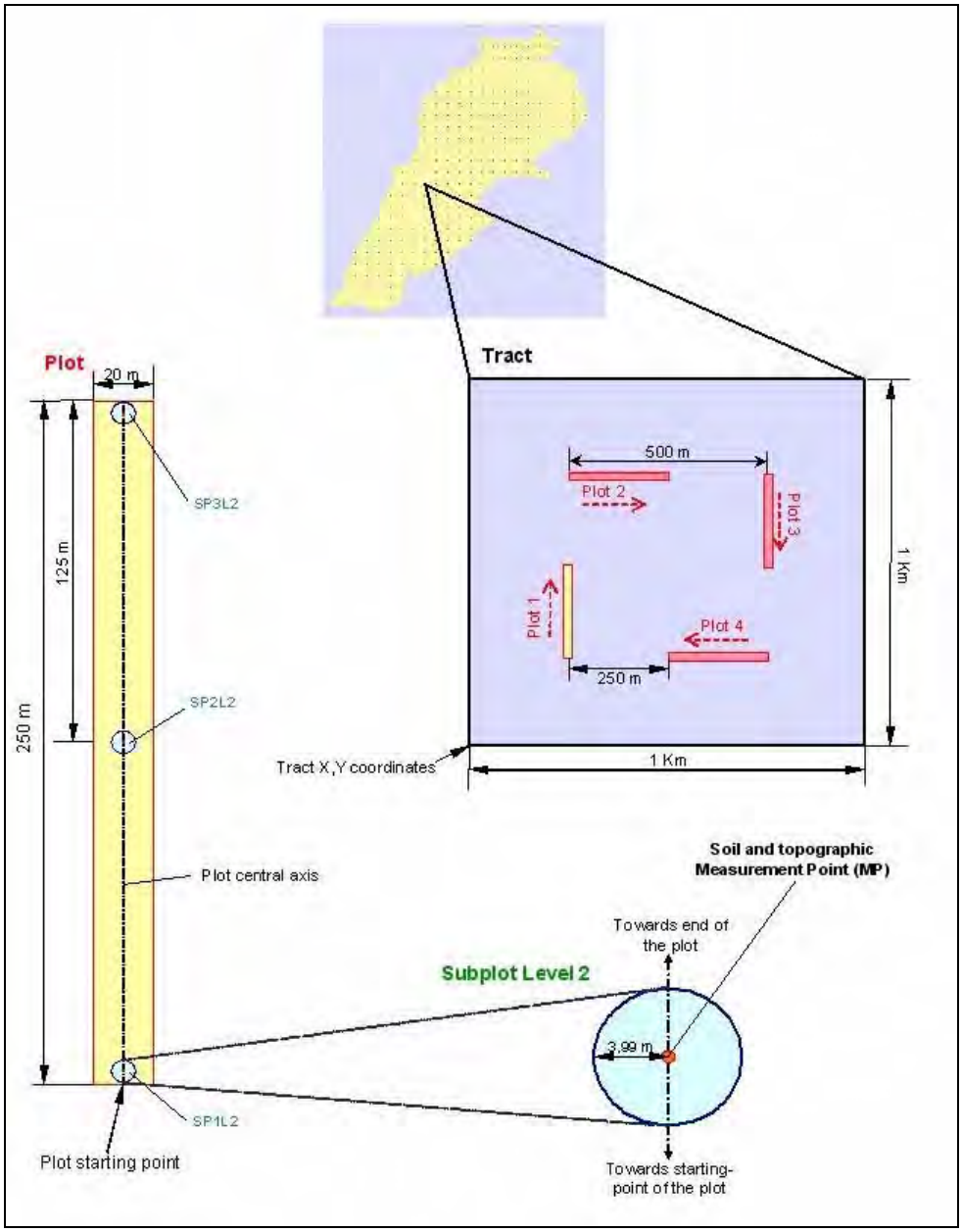

Figure 1: Sampling grid and Tract design in the NFI of Lebanon 2003-2005

2.1 *Identifying data for the NFI GIS Model*

The main data and information employed in this study involve the following:

1 Auxiliary data sets (non-NFI data)
2 NFI data and information
  2.1 Primary data
    2.1.1 Field inventory data
    2.1.2 Remote sensing data
  2.2 Processed NFI data (thematic maps)
  2.3 National NFI statistics incl. Forest cover / Land Use map

2.1.1 Auxiliary GIS Datasets

Existing GIS data and information covering the study area will be applied as auxiliary datasets to set the national environment in which the NFI data will be displayed. The auxiliary datasets may also serve as information for further analysis of NFI datasets. However, in this study they will only be applied for illustration purposes.

The following auxiliary datasets of high quality were identified:

Administrative division, district, border country limits, urban centres and villages, and roads (See Figure 2 - Figure **8**)

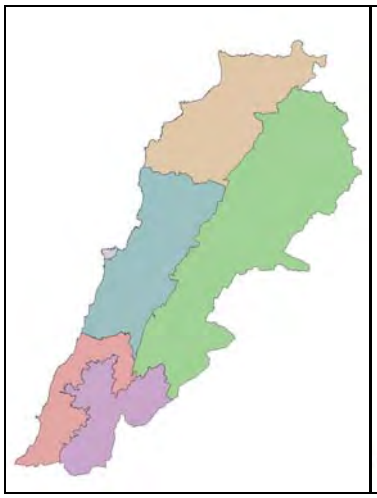

Figure 2: Administrative division, Mohafazas

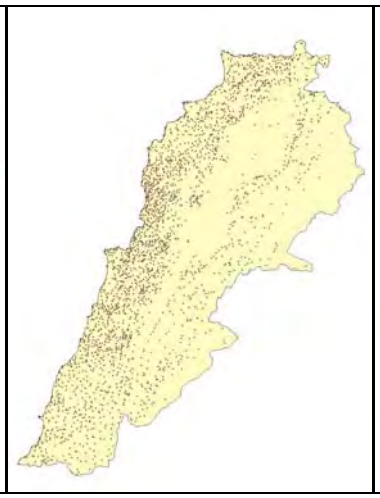

Figure 3: Urban centres and villages in Lebanon

Figure 4: Roads

Figure 5: Cazas

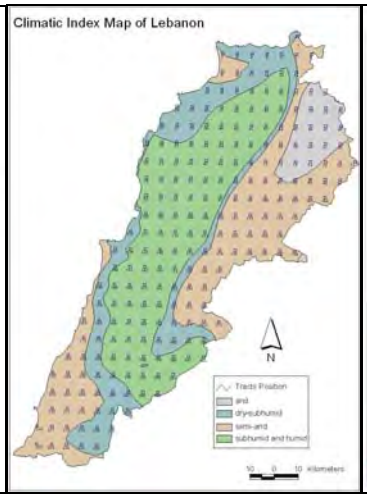

Figure 6: Climatic indices of Lebanon (MOA 2003) with NFI Tracts indicated

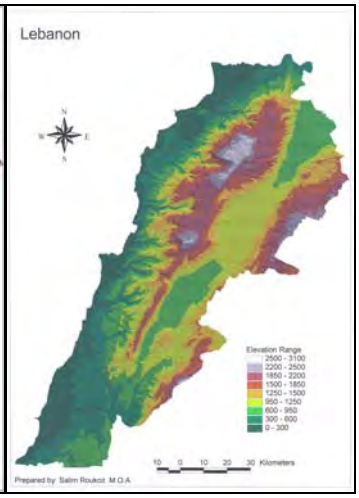

Figure 7: Elevation

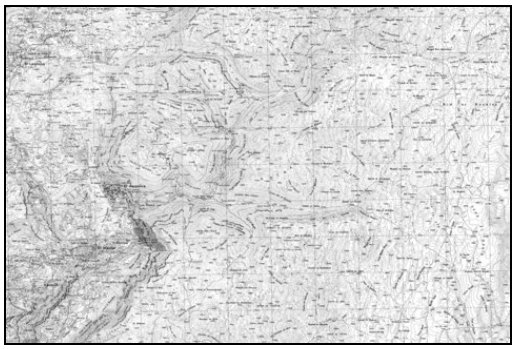

Figure 8: Topographic maps 1:20 000

2.1.2 NFI Data and Information

2.1.2.1 Primary Data

2.1.2.1.1 Field Inventory Data

The primary data from the NFI of Lebanon is kept in a MS Access database application, developed in collaboration with the Forest Department of FAO. This information and data is stored in different tables depending on the level of data collection and the tables are related to each other through defined relationships (see examples in Figure 1 and Figure 11). While most primary data (see Figure 9) are stored as codes there are corresponding code tables (see Figure 10), which define the meaning of these codes. The code tables together with forms and queries are kept in a separate database application to facilitate the development and maintenance of the NFI database application[4] .

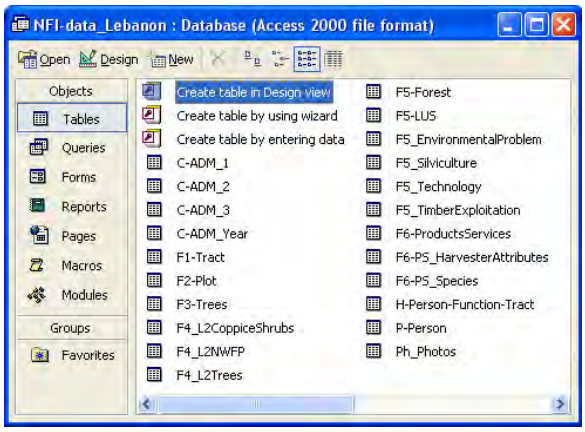

Figure 9: Database Window in MS Access showing the tables with primary data in the NFI "data" database application of Lebanon

[4] The structure of the NFA database application is further described in Annex I

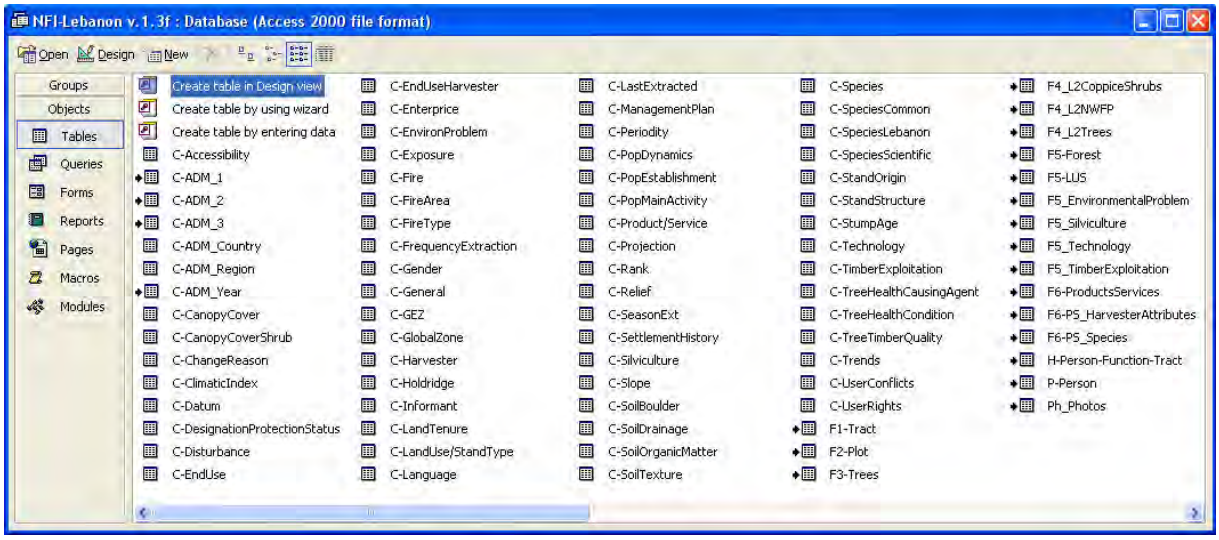

Figure 10: Database Window in MS Access showing the code tables in the NFI database application of Lebanon, and also the tables with primary data linked (shown with arrow next to the table icon) from the NFI "data" database application.

Figure 11 illustrates the relation between the different inventory levels Tract, Plot, LUS and Trees in the NFI "data" database of Lebanon. The database structure including the data table and their relationships are essential because they will defined how the links between the GIS features and the data in the NFI database of Lebanon shall be developed.

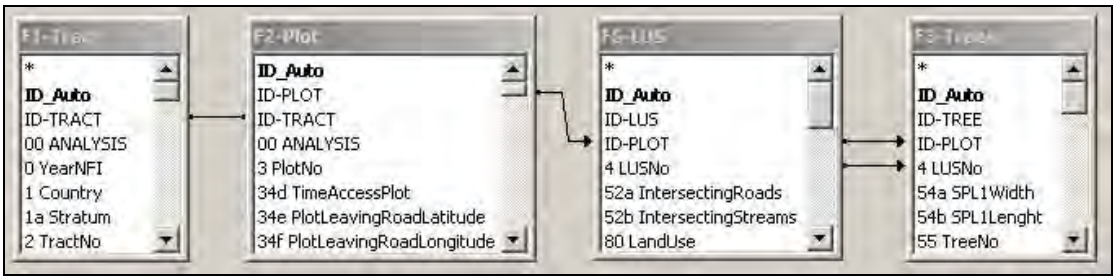

Figure 11: Example of relationships between different data levels in the NFI database application of Lebanon

Figure 12: NFI Tracts (226)

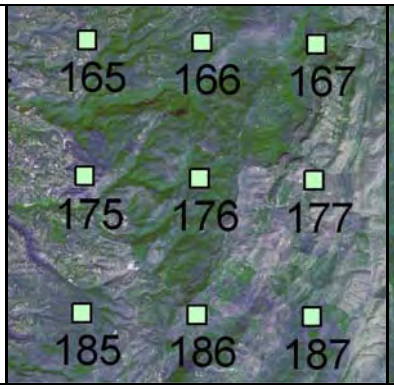

Figure 13: NFI Tracts and numbers

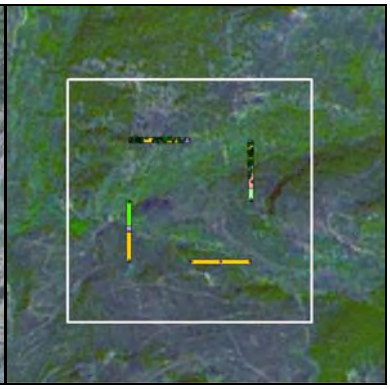

Figure 14: NFI Tract with Plots, SubPlots, Land Use Sections and Trees

2.1.2.1.2 Remote Sensing Data

Processed satellite imageries (Landsat TM resample to 5*5m pixels using SPOT PAN data) and mosaic covering the extent of Lebanon

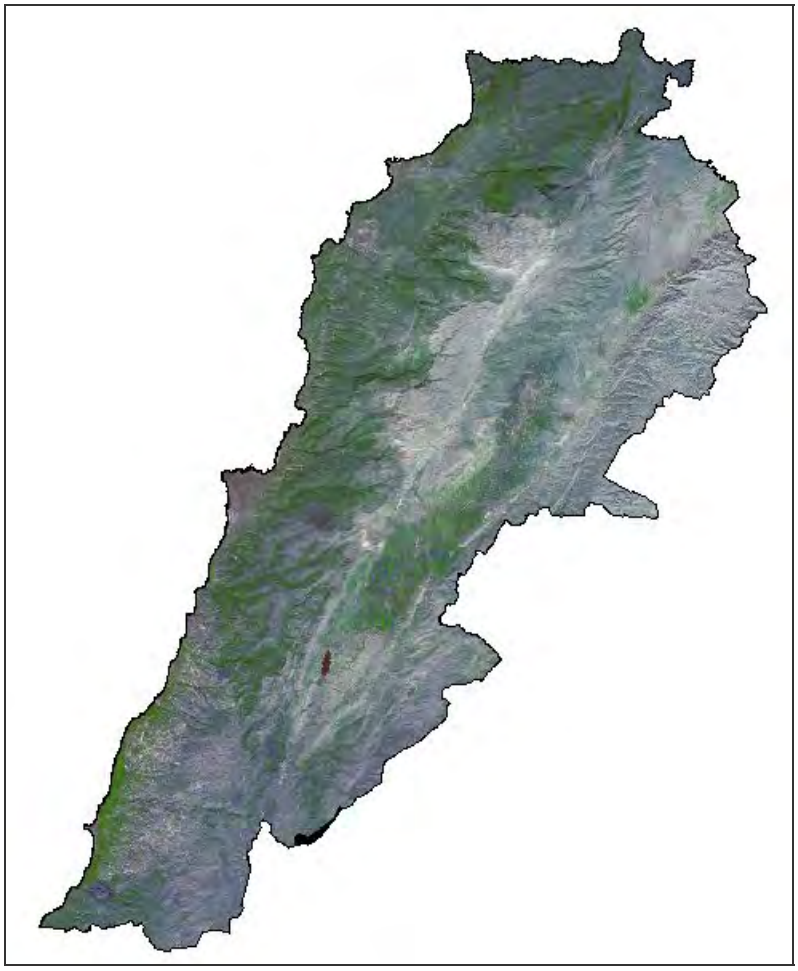

Figure 15: Mosaic of Landsat TM satellite data processed with Spot PAN data and resampled to 5 x 5 m resolution.

2.1.2.2 Processed NFI Data (Thematic maps)

Before the national forestry statistics can be generated from the NFI data, the primary data has to be processed[5] and analysed. The processed NFI data represent datasets where every tract (sample unit) presents one value per variable. From the processed datasets one can prepare thematic maps which show how the statistical information is distributed in the country.

On the following page are some examples of illustrations of processed data related to population, proximity to infrastructure and population activities:

[5] For further information and guidelines on data processing and data analysis please refer to extract of FRA Working Paper No. 95, .included in Annex II

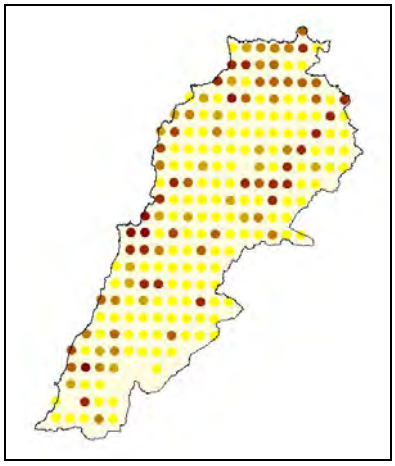

Figure 16: Population Size/Tract

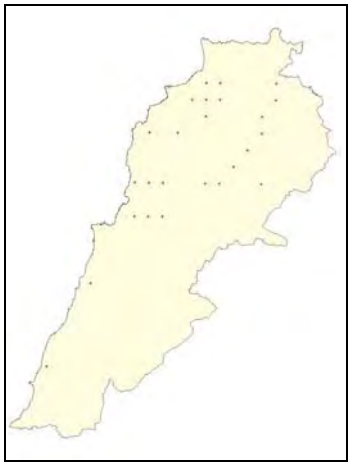

Figure 17: Charcoal Places in Tract

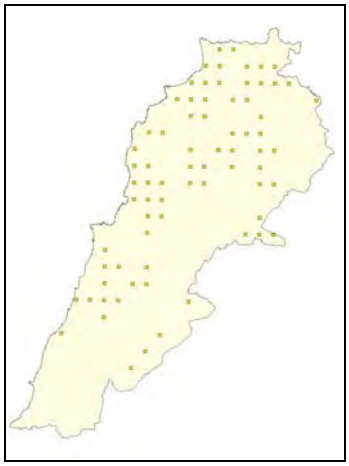

Figure 18: Beehives in Tract

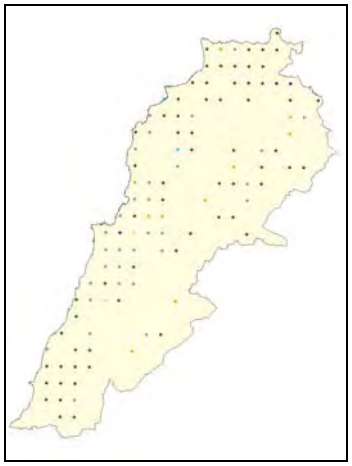

Figure 19: Main Activity of Permanent population in Tract

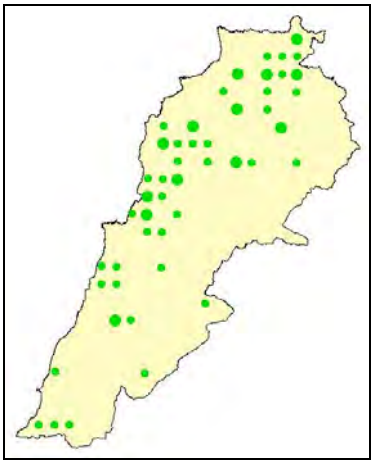

Figure 20 : Proportion of Forest area in Tract

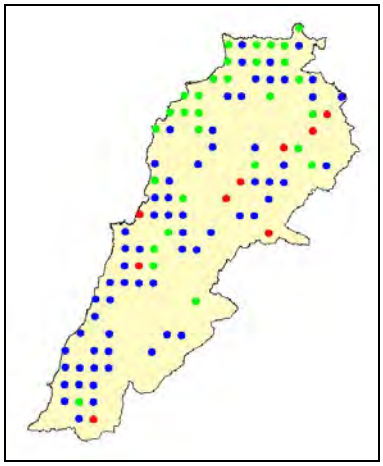

Figure 21 : Population dynamics in Tracts

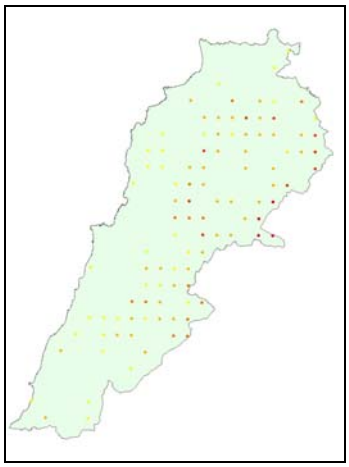

Figure 22: Distance Settlement

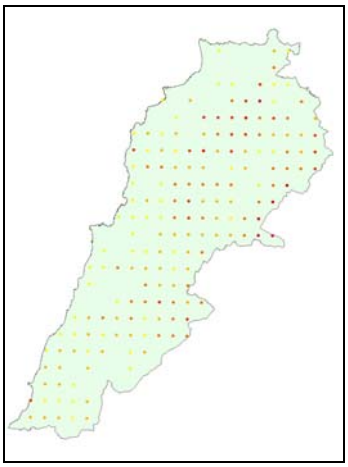

Figure 23: Distance School

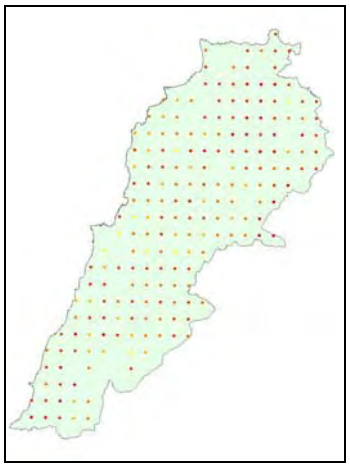

Figure 24: Distance Hospital

2.1.2.3 National NFI statistics incl. Forest cover / Land Use map

2.1.2.3.1 Land Use map

Based on the interpretation of satellite imaginary with support of maps on climatic index and elevation data a Forest Cover / Land Use map was derived.

Figure 25: Derived Forest Cover / Land Use map

2.2 *Creating GIS connection to data in NFI database application*

To start building the GIS data model in ArcGIS based on NFI data, a new GIS project is created and a *SQL connection* to the NFI database (*MS Access* application) is established to link to the data tables that are needed for the GIS data model.

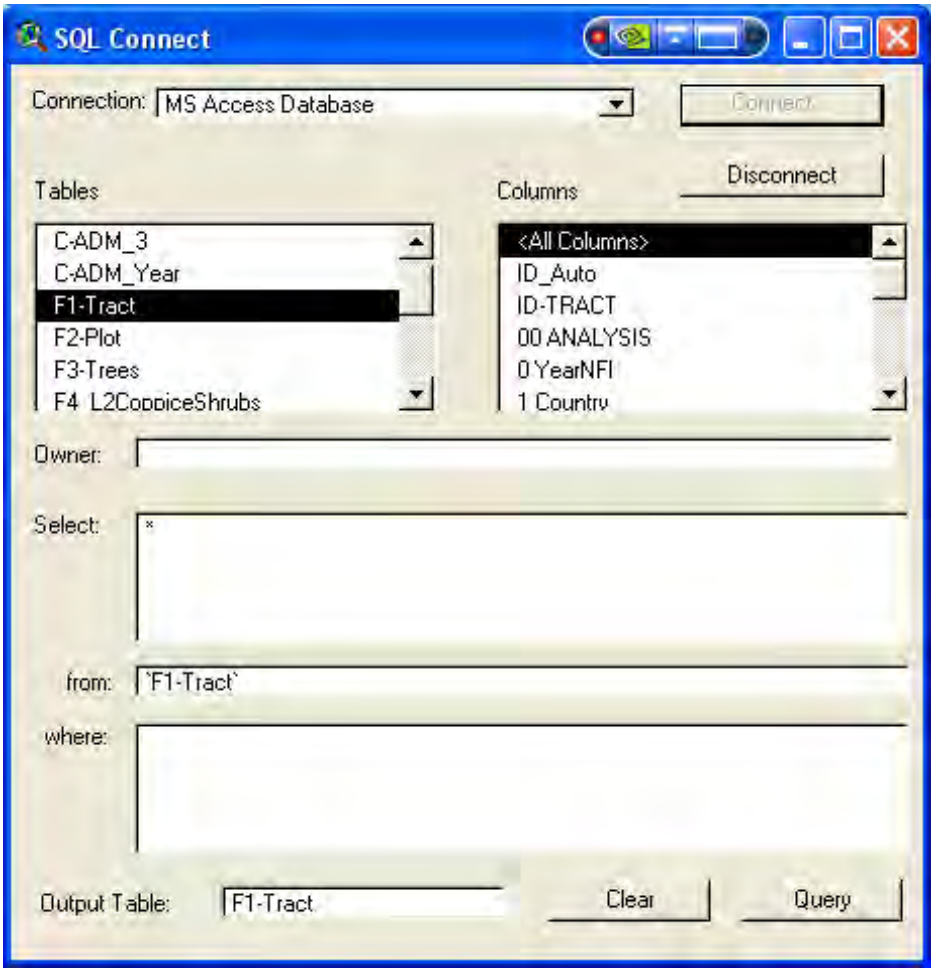

Figure 26: SQL Connection to NFI database (MS Access Database), choosing to select all fields (*) in the NFI table "F1-Tract" and naming the GIS linked table "F1-Tract".

2.3 *Creating NFI map features in the GIS*

When the NFI tabular data are accessible in the GIS model the map features can be generated and the links between the map features and the tabular data be created.

The following map features related to the NFI of Lebanon have been identified:

1. Tracts (Polygon)
2. Plots (Polygon)
3. SubPlots (SP) (Polygon)
4. Land Use Sections (LUS) (Polygon)
5. Trees and stumps (Point)
6. Reference points (Point)

In the NFI database tables the coordinates of the Tracts' SW corner and centre are given in the F1-Tract table, the coordinates of Plots' starting point are given in the F2-Plot table and the coordinates of the reference points are given in the Ph-Photo table. Further are the position of each tree within the Plot recorded as is the width and length of each LUS. Knowing these coordinates, relative positions and the Tract design, including the Plots and SubPlots allow the creation of all map features.

To create the Map features related to the Tract layout one complete Tract layout is created, comprising Tract, Plot SubPlot and LUS features. These map features are then multiplied until all Tracts are created.

2.3.1 Creating map features related to the Tracts

Tract SW corners: The Tracts' SW corner can be displayed as point objects in the GIS by creating an *event theme* where the Tract SW X and Y coordinates are employed to define the positions of the point objects.

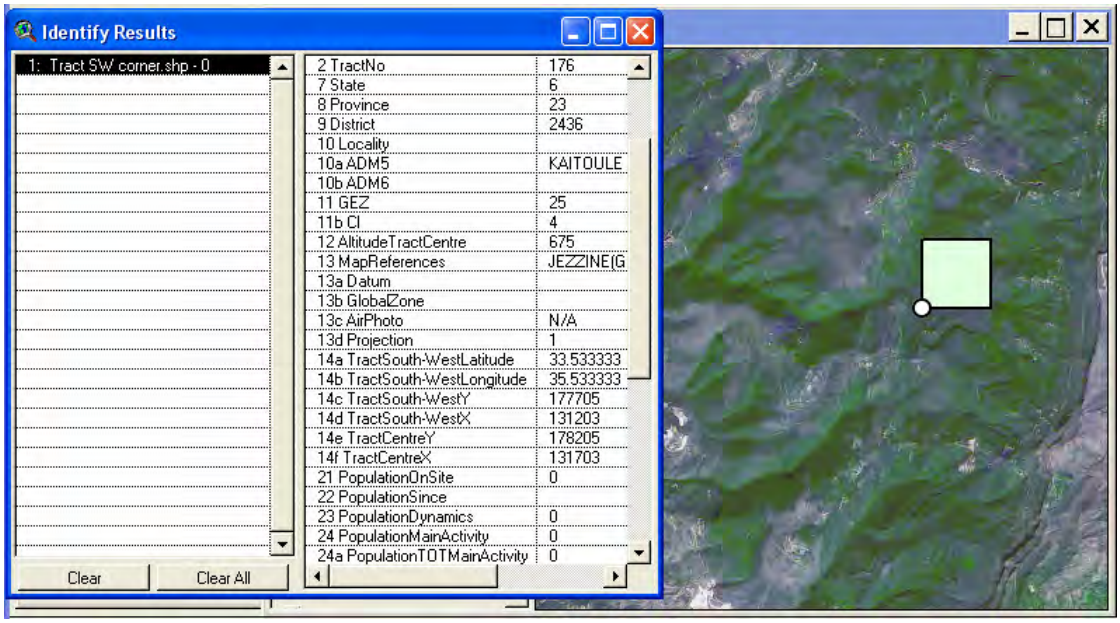

Figure 27: Attribute table of Tract SW corner point object, which corresponds to table F1-Tract in the NFI database application

Tract centres: In the same manner the Tracts' centre can be displayed as point objects in the GIS by creating an *event theme* where the Tract Centre X and Y coordinates are employed to define the positions of the point objects.

Tract graphics: Knowing that each Tract represents a square with the size 1km² and that the location of its South West (SW) corner is defined by the sample grid coordinates (latitude and longitude), the Tract features can be created and geographically positioned in the GIS.

First a Tract is created as rectangular graphics and its size and position is defined in *Graphics Size and Position*.

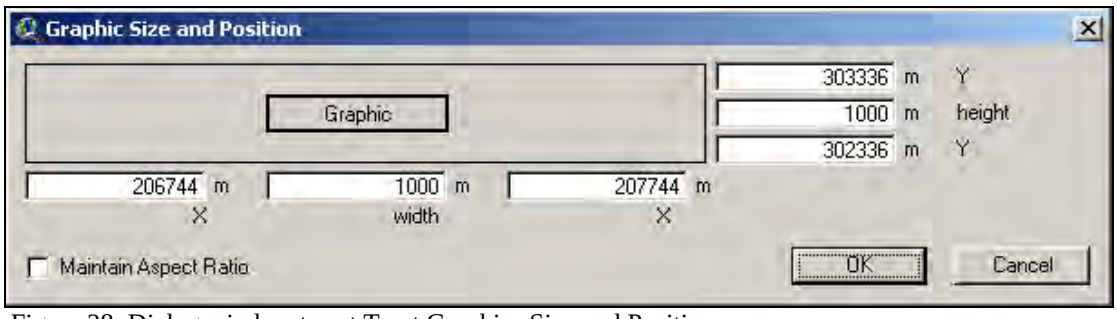

Figure 28: Dialog window to set Tract Graphics Size and Position

The size is set to 1000m wide and 1000m tall then the X and Y SW coordinates of the first Tract is chosen to position the lower left corner of the first Tract graphics. The position of the SW corner of the tracts is given in the table *F1-Tract* in the NFI database and can also be displayed by using the *information tool* when the *SW corner point object* is active and clicking on the of the first Tract SW point.

When the properties of the Tract graphics are set and accepted the Tract should appear at the position of the first Tract with the SW corner touching the Tract SW point object.

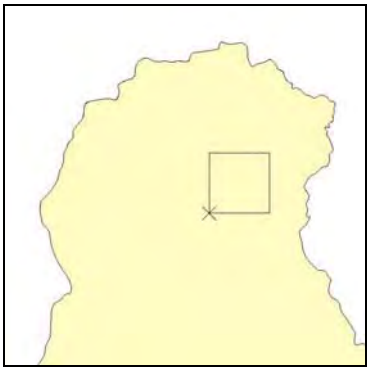

Figure 29: Tract Graphics and corresponding points of the Tract Centre and South-West corner

2.3.2 Creating map features related to the Plots

Plot Starting Points: The Plots' Starting Point can be displayed as point objects in the GIS by creating an *event theme* based on the table F2-Plot, where the Plot Starting Point X and Y coordinates are employed to define the positions of the point objects.

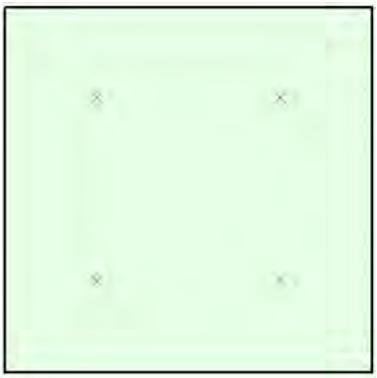

Figure 30: Tract Graphics and corresponding points of the Plot Starting Points

Plot graphics: Knowing that each Plot represents a rectangle with the size 20m x 250m and that the location of its Starting Point is defined as a function of the sample grid coordinates (latitude and longitude) and its orientation is defined by the Tract layout; the Plot features can be created and geographically positioned in the GIS. The Plot Starting Point coordinates can be found in the *Plot Starting Point theme*.

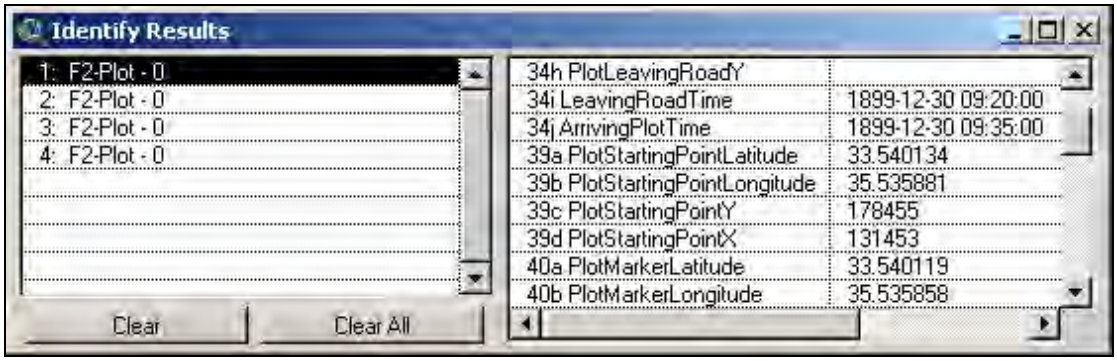

Figure 31: Attribute table of Plot Starting Point theme, which corresponds to table F1-Tract in the NFI database application. The table shows the Plot Starting Point X and Y coordinates.

Plot 1: A Plot is created as rectangular graphics and its size and position is defined in *graphics properties*. The size of Plot number 1 is set to **20m wide and 250m tall** then the **Plot Starting Point X coordinates - 10m** (X coordinate of Plot Starting Point represents the central axis of the Plot) and **Y coordinates** of the first Plot in the first Tract is chosen to position the **lower left** corner of the first Plot graphics.

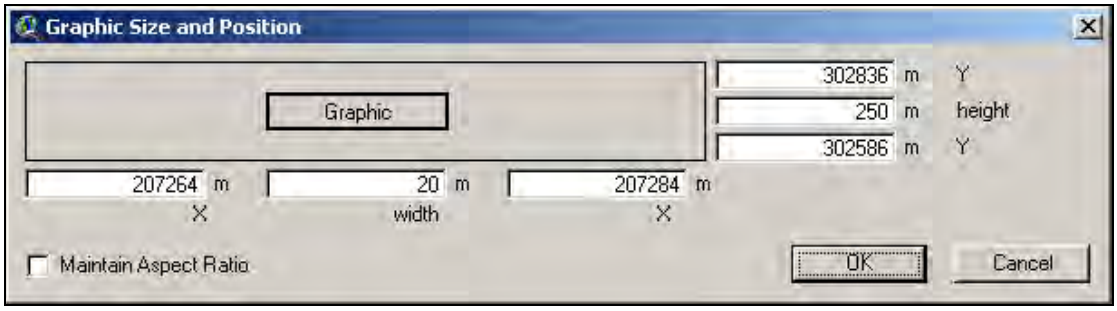

Figure 32: Dialog window to set Plot Graphics Size and Position. The Width and Height of the graphics do not directly correspond to the Width and Length of the Plot, but to the distance between the left and right side of the graphics and the distance between the lower and upper side of the graphics respectively.

Plot 2: A Plot is created as rectangular graphics and its size and position is defined in *graphics properties*. The size of Plot number 2 is set to **250m wide and 20m** tall then the **Plot Starting Point X coordinates** and **Y coordinates - 10m** (Y coordinate of Plot Starting Point represents the central axis of the Plot) of the second Plot in the first Tract is chosen to position the **lower left** corner of the second Plot graphics.

Plot 3: A Plot is created as rectangular graphics and its size and position is defined in *graphics properties*. The size of Plot number 3 is set to **20m wide and 250m** tall then the **Plot Starting Point X coordinates - 10m** (X coordinate of Plot Starting Point represents the central axis of the Plot) and **Y coordinates** of the third Plot in the first Tract is chosen to position the **upper left** corner of the third Plot graphics.

Plot 4: A Plot is created as rectangular graphics and its size and position is defined in *graphics properties*. The size of Plot number 4 is set to **250m wide and 20m tall** then the **Plot Starting Point X coordinates** and **Y coordinates - 10m** (Y coordinate of Plot Starting Point represents the central axis of the Plot) of the fourth Plot in the first Tract is chosen to position the **lower right** corner of the fourth Plot graphics.

The Plot Starting Point positions are given in the table *F2-Plot* in the NFI database and can also be displayed by using the *information tool* when the *Plot Starting Point object* is active and clicking on the corresponding Plot Starting Point. When the properties of the Plot graphics are set and accepted the Plots should appear at the corresponding positions within the first Tract with the Plot Starting Point touching the Plot Starting Point object.

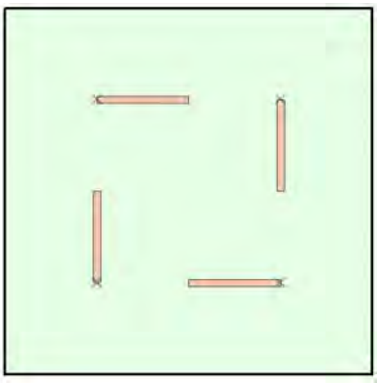

Figure 33: Tract and Plot Graphics and corresponding points of the Plot Starting Points

2.3.3 Creating map features related to the SubPlots

Measurement Point (MP) Point: The SubPlot's Centre Point refers to a Measurement Point, which can be displayed as point objects in the GIS by creating an *event theme* based on the table F2-Plot, where the Measurement Point X and Y coordinates are employed to define the positions of the point theme.

SubPlot graphics: Knowing that each SubPlot represents a circle with a **radius of 3.99m** and that its location within the Plot is defined as a function of the Plot Starting Point coordinates (X and Y) and the orientation of the Plots; the SubPlot features can be created and geographically positioned in the GIS. The X and Y coordinates of the SubPlots can be found in the attribute table of the *Measurement Point (MP) Point theme* (=SubPlot Centre), which corresponds to the F2-Plot table in the database application.

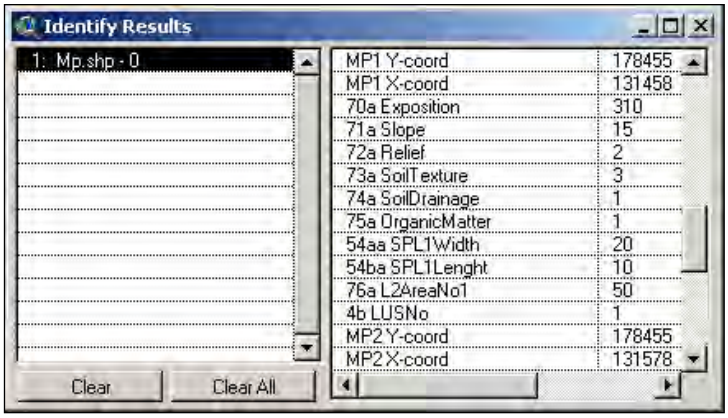

Figure 34: Attribute table of Measurement Point (MP) theme (SubPlot Centre), **,** which corresponds to table F2-Plot in the NFI database application. The table shows the X and Y coordinates of the Measurement Points (SubPlot Centre).

*SubPlots in **Plot 1**:*

SubPlot 1: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **first Plot** in the first Tract is chosen to position the **centre** of the first SubPlot graphics.

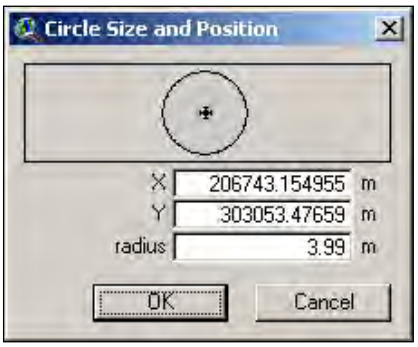

Figure 35: Dialog window to set SubPlot Graphics Size and Position

SubPlot 2: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **first Plot** in the first Tract is chosen to position the **centre** of the second SubPlot graphics.

SubPlot 3: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **first Plot** in the first Tract is chosen to position the **centre** of the third SubPlot graphics.

*SubPlots in **Plot 2**:*

SubPlot 1: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **second Plot** in the first Tract is chosen to position the **centre** of the first SubPlot graphics.

SubPlot 2: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **second Plot** in the first Tract is chosen to position the **centre** of the second SubPlot graphics.

SubPlot 3: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **second Plot** in the first Tract is chosen to position the **centre** of the third SubPlot graphics.

*SubPlots in **Plot 3**:*

SubPlot 1: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **third Plot** in the first Tract is chosen to position the **centre** of the first SubPlot graphics.

SubPlot 2: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to

3.99m then the **Plot Starting Point X coordinates** and **Y coordinates - 125m** of the **third Plot** in the first Tract is chosen to position the **centre** of the second SubPlot graphics.

SubPlot 3: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **third Plot** in the first Tract is chosen to position the **centre** of the third SubPlot graphics.

*SubPlots in **Plot 4**:*

SubPlot 1: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **fourth Plot** in the first Tract is chosen to position the **centre** of the first SubPlot graphics.

SubPlot 2: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **fourth Plot** in the first Tract is chosen to position the **centre** of the second SubPlot graphics.

SubPlot 3: A SubPlot is created as circle graphics and its size and position is defined in *graphics properties*. The radius of the SubPlot number 1 is set to 3.99m then the **MP1 X coordinates** and **MP2 Y coordinates** of the **fourth Plot** in the first Tract is chosen to position the **centre** of the third SubPlot graphics.

The MP1-3 X and Y coordinates are given in the table *F2-Plot* in the NFI database and can also be displayed by using the *information tool* when the *Plot Starting Point object* is active and clicking on the corresponding Plot Starting Point. When the properties of the SubPlot graphics are set and accepted the SubPlots should appear at the corresponding positions within the Plots (along the Plot central axis) in the first Tract.

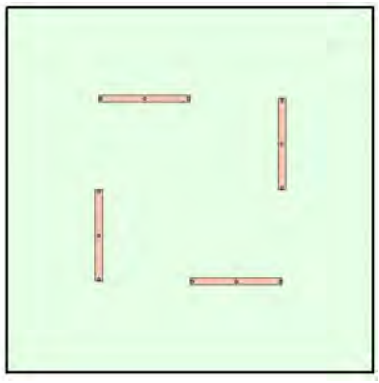

Figure 36: Tract, Plot and SubPlot graphics

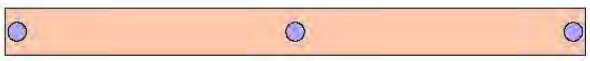

Figure 37: Plot graphics with three SubPlot graphics

2.3.4 Multiplying and positioning the graphics of the first Tract layout (Tract, Plots and SubPlots)

2.3.4.1 Grouping and multiplying Tract features

When the Tract-, Plot- and SubPlot- graphics of the first Tract have been created (and positioned according to the corresponding coordinates of the first Tract) they are grouped into a multiple graphics Tract. The grouped multiple graphics Tract is copied and multiplied and the lower left corner of each new multiple graphics Tract is positioned according to the coordinates of the Tract SW corner of the remaining Tracts until the graphics of all Tracts are created.

The position of the SW corner of each Tract is given in the table *F1-Tract* in the NFI database and can also be displayed by using the *information tool* when the *SW corner point object* is active and clicking on the of the corresponding Tract SW point. When all Tract graphics have been positioned they should appear at the corresponding positions of each Tract.

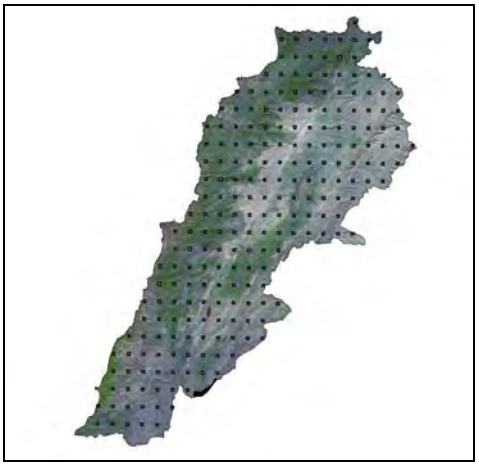

Figure 38: Lebanon with all 226 NFI Tracts, Plot and Subplot graphics

2.3.5 Creating Tract, Plot, SubPlot and LUS themes

2.3.5.1 Creating Tracts theme

To be able to link the database attributes to map objects, these need to be GIS themes and not graphics. To create a GIS theme corresponding to the Tracts a *new theme* is created as a polygon feature and saved as "*Tracts*". All grouped multiple graphics Tracts are selected and ungrouped. Then all of the Tract graphics are selected (only Tract graphics – NOT Plot and Subplot graphics) one by one. Cut the selected Tract graphics activate the *Tracts* theme and *Start editing* and then paste copied Tract graphics *save edits* with the new Tract features.

To assign the corresponding **Tract number** and **Tract ID** to each of the Tracts, two new fields are added to the *Tracts table*. First a *new field* "Tract_No" (number field, width 3 digits) is added in the *Tracts* attribute table using the *Field definition* tool.

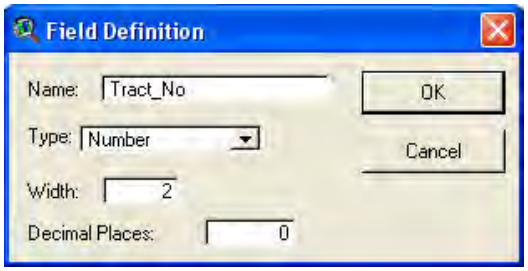

Figure 39: Field definition tool to define the "Tract_No" field.

To assign the **Tract numbers** there are two options:

1. Tracts are manually assigned the Tract numbers in the *Tract attribute table* by first selecting the *Tract feature* in the map view and then adding the corresponding Tract number in the "Tract_No" field in the selected record in the *Tract attribute table*. S*ave edits* with the new Tract attributes.

or…

2. A new number field "temp_ID1" (width 3 digits) is added to the *Tract attribute table* and unique numbers (1, 2, 3,…n) are added for all Tracts in this field. Then a new number field "temp_ID2" with three digits is created in the *Tract SW point theme*, and this new field "temp_ID2" is assign the corresponding unique numbers from "temp_ID1" are assigned from the *Tracts* theme through the *GeoProcessing* operation *assign data by location*. S*ave edits* with the new Tract attributes and then join the *Tract attribute table* with the *Tract SW point attribute table* using the "temp_ID1" and "temp_ID2" fields as common fields. Then *calculate* the new field "Tract_No" from the existing "Tract_No" field origining from the *Tract SW point attribute table* (which shows the Tract numbers from the NFI database table F1-Tract). *Remove Joins* and *save edits* with the new Tract attributes.

To assign the **Tract ID** a *new field* "ID-Tract" (number field, width 6 digits) is added in the *Tracts* attribute table using the *Field definition* tool. Then the values in the "ID-Tract" field are calculated using the *Field Calculator* (see Figure 40).

The ID-Tract is defined as ([Country code] * 100000) + ([Inventory] * 100000) + [Tract_No]

Where the following values are attributed to Lebanon:

[Country code] = 94
[Inventory code] = 1

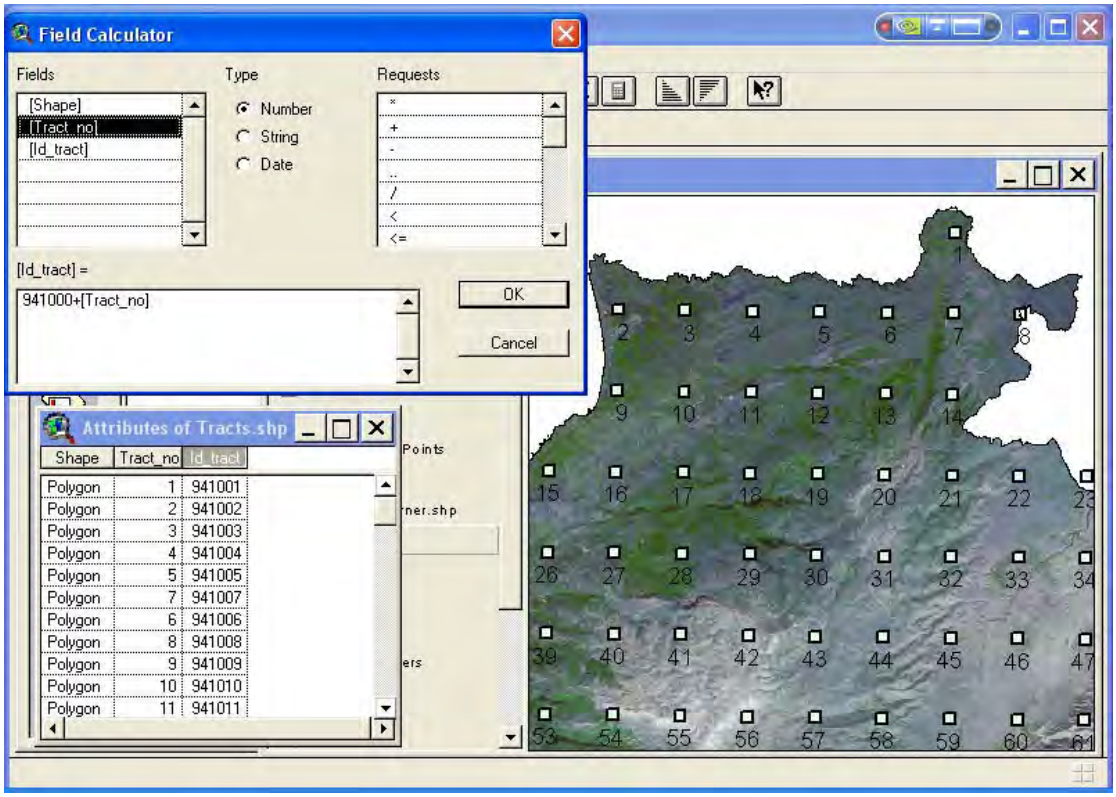

Figure 40: The Field Calculator is employed to assign new values in the ID-Tract field.

2.3.5.2 Creating Plots theme

To create a GIS theme corresponding to the Plots a *new theme* is created as a polygon feature and saved as "*Plots*". All of the Plot graphics are selected (only Plot graphics and NOT Subplot graphics should be selected) one by one. Cut the selected Plot graphics activate the *Plots* theme and *Start editing* and then paste copied Plot graphics *save edits* with all the new Plot features.

To assign the **Plot number** to each of the Plots a *new field* (number field, width 1 digit) is added in the *Plots* attribute table and the Plots are manually assigned the corresponding Plot number, always verifying the correct Plot number in the map view, or the second procedure described for assigning Tract numbers can be applied using Plot numbers. Then *save edits* with the new Plot attributes.

To assign the corresponding **Tract number** and **Tract ID** to each of the Plots two new fields are created: One *new field* "Tract_No_" (number field, width 3 digits) and one new field "ID-Tract_" (number field, width 6 digits) are added in the *Plots* attribute table. To assign the new field values a *GeoProcessing* operation (see Figure 41) is employed where the *Tracts theme assigns* its attribute *data by location*. Then the Field Calculator is used to update the new field values. Then *save edits* with the new Plot attributes.

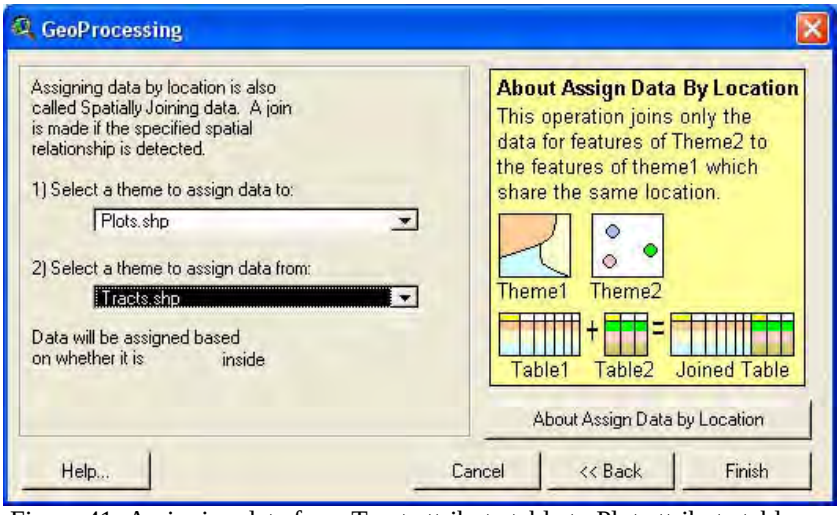

Figure 41: Assigning data from Tract attribute table to Plot attribute table by location, using the GeoProcessing tool.

To assign the corresponding **Plot ID** to each of the Plots a *new field* "ID-Plot" (number field, width 7 digits) is added in the *Plots* attribute table and the corresponding Plot ID numbers are assigned using the *Field Calculator*: (ID-Tract]*10)+[Plot_No].

Attributes of Plots.shp

Shape	Plot_no	Id_plot	Id_tract	Tract_no
Polygon	3	9410013	941001	1
Polygon	4	9410014	941001	1
Polygon	2	9410012	941001	1
Polygon	1	9410011	941001	1
Polygon	3	9410023	941002	2
Polygon	4	9410024	941002	2
Polygon	2	9410022	941002	2
Polygon	1	9410021	941002	2
Polygon	3	9410033	941003	3
Polygon	4	9410034	941003	3
Polygon	2	9410032	941003	3
Polygon	1	9410031	941003	3

Figure 42: Attribute table of the Plot theme

2.3.5.3 Creating SubPlots theme

To create a GIS theme corresponding to the SubPlots a *new theme* is created as a polygon feature and saved as "*SubPlots*". All of the SubPlot graphics are selected. Cut the selected SubPlot graphics activate the *SubPlots* theme and *Start editing* and then paste copied SubPlot graphics *save edits* with all the new SubPlot features.

To assign the **SubPlot number** to each of the SubPlot a *new field* "SubPlot_No" (number field, width 1 digit) is added in the *SubPlots* attribute table and the SubPlot are manually assigned the corresponding SubPlot number, always verifying the correct SubPlot number in the map view. Then *save edits* with the new SubPlot attributes.

To assign the corresponding **Tract number, Tract ID, Plot number and Plot ID** to each of the SubPlot four new fields are created in the SubPlots attribute table:

Tract number: "Tract_No" (number field, width 3 digits)

Tract ID: "ID-Tract" (number field, width 6 digits)

Plot number: "Plot_No_" (number field, width 1 digit)

Plot ID: "ID-Plot" (number field, width 7 digits)

To assign the new field values a *GeoProcessing* operation is employed where the *Plots theme assigns* its attribute *data by location*. Then the Field Calculator is used to update the new field values. Then *save edits* with the all new SubPlot attributes.

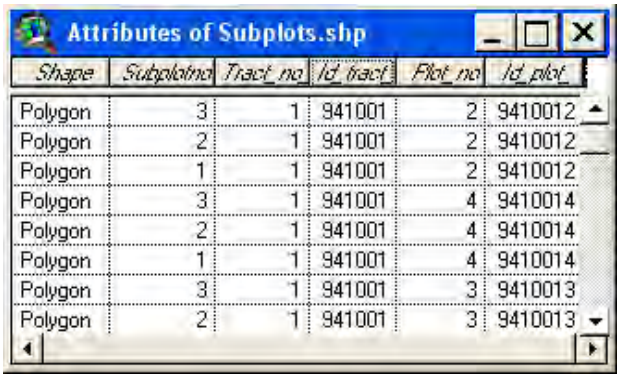

Figure 43: Attribute table of the SubPlot theme

2.3.5.4 Creating a Land Use Sections (LUS) theme

The outer boundaries of the Land Use Sections (LUS) are limited by the Plot borders, so to create a GIS theme corresponding to the Land Use Sections (LUS) the *Plot* theme is activated and *converted to shapefile* which is named "*LUS*". The corresponding **Tract number, Tract ID, Plot number** and **Plot ID** were inherited by the *Plot* theme when it was converted to the *new shapefile*. Activate the *LUS* and *start editing* and then, by using the *split polygon* tool, delineate the different LUS according to their form size in the *Plot Plan* in *Field Form F2-Plot* or according to their length in the *F5-LUS Table.*

To assign the **LUS number** and **ID-LUS** to each of the LUS two *new fields* are added in the *LUS* attribute table. One number field, width 2 digits, named "LUS_No" to which the corresponding LUS number are manually assigned, always verifying the correct LUS number in the map view. Another number field, width 9 digits, named "ID-LUS" to which the unique LUS ID is calculated by the field calculator as *([ID-Plot]*100)+[LUS_No])*. Then *save edits* with the new LUS features and attributes.

Attributes of Lus.shp

Shape	LUS_No	ID_LUS	Plot_no	Id_plot	Id_tract	Tract_no
Polygon	1	941001301	3	9410013	941001	1
Polygon	1	941001401	4	9410014	941001	1
Polygon	1	941002301	3	9410023	941002	2
Polygon	1	941002401	4	9410024	941002	2
Polygon	1	941002201	2	9410022	941002	2
Polygon	1	941002101	1	9410021	941002	2
Polygon	1	941003301	3	9410033	941003	3
Polygon	1	941003401	4	9410034	941003	3
Polygon	1	941003201	2	9410032	941003	3
Polygon	1	941003101	1	9410031	941003	3
Polygon	1	941004201	2	9410042	941004	4

Figure 44: Attribute table of the LUS theme

2.3.5.5 Creating a Trees (and Stumps) theme

Trees and Stumps: The Trees and Stumps can be displayed as point objects in the GIS by creating an *event theme* where the Trees or Stumps X and Y coordinates are employed to define the positions of the point objects. By converting the new event theme to a *Shapefile* "Trees" the trees and stumps and the corresponding attribute data are permanent in the GIS application.

Figure 45: Trees and stumps in one Plot illustrated on top of LUS data.

2.3.5.6 Creating a Reference points theme

Reference points: The Reference points to access paths, measurement points, photographs, etc. can be displayed as point objects in the GIS by creating an *event theme* where the Reference points X and Y coordinates are employed to define the positions of the point objects. By converting the new event theme to a *Shapefile* "Ref-points" the Reference points and the corresponding attribute data are permanent in the GIS application.

2.4 *Linking NFI map features with NFI data tables*

When the NFI map features are created these can be linked with data in the NFI database tables by *Joining* or *Linking* a field in the map feature attribute table with a *common field* in the database table. The common fields are the corresponding *ID fields* (ID-Tract, ID-Plot and ID-LUS)

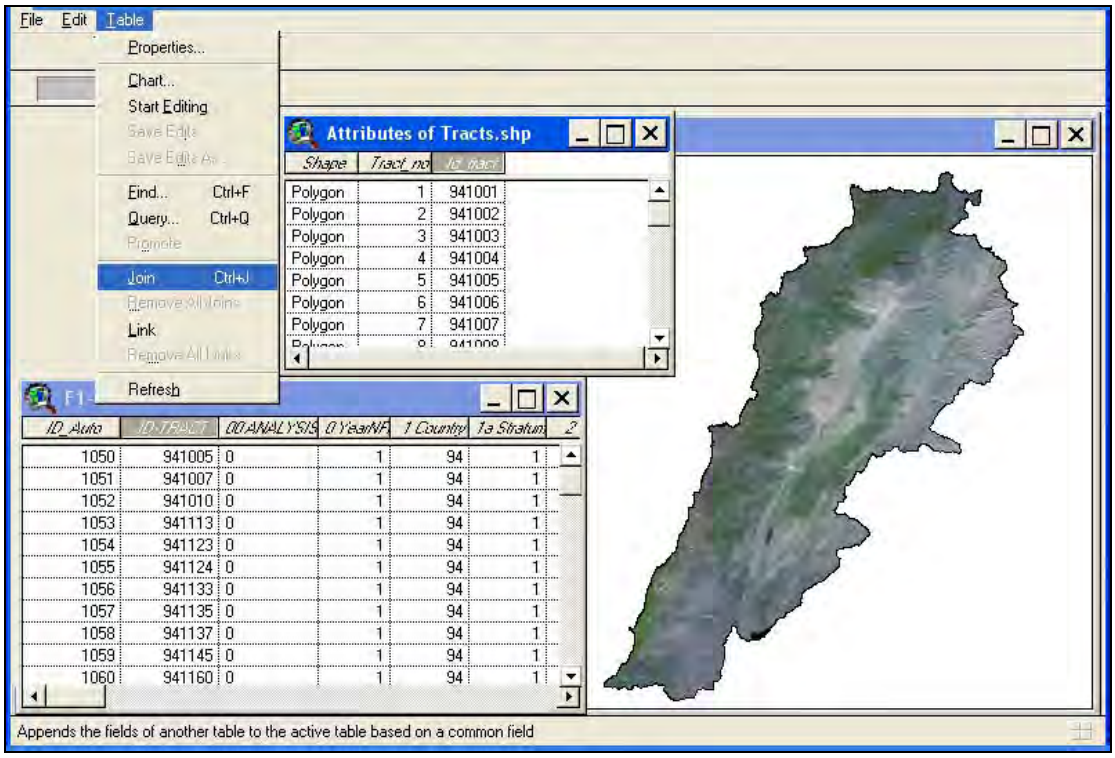

Figure 46: Joining or Linking map feature attribute (Tracts) table with database table (F1-Tract).

When the NFI map features are linked with data in the NFI database tables all primary NFI data can be displayed through the GIS application.

By *Linking/Joining* the *Tract Centre point theme* with the results (Query saved as Table) from the *processed data* in the NFI database, thematic maps showing how the statistical information is distributed can be prepared (see Figure 16-Figure 21).

3 BIBLIOGRAPHY

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4 ANNEXES

ANNEX I - Description NFA Database application of Lebanon
ANNEX II - Guidelines in DB Query design
ANNEX III - Links to Web Sites with Information on related GIS Applications

Annex I
Description NFA Database application of Lebanon

STUCTURE OF NFA DATABASE APPLICATION

To store and manage the collected NFA data a database application was developed by FAO/FRA in collaboration with the country national team. The database application, based on the MS Access software (2000/2002), comprises two database files; one "data" database (NFI-data_<*COUNTRY*>.mdb) and one "application" database (NFI-<*COUNTRY*> v.*x.x*.mdb). All collected field data (dynamic data) are stored in inter-related tables in the "data" database, while the "application" database contains code tables (static data), forms and queries and macros. The users of the NFA database manage the data through the application database. To open the database application the users double-click on the *NFI-<COUNTRY> v.x.x.mdb* file. The data are managed through forms and the user navigates in the database by selecting different forms according to required operation.

The efforts in developing the NFA database application have initially been focused on wise data storage and on facilitating the input of primary data, why until now the only activated section in the database application is the section on "*Field Data*".

The design of the forms for adding/editing field data in the database application follows the same as the field forms employed for the data collection in the field inventory. The idea with this coherence is to facilitate the entering of field data into the database application since the instructions on how to register field data are given in the field manual (refer to ANNEX I).

Tables

All data in the NFA is stored in tables. All tables with collected inventory data (primary data) is kept in the "data" database (NFI-data_<*COUNTRY*>.mdb), while all static data like codes, expansion factors, etc. are kept in the "application" database (NFI-<*COUNTRY*> v.*x.x*.mdb) (refer to Figure 48).

Code tables

For each variable with attribute options there is a corresponding code table with defined options. The names of code tables all begin with "C-" and they contain internationally harmonized terminology and nationally adapted options to the variables, where every option has a unique code.

Data tables

For each level of data collection there is a corresponding data table with defined variables. The variables are internationally harmonized and nationally adapted terminology, and may have unbound values or may be bound to predefined attribute options according to code tables. The names of data tables begin with "F-", "P-", "Ph-" or "H-"(refer to Figure 49). The *F-tables* contain the values of all the variables that are collected at corresponding inventory level; Tract data is stored in the *F1-Tract* table, Plot data is stored in the *F1-Plot*, LUS data is stored in the *F5-LUS* table, etc. The *P-table* contains data on informants or other persons involved in the inventory, the *Ph-table* contains data on photos taken during the NFA, and the *H-tables* are help-tables that relate the data from two data tables to each other, for example the *H-*

Person-Function-Tract relates the information of persons to tracts and indicates what function the person had in that tract.

Relation database

The NFA database application is developed in MS Access, which is a relation database. A relation database allows that data can be collected at different inventory levels (Tract, Plot, LUS, Tree, etc.) and still relate to each other. In practice this is accomplished by creating separate data tables for each inventory level. To relate (link) the data in on table to another the tables must have at least one common field. In this way the tract attributes can be related to the attributes in all plots in the tract through the "ID-TRACT" field, and the Plot attributes can be related to the attributes in all LUS in the plot through the "ID-PLOT" field, and the LUS attributes can be related to all product/service attributes in the LUS through the ID-LUS field and further to the attributes of all trees through the two common fields ID-PLOT and ID-LUS, etc (see Figure 47).

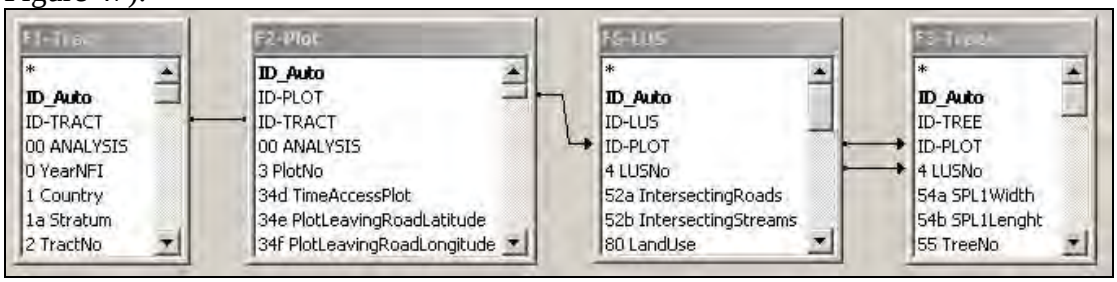

Figure 47: Illustration of the relationship between different data tables

Tables can be linked to each other even though they are not physically in the same database file. A fixed location of the database files is necessary as the database application has linked to the dynamic tables in the "data" database and therefore need to know where the "data" database is located. The NFA database application consists of the two database files "*NFI-data_<COUNTRY>.mdb*" and "*NFI-<COUNTRY> v.x.x.mdb*" and the location of the "data" database is set to the C:\NFA\ folder (see Figure 48).

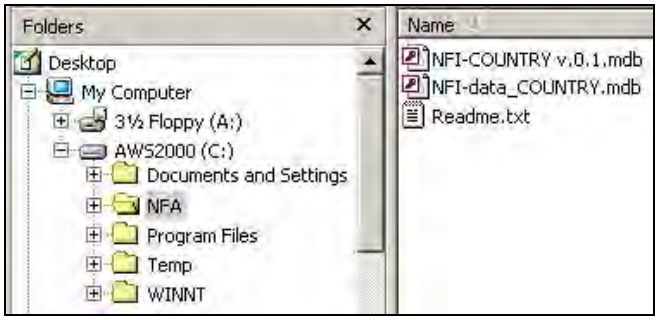

Figure 48: Location of database files

In Figure 49 the database window from the application database (*NFI-<COUNTRY> v.x.x.mdb*) is displaying some of the tables in the database application. The tables displayed with only a table symbol next to the table name are tables stored in the same application database, while the tables with an arrow symbol next to the table symbol are the tables with dynamic data (primary field data) and they are linked from the data database (*NFI-data_<COUNTRY>.mdb*).

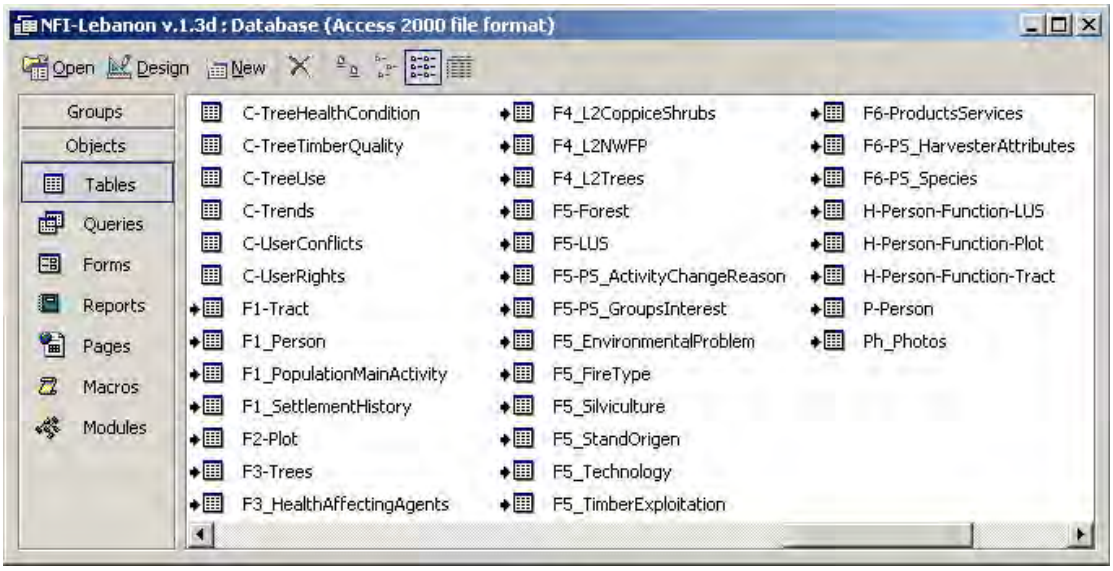

Figure 49: Database window in the NFA application database ("*NFI-<COUNTRY> v.x.x.mdb*") showing some of the code tables in the database (beginning with "C-") and some of the linked data tables (with an arrow symbol next to the table symbol).

The purpose of separating the dynamic field data from the rest of the database application is to allow users to work with the database application from different computers in a network and only have one main database with the inventory data. The NFA application database can be installed on computers in the network and they are all related to one database where the inventory data are stored. In this way only one version of the inventory data exist. Another benefit with separating the dynamic data from the rest of the database is to allow a smoother actualisation of the features in the database application without altering the primary data. A database specialist can in this way develop new versions of the NFA database application, with improved functionality, while other users continue to enter/edit data through an older version of the database application. When the new version of the application database ("*NFI-<COUNTRY> v.x.x.mdb*") is ready it will substitute the older version, but the primary data remains unaltered in the data database (*NFI-data_<COUNTRY>.mdb*).

Forms

The users of the NFA database manage the data through forms. There is a form corresponding to every field form for field data collection, and further sub-forms within these forms (see Figure 50). The users add and edit the NFA field data through these forms. A validation of the field data built-in in the forms. Criteria for acceptable values and reasonable values are defined for most of the variables, so when the users enter the field data through the forms they automatically go through a general validation. For more information on the forms and on how to navigate in the NFA database application please refer to ANNEX I.

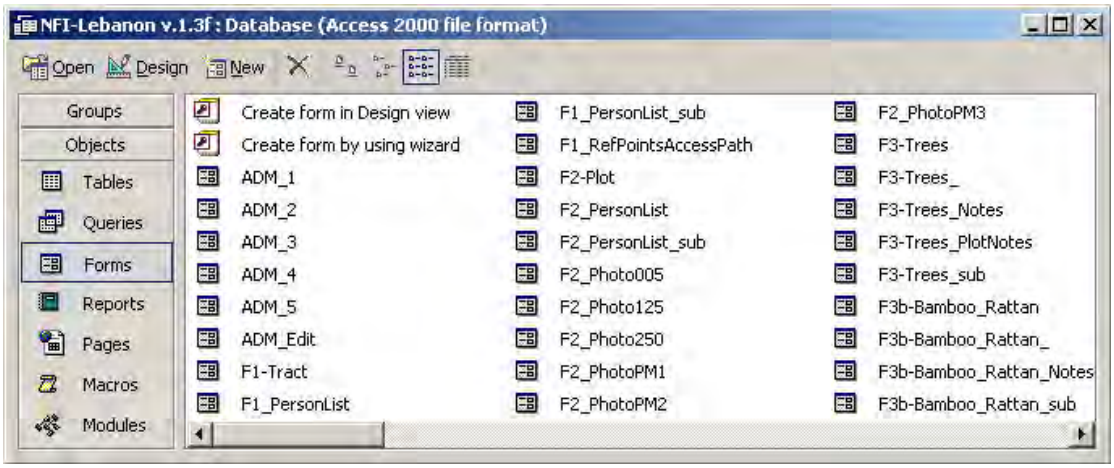

Figure 50: Database window in the NFA application database ("*NFI-<COUNTRY> v.x.x.mdb*") showing some of the forms that are employed in the database application.

Queries

Queries can be used for processing and analysing data that are stored in tables. However it is not recommended to process or analyse the NFA data in any of the two database application files, *NFI-data_<COUNTRY>.mdb* and *NFI-<COUNTRY> v.x.x.mdb*, as it would cause the application to become very "heavy". Instead the data processing and analysis should be carried out in a separate database that is linked to the two database application files.

In the NFA database application the Queries are only employed to filter the data in Tables or in other Queries. The information displayed through forms is filtered through Queries or through Tables with applied filters. For each form there can be one or more Queries employed depending on the structure and functionality of the form. For example the data source for every sub-form in a form could be based on a separate Query. Some of the Queries that are used as data sources for the forms in the NFA database application are displayed in Figure 51.

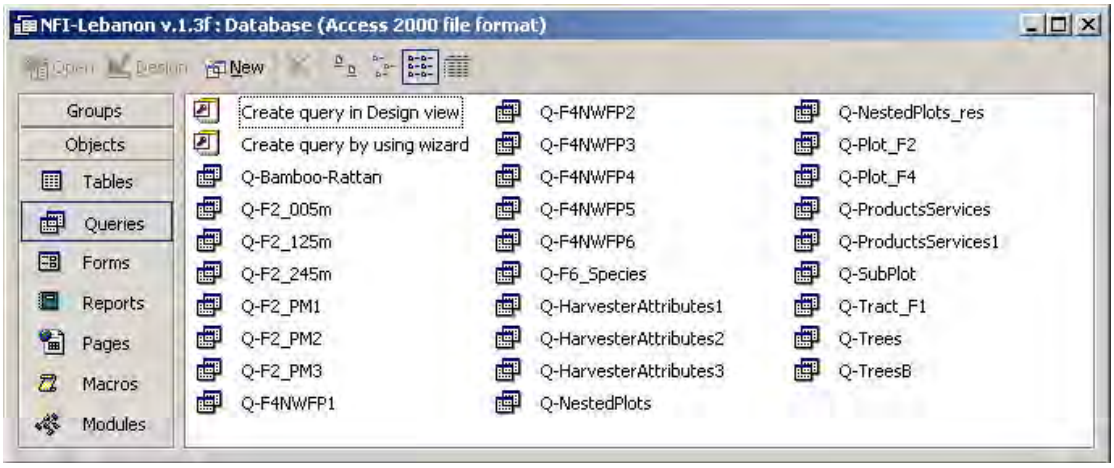

Figure 51: Database window in the NFA application database ("*NFI-<COUNTRY> v.x.x.mdb*") showing the queries in the database application.

Appendix I

NFA DATABASE APPLICATION - Getting started

Database file location

The two database files "*NFI-data_<COUNTRY>.mdb*" and "*NFI-<COUNTRY> v.x.x.mdb*" should be stored in a folder named "NFA" directly under C:\ (i.e. in C:\NFA\ see Figure 52).

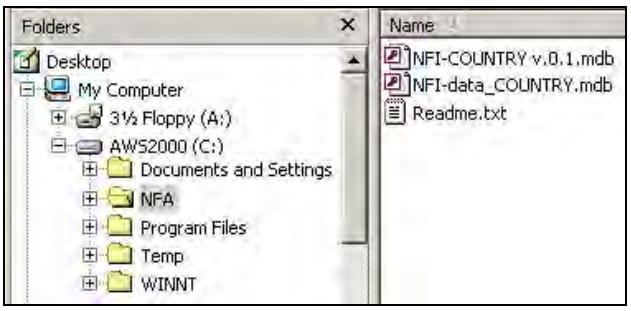

Figure 52: Location of database files

The fixed location of the database files is necessary as the database application has linked to the dynamic tables in the "data" database and therefore need to know where the "data" database is located. In the database application the location of the "data" database is set to the C:\NFA\ folder.

Opening the NFA database application

The user of the NFA database is managing the data through the application database. To open the database application the user double-clicks on the *NFI-<COUNTRY> v.x.x.mdb* file. The data are managed through forms and the user navigates in the database by selecting different forms according to required operation.

When starting the database application the user must enter a password in a dialogue box (Figure 53) to access the application:

Figure 53: Log-on dialogue box

Selecting database operation

After logging on with the password an initial form appears (Figure 54) where the user selects what kind of operations he/she wants to carry out.

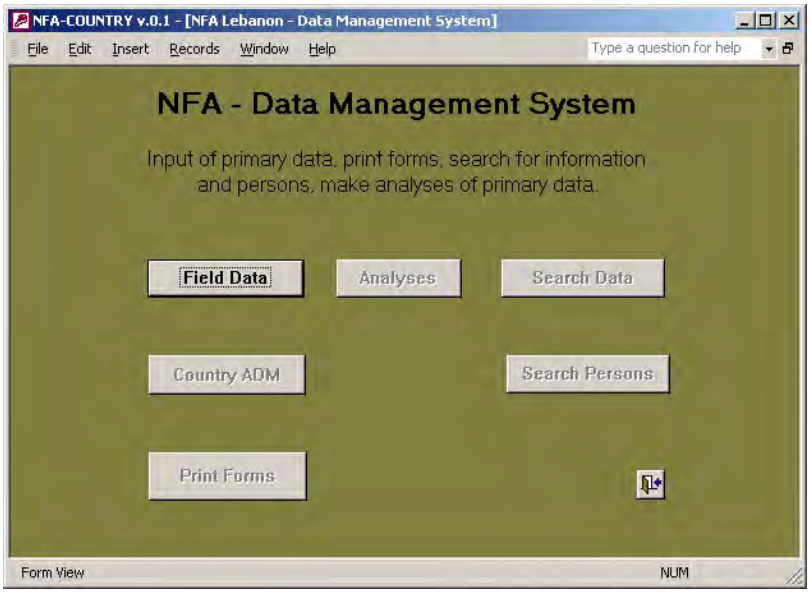

Figure 54: Database operation selection form

The efforts in developing the NFA database application have initially been focused on wise data storage and on facilitating the input of primary data, why until now the only activated section in the database application is the section on "*Field Data*".

Field data enter and management

Selecting Field form

Through the "*Field Data*" button in the *Database operation selection form* (Figure 54) the user accesses a form with a button for every corresponding field form (Figure 55).

In Figure 55 the *Field Form selection form* shows six [-F -] buttons which represent the six main field forms employed for the field data collection. The user selects the button that corresponds to the field form he/she wants to edit.

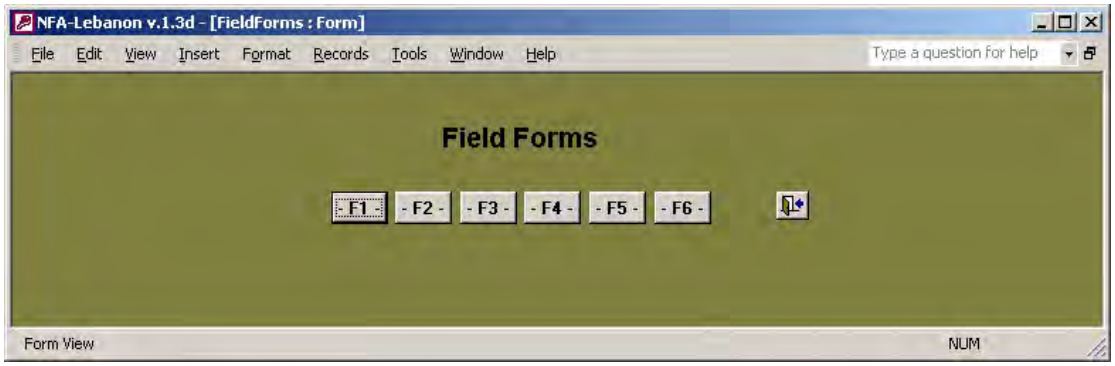

Figure 55: Field Forms selection interface

Figure 4 to Figure 18 illustrate the forms that are used to add/edit the NFA field data. Please refer to the Field Manual in ANNEX I for detailed description on how the fill in the forms.

Field data enter and editing

The design of the forms for adding/editing field data in the database application follows the same as the field forms employed for the data collection in the field inventory. The idea with this coherence is to facilitate the entering of field data into the database application since the instructions on how to register field data are given in the field manual (refer to ANNEX I).

Field form F1-Tract

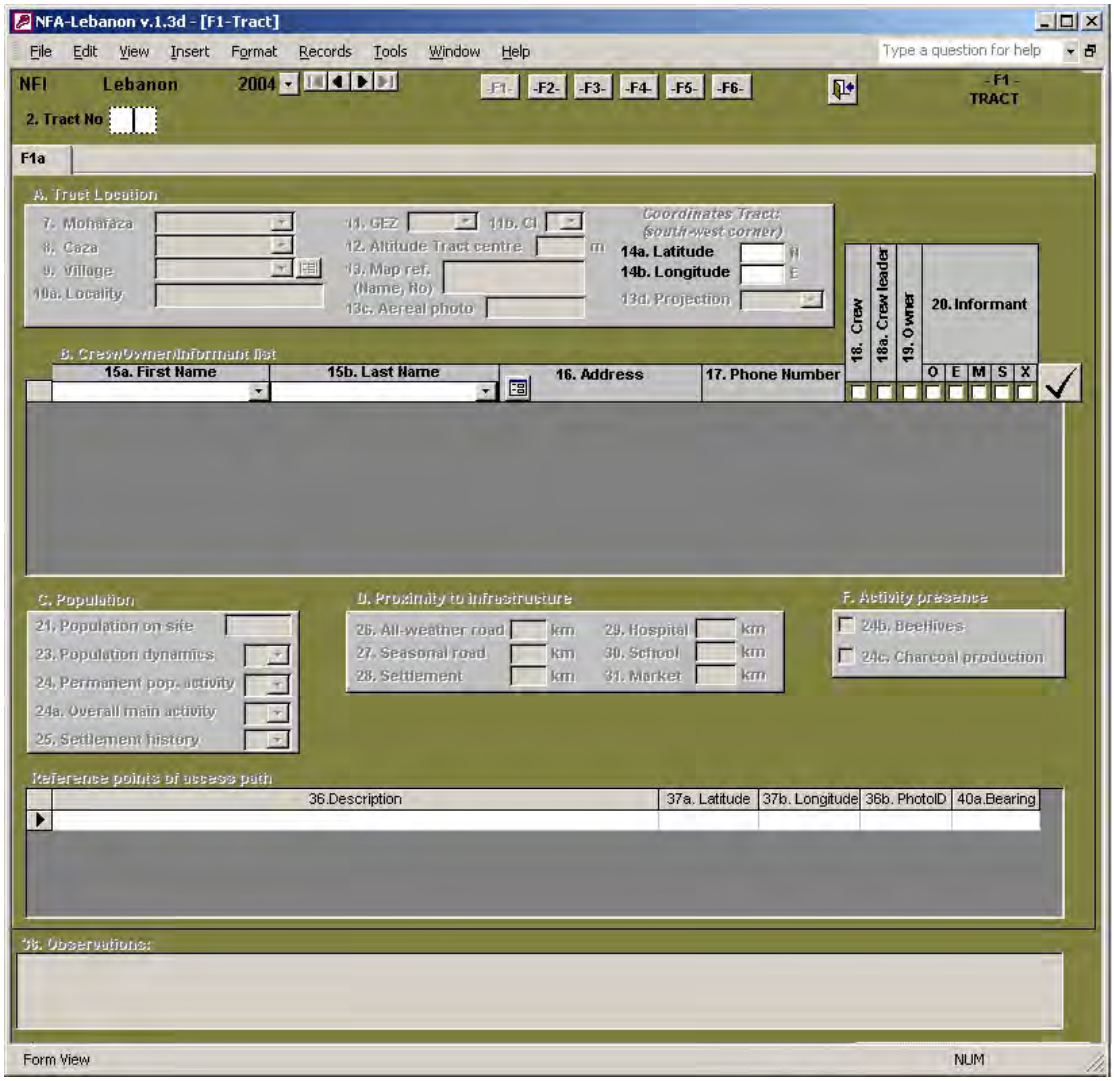

Figure 56: F1 - Tract attributes Form

Field form F2-Plot

General logistic of the plot

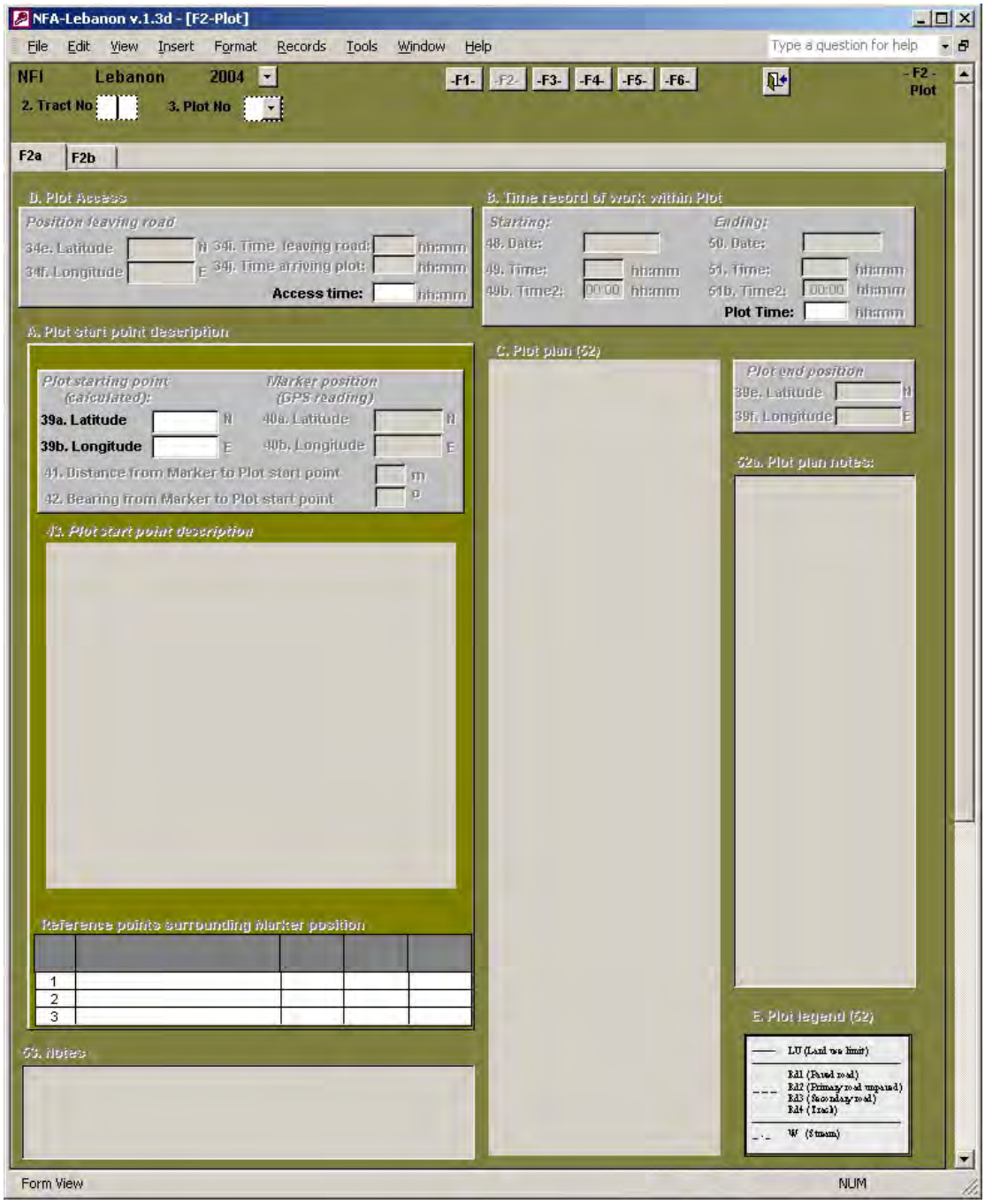

Figure 57: F2a - Plot attributes form

Photo register

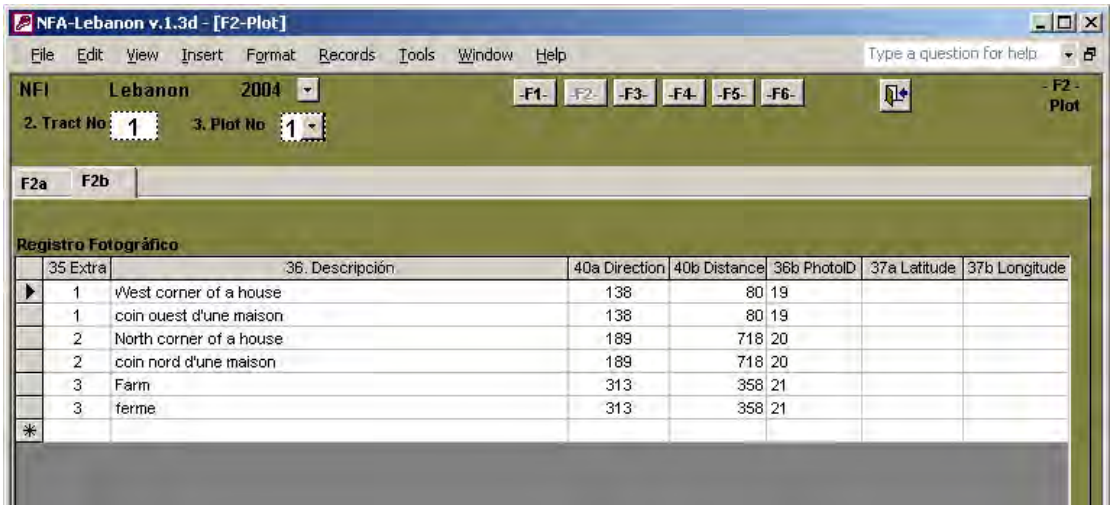

Figure 58: F2b - Plot Photo Register form

Field form F3-Trees

F3a-Tree attribute data

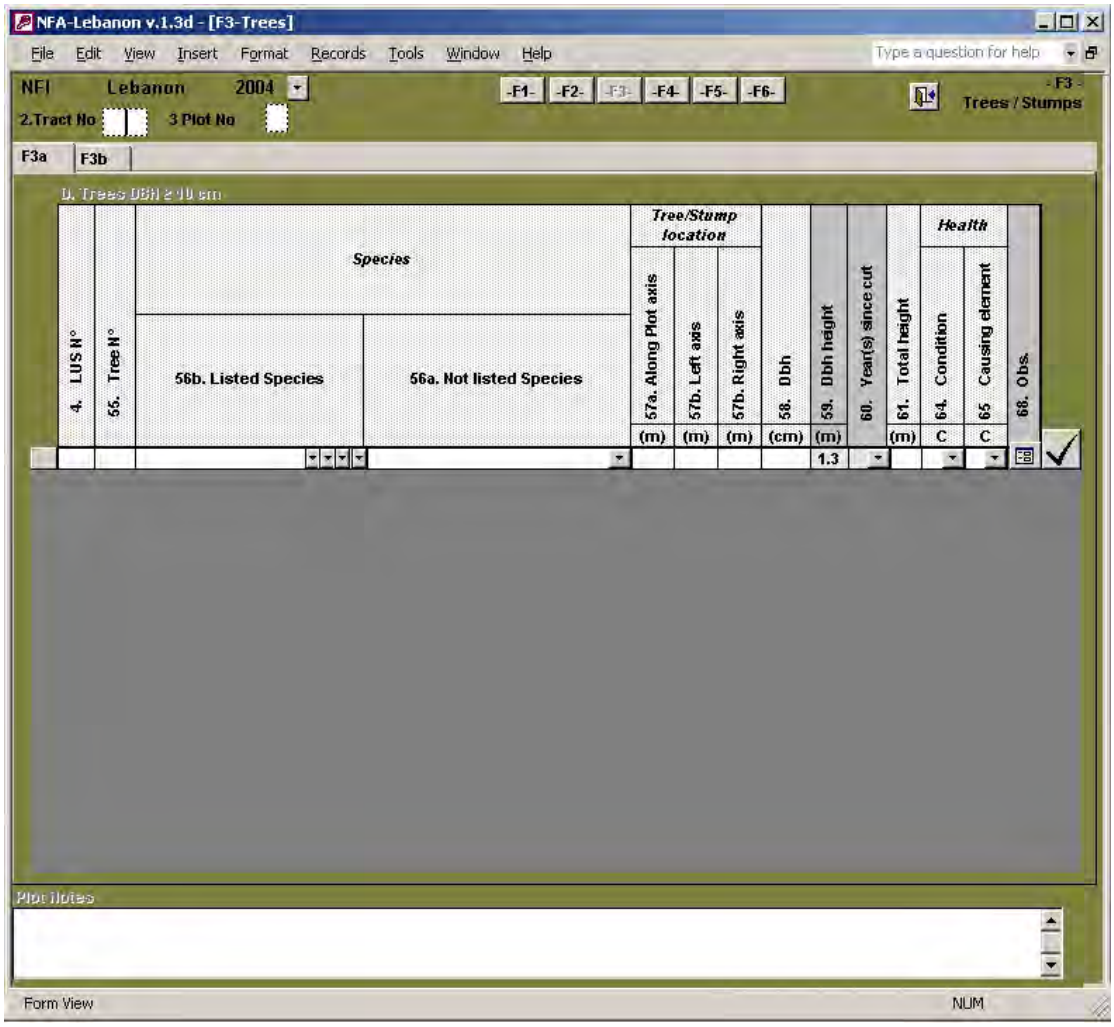

Figure 59: F3a – Tree attributes form

F3b-Tree attribute data including branches

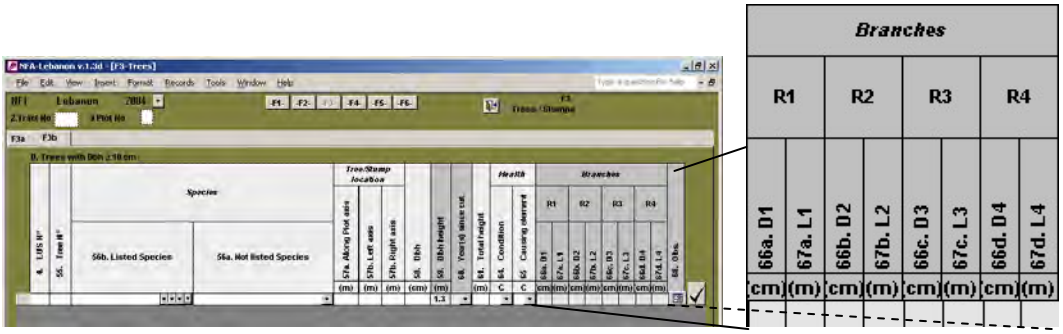

Figure 60: F3b – Tree attributes form including branches

Figure 61: F3 – Tree attributes notes form

F4-Measurement Points & Subplots

Measurement Points

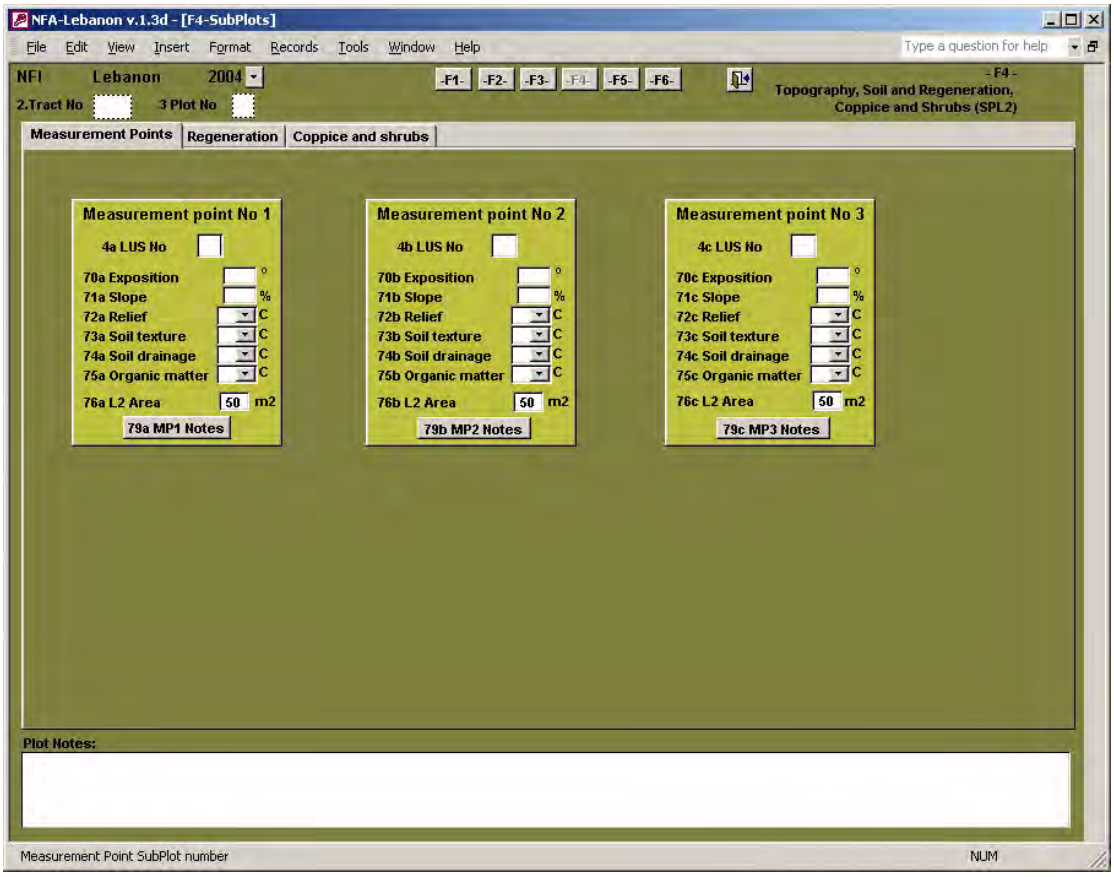

Figure 62: F4a – Measurement point attributes form

Figure 63: Measurement Point Notes form

Tree regeneration

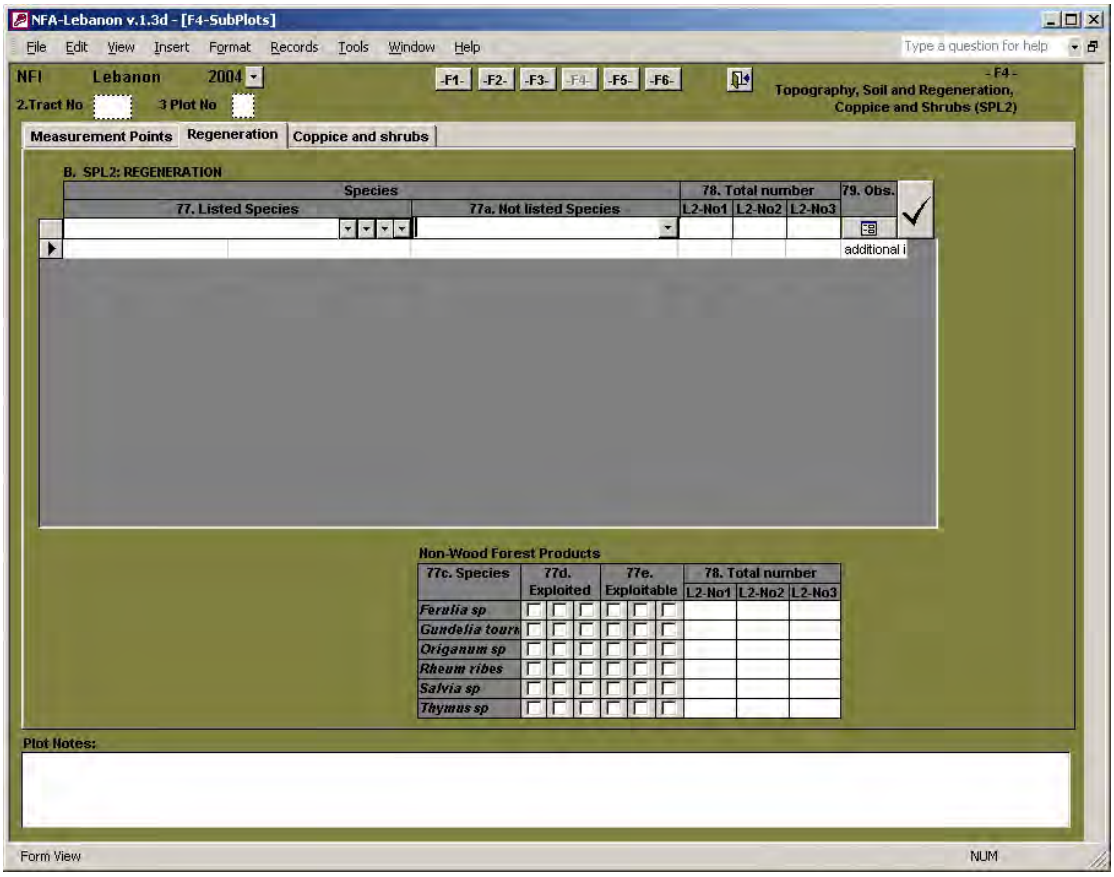

Figure 64: F4b – Tree regeneration attributes form (sub-plots)

Figure 65: F4 – Tree Regeneration Notes form

Coppices and Shrubs

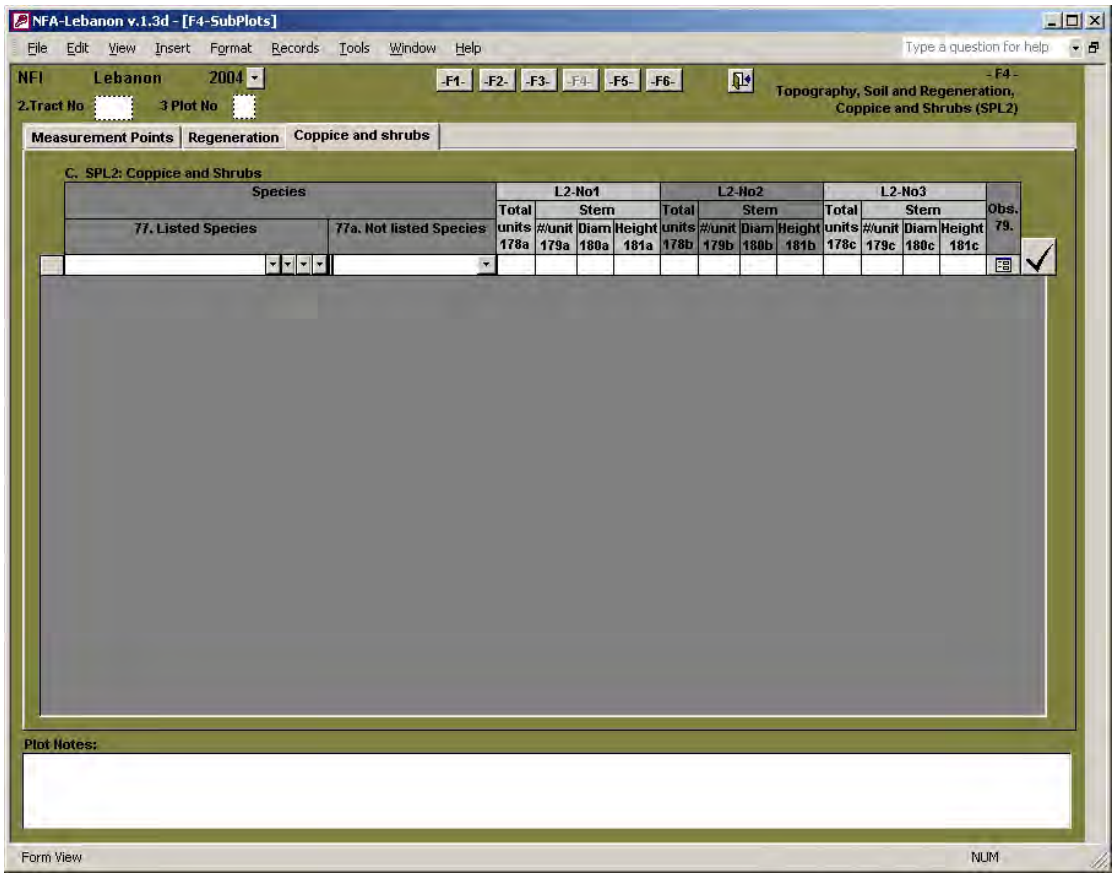

Figure 66: F4c – Coppice and Shrub attributes form (sub-plots)

Figure 67: F4 – Coppice and Shrub Notes form

F5-Land Use Section

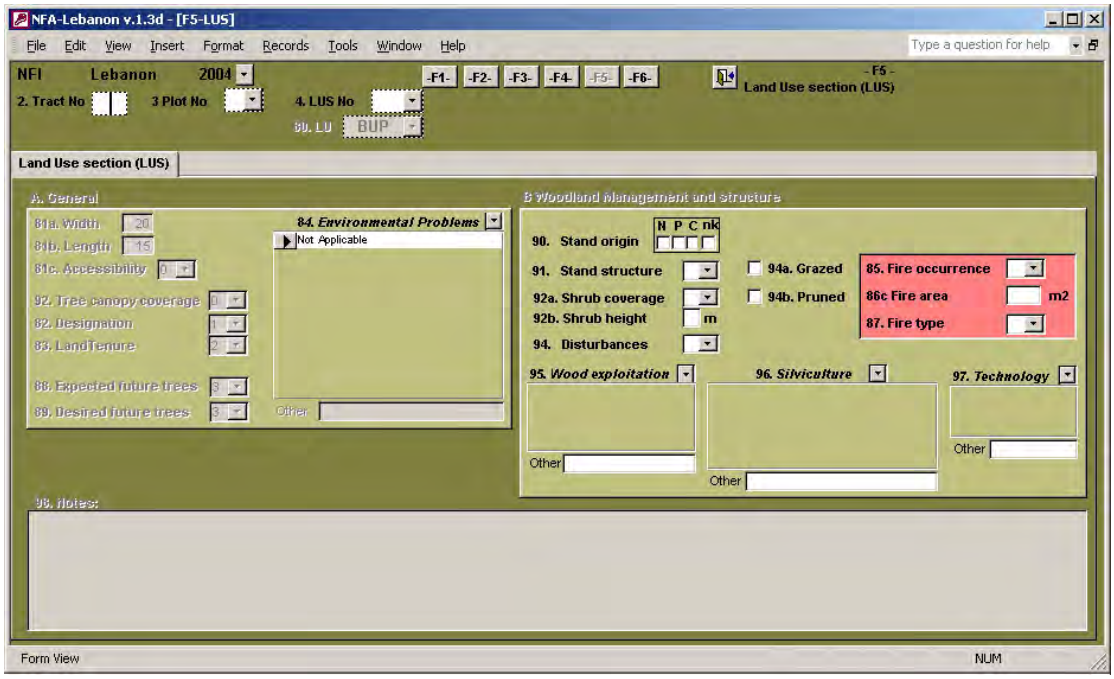

Figure 68: F5 – Land Use Section (LUS) attributes form

F6-Products and Services

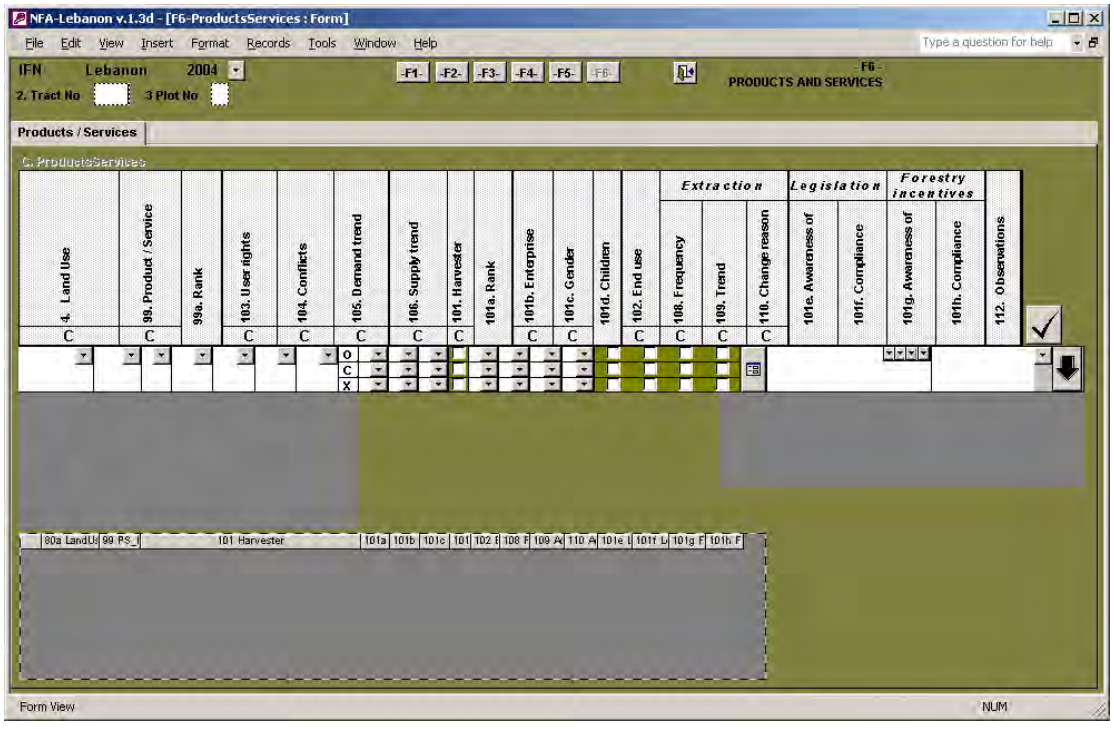

Figure 69: F6 – Product and Service attributes form

Figure 70: Products and Services Notes form

Annex II
Guidelines in DB Query design - Data Processing and Data Analysis

To quickly estimate national statistics of high precision the most efficient approach is to sample the country and then calculate the statistics based on the sampled data, including expressions showing the precision of the estimates.

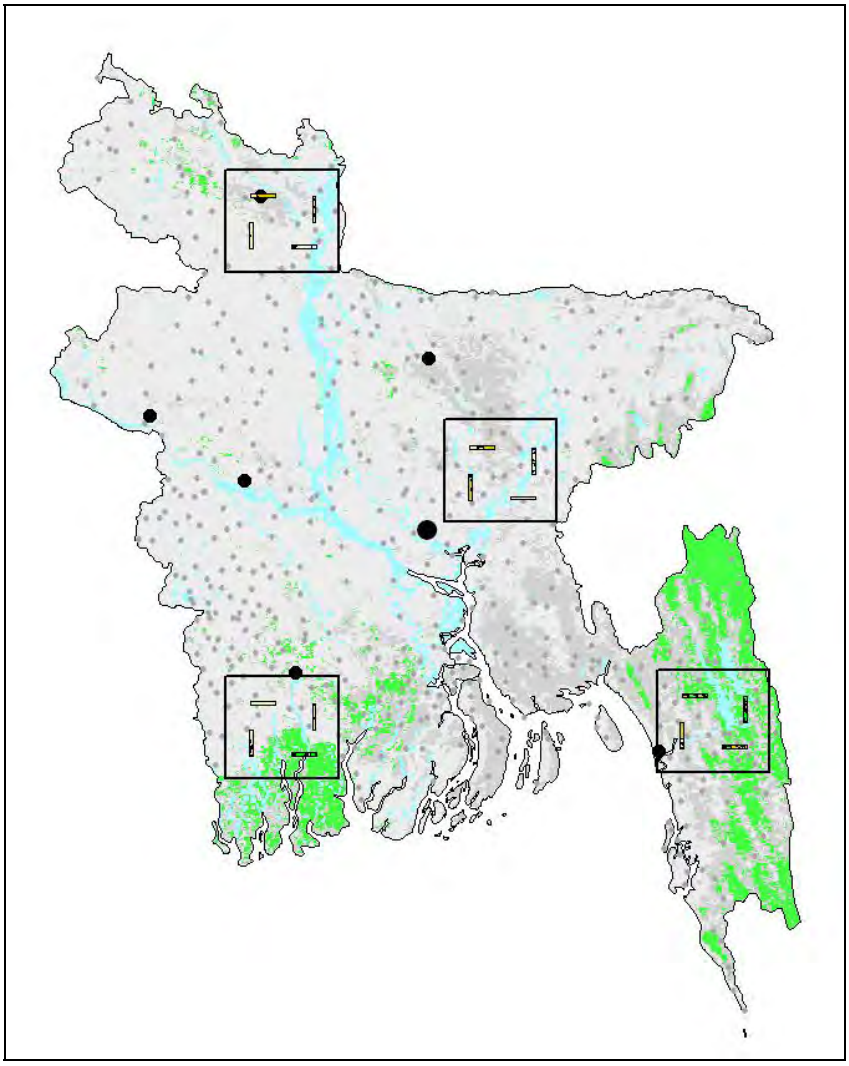

Figure 71: Map of Bangladesh showing a sample example of 4 units
.

Figure 71 shows, as an example, a country with a sample of 4 units, which will be used to explain the logic of how to generate national statistics.

Before NFA data can be analyzed and results can be generated, data in the NFA database must be processed in order to prepare consistent datasets. A dataset should contain the same number of records as the total number of Tracts (sampling units) in the country, meaning that every Tract should generate one record in the dataset.

Employing the example of a NFA sample consisting of 4 Tracts we will see how data from these 4 Tracts are processed to generate a dataset containing 4 records:

Below are presented the spatial composition of the 4 Tracts in our sample. Each Tract covers an area of 1 km^2 and consists of a cluster of 4 Plots with the size 20m*250m (0,5ha). Within the Plots, Land Use classification and area measurements are carried out together with a variety of measurements and observations, such as tree measurements, fire occurrence, environmental problems, use and users of products and services provided by trees and forests, etc. The Plots are numbered from 1 to 4 clockwise in each Tract, starting from the South-Western-most Plot. The inventory records follow the same clockwise direction.

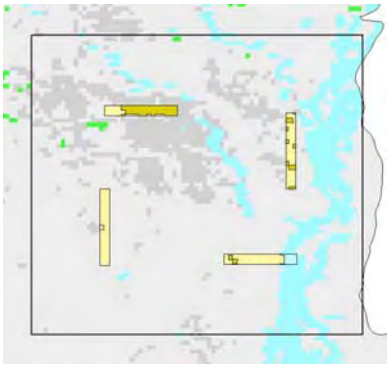

Figure 72: Tract 1

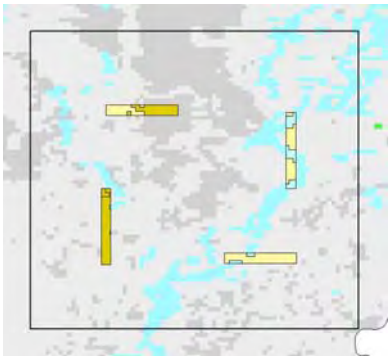

Figure 73: Tract 3

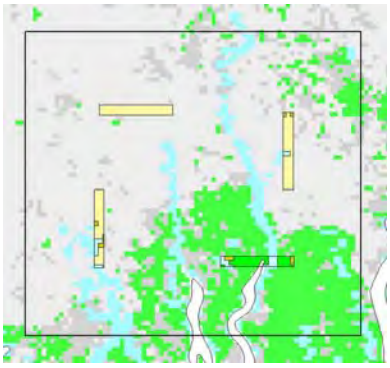

Figure 74: Tract 2

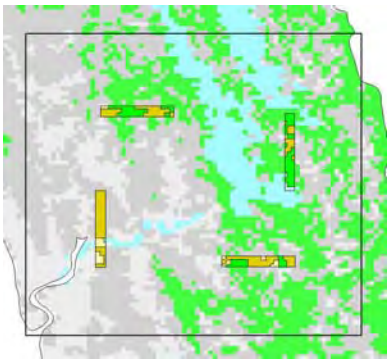

Figure 75: Tract 4

In Table 1 all Land Use Sections (LUS) with their corresponding Area value (calculated as [LUS Length] * [LUS Width]) and Land Use Class (global) are presented by Tract and Plot number.

ract	Plot	Land Use Section (LUS)				
		#	Width (m)	Length (m)	Area (ha)	Land Use
1	1	1	20	245	0,490	OL
		2	10	10	0,010	O
	2	1	20	59	0,118	OL
		2	18	190	0,342	O
		3	5	50	0,025	OL
		4	5	10	0,005	OL
		5	5	20	0,010	OL
	3	1	18	180	0,324	OL
		2	18	10	0,018	O
		3	5	10	0,005	O
		4	6	10	0,006	O
		5	5	10	0,005	O
		6	5	10	0,005	O
		7	18	10	0,018	O
		8	20	55	0,110	OL
		9	18	5	0,009	O
	4	1	20	50	0,100	W
		2	20	180	0,360	OL
		3	20	20	0,040	O
2	1	1	18	10	0,018	W
		2	16	60	0,096	OL
		3	10	60	0,060	W
		4	5	40	0,020	O
		5	20	148	0,296	OL
		6	10	10	0,010	O
	2	1	20	250	0,500	OL
	3	1	20	240	0,480	OL
		2	5	10	0,005	O
		3	5	10	0,005	O
		4	10	10	0,010	W
	4	1	18	10	0,018	O
		2	20	50	0,100	F
		3	20	40	0,080	W
		4	20	105	0,210	F
		5	10	11	0,011	OU
		6	17	30	0,051	W
		7	8	30	0,024	O
		8	4	15	0,006	F
3	1	1	20	212	0,424	OL
		2	6	10	0,006	O
		3	5	20	0,010	W
		4	15	40	0,060	O
	2	1	20	115	0,230	OL
		2	8	10	0,008	O
		3	20	128	0,256	O
		4	6	10	0,006	OL
	3	1	16	10	0,016	OL
		2	20	45	0,090	W
		3	20	65	0,130	OL
		4	20	40	0,080	W
		5	20	65	0,130	OL
		6	18	30	0,054	W
	4	1	20	235	0,470	OL
		2	5	20	0,010	W
		3	5	40	0,020	W
4	1	1	10	80	0,080	O
		2	18	50	0,090	OL
		3	18	30	0,054	OL
		4	6	10	0,006	W
		5	20	135	0,270	O
	2	1	15	60	0,090	O
		2	5	20	0,010	OL
		3	20	85	0,170	F
		4	20	85	0,170	O
		5	11	50	0,055	F
		6	5	10	0,005	O
	3	1	15	80	0,120	F
		2	6	10	0,006	O
		3	15	30	0,045	O
		4	6	10	0,006	OL
		5	15	30	0,045	O
		6	6	10	0,006	F
		7	20	115	0,230	F
		8	6	10	0,006	O
		9	6	10	0,006	W
		10	20	15	0,030	W
	4	1	20	30	0,060	O
		2	20	25	0,050	F
		3	13	20	0,026	OL
		4	12	195	0,234	O
		5	5	10	0,005	OL
		6	15	70	0,105	F
		7	5	30	0,015	OL
		8	5	10	0,005	OL

Table 1: Primary data on Land Use Sections (LUS) showing the Tract, Plot and LUS number and also width, Length, derived Area and Land Use Class of the LUS.

To prepare a dataset showing the area of each land use, the LUS Areas are summarized by Land Use for each Tract and presented as one record per Tract as in Table 2.

	Area (ha)			
Tract	F	OWL	OL	W
1	0	0,458	1,442	0,100
2	0,316	0,082	1,372	0,219
3	0	0,330	1,406	0,264
4	0,736	1,011	0,211	0,042

Table 2: Dataset showing Area of the "global" Land Uses by Tract

In Table 3 the total area of all Land Uses are calculated for each Tract (TOT.) and the total area for each Land Use is calculated for the whole sample (Sum:)

	Area (ha)				
Tract	F	OWL	OL	W	**TOT.**
1	0	0,458	1,442	0,100	2,000
2	0,316	0,082	1,372	0,219	1,989
3	0	0,330	1,406	0,264	2,000
4	0,736	1,011	0,211	0,042	2,000
Sum:	**1,052**	**1,881**	**4,431**	**0,625**	**7,989**

Table 3: Dataset for Land Use Areas showing the sum of Land Use Areas by Tract and by Land Use for the whole sample

In our example the 4 Plots in Tract number 2 do not summarize exactly 2 ha, as we would have expected from the sampling design. The reason for this is that a small area within one of the plots (4) was classified as being outside of contry borders (in our example!), and only areas within the country borders are included in the inventory.

To estimate the area proportions of the different Land Uses in the total sample of 4 Tracts (=proportion of country area), ratio estimates (R) are calculated as the sum of the specific Land Use area divided by the sum of all Land Use areas (see Table 4). For example the proportion of Forest Area in the sample is calculated as a ratio estimate by dividing the sum of all Forest Areas in the whole sample (1,052 ha) by the sum of all Land Use Areas in the whole sample (7,989 ha), which gives us a ratio estimate of 0,132, meaning that 13,2% of the country area is Forest Area. In the following table the ratio estimates (R) are calculated for all of the global Land Uses.

	Area (ha)				
Tract	F	OWL	OL	W	**TOT.**
1	0	0,458	1,442	0,100	2,000
2	0,316	0,082	1,372	0,219	1,989
3	0	0,330	1,406	0,264	2,000
4	0,736	1,011	0,211	0,042	2,000
Sum:	**1,052**	**1,881**	**4,431**	**0,625**	**7,989**
R	***0,132***	***0,235***	***0,555***	***0,078***	

Table 4: Dataset for Land Use Areas presenting the ratio estimates for global Land Use Areas in the sample (=in the country)

To calculate the precision in the ratio estimates as shown in Table 5 the statistical functions for ratio estimates are employed (see Annex I).

	Area (ha)				
Tract	F	OWL	OL	W	**TOT.**
1	0	0,458	1,442	0,100	2,000
2	0,316	0,082	1,372	0,219	1,989
3	0	0,330	1,406	0,264	2,000
4	0,736	1,011	0,211	0,042	2,000
Sum:	**1,052**	**1,881**	**4,431**	**0,625**	**7,989**
R	***0,132***	***0,235***	***0,555***	***0,078***	
V					
Sd					
V_R					
S_R					
SE_R					
SE_R%					

Table 5: Dataset for Land Use Areas presenting the ratio estimates and various examples of statistical expressions for the precision of the estimations of Land Use Areas

Following the same example of a sample size of 4 Tracts, Table 6 is showing all the measured trees, bamboos and tree stumps in the sample together with their corresponding stem volume (Vol_{tot} , calculated as $[D_{bh}]^2 * \pi * [H_{tot}] * f_{form} /40000$), where the stem form factor (in relation to a cylinder volume), $f_{tree\text{-}tot} = 0,6$ has been used for trees and $f_{bamboo} = 0,8$ has been used for bamboos and $f_{stump\text{-}extr} = 0,5$ has been used for stumps to calculate the extracted tree stem volume.

			Trees						
Tract	Plot	LUS#	FORM	Species	Stump	Culms/ Clump	$D_{bh/sh}$ (cm)	H_{tot} (cm)	Vol_{tot} (m^3)
1	1	1	3a	Mehagini	0		12	6	0,040694
			3a	Akachi	0		15	7	0,074183
			3a	Mula	0		20	9	0,16956
			3a	Cowa	0		16	6	0,072346
	2	2	3a	Ayapan	0		37	12	0,773759
	4	1	3a	Babla	0		68	28	6,098131
			3a	Cowa	0		13	5	0,0398
2	1	1	3a	Dab	0		34	14	0,762266
			3b	Bansini	0	15	7	6	0,276948
			3a	Ekleja	0		21	12	0,249253
			3a	Ayapan	0		11	4	0,022796
	2	2	3a	Akachi	0		23	9	0,224243
			3a	Fulkat	0		10	4	0,01884
			3a	Akachi	0		12	5	0,033912
	4	1	3a	Ayapan	0		21	7	0,145398
			3a	Cowa	0		33	15	0,769379
3	1	1	3a	Cowa	0		21	11	0,228482
		2	3b	Bansini	0	25	9	4	0,50868
			3a	Babla	0		32	13	0,626995
			3b	Mitenga	0	9	8	5	0,180864
	2	1	3a	Karja	0		13	5	0,0398
			3a	Gadal	0		42	21	1,744772
			3a	Ekleja	0		54	32	4,394995
4	1	1	3a	Fulkat	-1		58	1	0,132037
			3a	Ekleja	-1		65	1	0,165831
	2	2	3a	Malong	0		19	8	0,136025
			3a	Ayapan	0		17	6	0,081671
	3	2	3a	Cowa	0		12	5	0,033912
			3a	Mahua	0		14	5	0,046158
			3a	Cowa	0		21	9	0,18694
	4	1	3a	Fulkat	0		18	8	0,122083

Table 6: Primary data on all measured Trees, Tree Stumps and Bamboos showing in which Tract, Plot and LUS number they are located and also the corresponding Species Name, D_{bh}, H_{tot}, derived Vol_{tot}, Culms/Clump and indicators for Bamboo/Tree, Stump.

	Total Tree Stem Volume (m^3)			
Tract	F	OWL	OL	W
1	0,3568	6,9117	0	
2	2,2261	0		0
3			6,8066	0,2285
4	0,4847	0	0,1221	
Sum:	**3,0676**	**6,9117**	**6,9286**	**0,2285**

Table 7: Dataset showing Total Tree Stem Volume by global Land Use and Tract

	Bamboo Culm Volume (m^3)			
Tract	F	OWL	OL	W
1	0	0	0	
2	0,2769	0		0
3			0,6895	0
4	0	0	0	
Sum:	**0,2769**	**0**	**0,6895**	**0**

Table 8: Dataset showing Total Bamboo Culm Volume by global Land Use and Tract

	Extracted Stem Volume (m^3)			
Tract	F	OWL	OL	W
1	0	0	0	
2	0	0		0
3			0	0
4	0	0	0,2979	
Sum:	**0**	**0**	**0,2979**	**0**

Table 9: Dataset showing Total Extracted Tree Stem Volume by global Land Use and Tract

Design of NFA database Queries

Objective: Prepare a dataset containing Total Land Use **Area** measured for each Global Land Use in the NFA sample

1. Open the MS Access program
2. Create "New Database"
3. Select "Blank Database"
4. Specify the location where the DB shall be saved and specify the name of the new DB (ex. "NFA-Processing")
5. Link to existing tables in the databases "**NFA-data_Bangladesh"** and **"NFA Bangladesh"** by **<File menu> => <Get External Data> => <Link Tables>**
6. Brows to folder where you find the DBs that contain the tables you want to link to
7. Select the tables you want to link to (all) and press OK
8. Repeat step 5-7 to link to tables in other databases
9. Select "**Queries**" object in the project window
10. **Create a new Query** in **Design view**
11. Open the "**Show Tables**" window
12. Select the tables that are needed for the query and press **Add**, then press Close to close the *Show Tables* window
13. **Select Fields** from the Tables on the top section of the Query window and drag-and-drop (or dubble-click) them on the lower section of the Query window
14. **Create links** between the tables using the **common fields**
15. Set the **Joint Properties** of the links
16. **Save** the Query and specify its name (ex. "Areas")

a) Areas are represented by the **Length** and **Width** of the Land Use Section (**LUS**) in table ***F5-LUS***.

b) The dataset shall contain one record per Tract. Tract number is found in table ***F1-Tract*** but the F5-LUS table has no common fields the F1-Tract table and can therefore not be linked directly.

c) Table ***F2-Plot*** has the field **ID-PLOT** common with table *F5-LUS* and the field **ID-TRACT** common with table *F1-Tract*

d) *F2-Plot* table is related to the *F5-LUS* through a **one-to-many** relation where all records in the *F2-Plot* table are included and only the matching records in *F5-LUS* are included.

e) *F2-Plot* table is related to the *F1-Tract* through a **many-to-one** relation where all records in the *F1-Tract* table are included and only the matching records in *F2-Plot* are included.

f) The Land Use codes registered in the F5-LUS table can be decoded with the field **Code_ID_N** in the table ***C-Codes***

g) To decode the Land Use the *C-Codes* table relates to the *F5-LUS* table through the **Code_ID** in the *C-Codes* table and the **80 LandUse** field in the *F5-LUS* table. The relationship is **one-to-many** where all records in the *F5-LUS* table are included and only the corresponding records in *C-Codes* are included

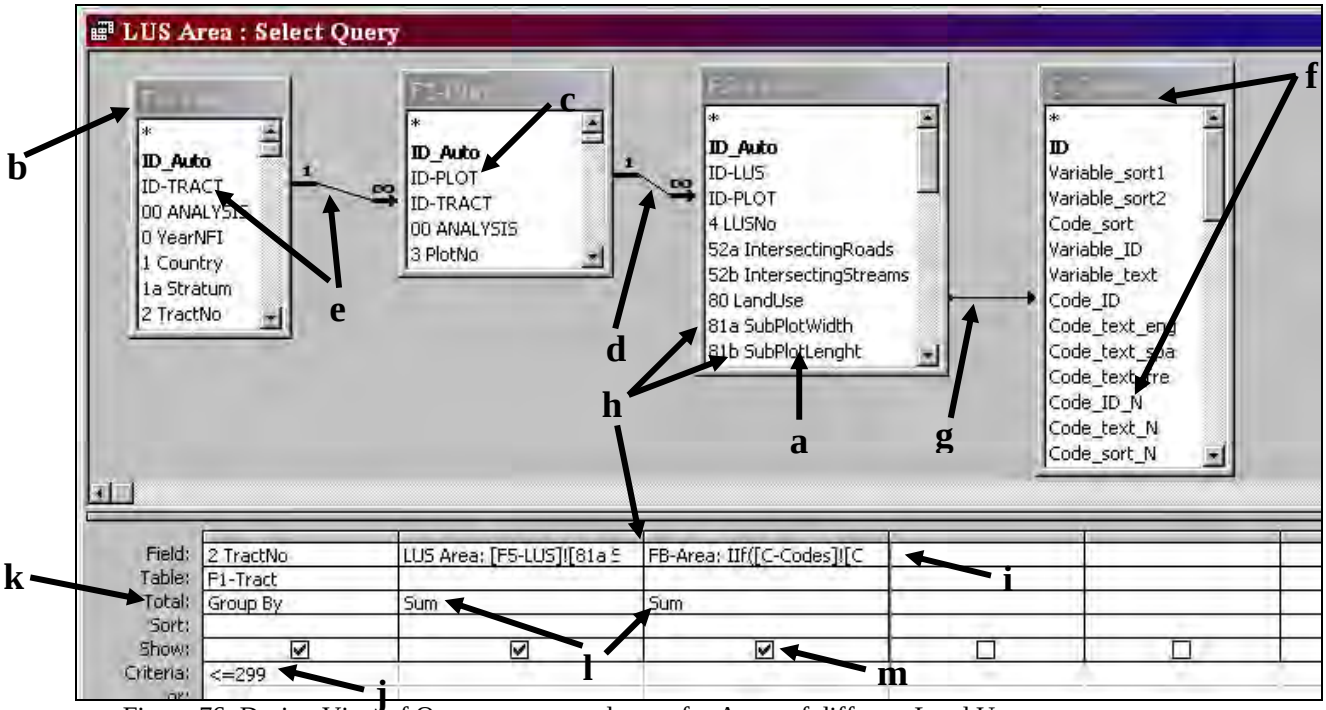

Figure 76: Design View of Query to present dataset for Areas of different Land Uses

h) The LUS area is calculated through multiplying the LUS Width (81a SubPlotWidth) by the LUS Length (81b SubPlotLength), which both are found in the F5-LUS table

LUS Area: ([F5-LUS]![81a SubPlotWidth] * [F5-LUS]![81b SubPlotLenght])

The "IIF" statement is used to limit the result of the field to return values that meet a certain criterion (=TRUE) or that not meet the criterion (=FALSE):

IIF(<CRITERIA>,<TRUE>,<FALSE>)

i) The area of all registered Bamboo Forest LUS is calculated through multiplying the Width of the LUS (81a SubPlotWidth) by the Length of the LUS (81b SubPlotLength) for the LUS where the Land Use is Bamboo Forest (=11400 or "FB")

FB-Area: IIf([F5-LUS]![80 LandUse] = 114000,[F5-LUS]![81a SubPlotWidth]*[F5-LUS]![81b SubPlotLenght],0)

or

IIf([C-Codes]![Code_ID_N]="FB",[F5-LUS]![81a SubPlotWidth]*[F5-LUS]![81b SubPlotLenght],0)

Where [F5-LUS]![80 LandUse] = 114000 and [C-Codes]![Code_ID_N]="FB" are examples of expressions for the criteria and;

[F5-LUS]![81a SubPlotWidth]*[F5-LUS]![81b SubPlotLenght] is the expression of the value when the criteria are ***true*** and 0 is the (expression of the) value if the criteria are ***false***

To generate an area value where all forest types are grouped into "Forest" the criteria to limit the land use class should be written to include as a range of forest types (land uses):

Forest-Area: IIf([F5-LUS]![80 LandUse] >=100000 And [F5-LUS]![80 LandUse] <200000, [F5-LUS]![81a SubPlotWidth]*[F5-LUS]![81b SubPlotLenght],0)

Where the Land Use codes >= 10000 and < 200000 are forest land uses. Refer to for land use codes employed:

Code_ID	Code_ID_N	Code_text_N
111000	FH	Hill forest
111002	Fsa	Sal forest
111150	FSw	Swamp forest (freshwater)
111160	FM	Mangrove forest (saltwater)
114000	FB	Bamboo or mixed Bamboo/broad-leaved forest
121010	PL	Long rotation forest plantation
121020	PS	Short/medium rotation forest plantation
121160	PM	Mangrove Plantation
121170	PR	Rubber Plantation
210000	Sh	Shrubs
210010	Sw	Swamps with shrubs
312000	BG	Barren Land/Grassland
321001	CA0	Annual Crops Without trees
321002	CA1	Annual Crops With trees 0,1 – 0,5 ha
321003	CA2	Annual Crops With trees >0,5 ha
322001	CP0	Perennial Crops Without trees
322002	CP1	Perennial Crops With trees 0,1 – 0,5 ha
322003	CP2	Perennial Crops With trees > 0,5 ha
323000	RL	Range Land/Pasture
324000	Fa	Wooded land with shifting cultivation (Fallow)
331000	SU	Urban settlements
332001	SR0	Rural settlement without trees
332002	SR1	Rural settlement With trees 0,1 – 0,5 ha
332003	SR2	Rural settlement With trees > 0,5 ha
333000	HA	Highways and other artificial areas
400040	WHB	Haor & Baor
400010	WL	Lake
400020	WR	River
400030	WP	Pond
500000	OUT	Outside land area

Table 10: Land Use Codes; numeric (Code_ID) and alphanumeric (Code_ID_N)

j) The data set shall contain **299** records (= number of Tracts in Bangladesh)

k) The dataset shall contain one record per Tract, so the data set is **Grouped** by the field **2 TractNo** and

l) **Summarize** the calculated area values of LUS Area and FB-Area

m) The **Checkboxes** on the **Show** line have to be checked to if the field shall shown in the "Table View"

When we apply the "Table View" to the query the IIF statements are now returning the value "0" when the criteria is not met.

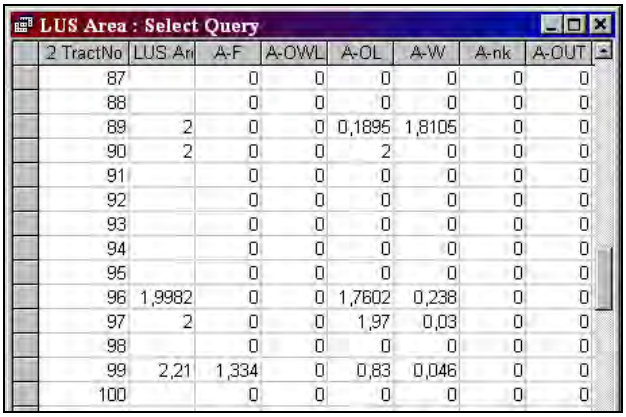

Table 11: Table view of the Land Use area query showing Tract record 87 to 100

If we do not want the IIF statement to return "0" but "NULL" for those Tracts where no LUS have been registered yet, the IIF statement need to be further developed with an additional criterion:

IIf([F5-LUS]![80 LandUse]>=100000 And [F5-LUS]![80 LandUse]<=500000;
IIf([F5-LUS]![80 LandUse]>=100000 And [F5-LUS]![80 LandUse]<200000;[F5-LUS]![81a SubPlotWidth]*[F5-LUS]![81b SubPlotLenght]/ 10000;0);Null)

The IIF statements above return values (*area expression*) for the LUS where the Land Use is "Bamboo Forest", and return a "0" for the LUS where the Land Use is NOT "Bamboo Forest". However, if the Land Use of a LUS is "Bamboo Forest", but the Length and/or Width of the LUS is missing, the IIF statements will not return a value (=empty/missing/NULL). To exclude LUS with missing *Length* and/or *Width* values the yellow marked criteria in the expression below is added to the first criteria:

IIf([F5-LUS]![80 LandUse]>=100000 And [F5-LUS]![80 LandUse]<=500000 And [F5-LUS]![81a SubPlotWidth]* [F5-LUS]![81b SubPlotLenght]>=1;IIf([F5-LUS]![80 LandUse]>=100000 And [F5-LUS]![80 LandUse]<200000;[F5-LUS]![81a SubPlotWidth]*[F5-LUS]![81b SubPlotLenght]/10000;0);Null)

When we now apply the "Table View" to the query the IIF statements are returning values only for LUS where Land Use, Length and Width are registered:

LUS Area : Select Query

2 TractNo	LUS An	A-F	A-OWL	A-OL	A-W	A-nk	A-OUT
87							
88							
89	2	0	0	0,1895	1,8105		0
90	2	0	0	2	0		0
91							
92							
93							
94							
95							
96	1,9982	0	0	1,7602	0,238		0
97	2	0	0	1,97	0,03		0
98							
99	2,21	1,334	0	0,83	0,046		0
100							

Record: 94 of 299

Table 12: Table view of the Land Use area query showing Tract record 87 to 100

Objective: Prepare a dataset containing Total Stem Volume for the Trees and Bamboos measured in each Global Land Use in the NFA sample. The dataset shall also contain the extracted stem volume based on the stump data.

1. Open the Access program
2. Repeat the steps 2-15 in earlier chapter (or open an existing DB)

a) Volumes are represented by the **Tree Diameter at breast height** ($\mathbf{D_{bh}}$) and **Total Tree Height** ($\mathbf{H_{tot}}$) in table ***F3-Trees***.

b) The dataset shall contain one record per Tract. Tract number is found in table ***F1-Tract*** but the table *F3-Trees* has no common fields the F1-Tract table and can therefore not be linked directly.

c) Table ***F5-LUS*** has the fields **ID-PLOT** and **4 LUSNo** common with table *F3-Trees* and the field **ID-PLOT** common with table *F2-PLot*

d) ***F2-Plot*** has the field **ID-PLOT** common with table *F5-LUS* and the field **ID-TRACT** common with table *F1-Tract*

e) *F5-LUS* table is related to the *F3-Trees* through a **one-to-many** relation where all records in the *F5-LUS* table are included and only the matching records in *F3-Trees* are included.\

f) *F2-Plot* table is related to the *F5-LUS* through a **one-to-many** relation where all records in the *F2-Plot* table are included and only the matching records in *F5-LUS* are included.

g) *F2-Plot* table is related to the *F1-Tract* through a **many-to-one** relation where all records in the *F1-Tract* table are included and only the matching records in *F2-Plot* are included.

h) The Land Use codes registered in the F5-LUS table can be decoded with the field **Code_ID_N** in the table ***C-Codes***

i) To decode the Land Use the *C-Codes* table relates to the *F5-LUS* table through the **Code_ID** in the *C-Codes* table and the **80 LandUse** field in the *F5-LUS* table. The relationship is **one-to-many** where all records in the *F5-LUS* table are included and only the corresponding records in *C-Codes* are included

j) *The total stem volume is calculated as:*

Total Tree Stem Volume (V_{tot}): $((D_{bh})^2 * H_{tot} * \pi * f_{tree\text{-}tot})/(4 * 100^2)$ =>

=> ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.6/40000

k) To calculate the Total Stem Volume of all measured trees in all Land Uses the Bamboos and Stumps, which are also stored in the F3-Trees table, must be excluded:

Vol-Tot: IIF([F3-Trees]![FORM] = "3a" And [F3-Trees]![55b Stump] <>-1 And [F3-Trees]![60 YearCut] Is Null, ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.6/40000,0)

[F3-Trees]![FORM] = "3a" selects records entered in the F3a-Form (=Trees and Stumps)
[F3-Trees]![55b Stump] <>-1 excludes records where the ***55b Stump*** variable has been checked
[F3-Trees]![60 YearCut] Is Null includes records where no data has been entered in the ***60 YearCut*** variable

To generate data on tree volume measured in LUS with Forest Land Use, in addition to the criteria for the total volume (Vol-Tot) the criteria for forest Land Use is included; …*And [F5-LUS]![80 LandUse] >=100000 And [F5-LUS]![80 LandUse] <200000*… (Land Use codes >=100000 and < 200000 represent forest Land Use)

Vol-Forest: IIF([F5-LUS]![80 LandUse] >=100000 And [F5-LUS]![80 LandUse] <200000, IIF([F3-Trees]![FORM] = "3a" And [F3-Trees]![55b Stump] <>-1 And [F3-Trees]![60 YearCut] Is Null, ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.6/40000,0),Null)

or

Vol-For: IIf([C-Codes]![CodeGrouping1]=1, IIF([F3-Trees]![FORM]="3a" And [F3-Trees]![55b Stump]<>-1 And [F3-Trees]![60 YearCut] Is Null,([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.6/40000,0),Null)

(if the *C-Codes* table has been linked to the *F5-LUS* table through the **Code_ID** field and the **80 LandUse** field respectively as shown in figure ??, the **CodeGrouping1** can be used to limit the Global Land Uses, where 1=Forest, 2=OWL, 3=OL, 4=W and 5=OUT)

The [F5-LUS]![80 LandUse] >=100000 And [F5-LUS]![80 LandUse] <200000 and [C-Codes]![CodeGrouping1]=1 respectively represent a first criterion to select LUS which are forest. If the criterion is not met the false value Null will be return, while if the first criterion is met a second criterion will be tested; [F3-Trees]![FORM] = "3a" And [F3-Trees]![55b Stump] <>-1 And [F3-Trees]![60 YearCut] Is Null. If the first criterion is met but not the second, the value "0" will be return, while the value of the expression [F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.6/40000 will be returned if both criteria are met

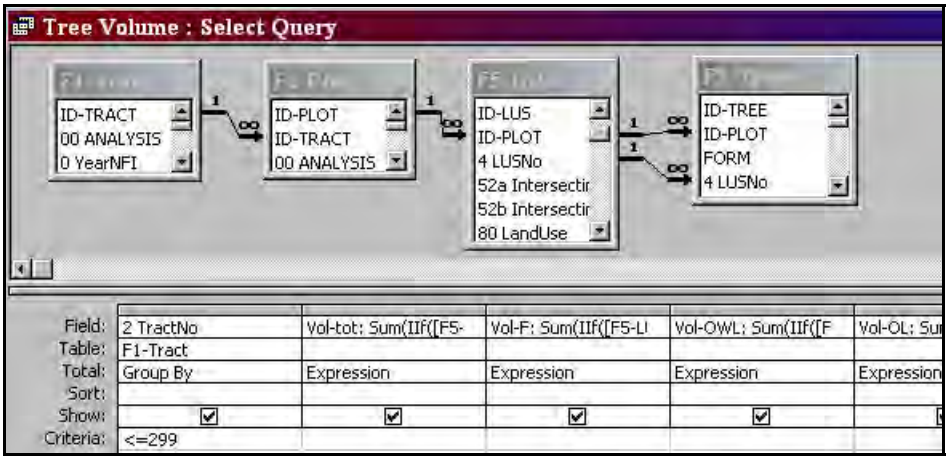

Figure 77: Design view of the Volume query for Trees, Bamboos and Extracted stem volume

Tree Volume : Select Query

2 TractNo	Vol-tot	Vol-F	Vol-OWL	Vol-OL	Vol-W	Vol-nk	Vol-OUT
87						0	
88						0	
89	6,9415			0	6,9415		
90	0			0			
91						0	
92						0	
93						0	
94						0	
95						0	
96	121,40			121,40	0		
97	56,201			56,201	0		
98						0	
99	49,977	36,646		13,332	0		
100						0	

Record: 87 of 299

Table 13: Table view of the query for Tree Stem Volume

l) *The Bamboo culm volume per clump is calculated as:*

Bamboo culm Volume per clump (V_{clump}): CulmsTotal * $((D_{bh})^2 * H_{tot} * \pi * f_{bamboo})/(4 * 100^2)$ =>

=> [F3-Trees]![58b CulmsTotal] ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.8/40000

m) To calculate the Total Bamboo Culm Volume of all measured Bamboo clumps in all Land Uses the Trees and Stumps, which are also stored in the F3-Trees table, must be excluded:

Vol_Bamboo-F: Sum(IIf([F5-LUS]![80 LandUse]>=100000 And [F5-LUS]![80 LandUse]<200000;IIf([F3-Trees]![FORM]="3b"; [F3-Trees]![58b CulmsTotal] * ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3,14*0,8/40000;0);Null))

[F3-Trees]![FORM] = "3b" selects records entered in the F3b-Form (=Bamboo)

n) *The Extracted Tree stem volume is calculated as:*

Extracted tree stem Volume (V_{extr}): $((D_{sh})^2 * H_{tot} * \pi * f_{stump})/(4 * 100^2)$ =>

=> ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3.14*0.5/40000

o) To calculate the Total Bamboo Culm Volume of all measured Bamboo clumps in all Land Uses, the Trees and Bamboo, which are also stored in the F3-Trees table, must be excluded:

Vol_Extracted-F: Sum(IIf([F5-LUS]![80 LandUse]>=100000 And [F5-LUS]![80 LandUse]<200000;IIf([F3-Trees]![55b Stump] = -1 Or [F3-Trees]![60 YearCut] >=1; [F3-Trees]![58b CulmsTotal] * ([F3-Trees]![58 Dbh])^2*[F3-Trees]![61 TotalHeight]*3,14*0,8/40000;0);Null))

[F3-Trees]![55b Stump] =-1 includes records where the ***55b Stump*** variable has been checked
[F3-Trees]![60 YearCut] >=1 includes records where data has been entered in the ***60 YearCut*** variable.

Tree Volume : Select Query

2 TractNo	Vol-tot	Vol-F	Vol-OWL	Vol-OL	Vol-W	Vol-nk	Vol-OU	Vol_Bamboos-F	Vol_Extracted-F
87						0			
88						0			
89	6,9415			0	6,9415				
90	0			0					
91						0			
92						0			
93						0			
94						0			
95						0			
96	121,40			121,40	0				
97	56,201			56,201	0				
98						0			
99	49,977	36,646		13,332	0			1,3189884	0,1635155
100						0			

Record: 94 of 299

Table 14: Table view of the Volume query for Trees, including also volume of Bamboos and Extracted stem volume

Objective: Prepare a dataset containing data on Products and Services in each Global Land Use in the NFA sample. The dataset shall show the value of each attribute as the area in which the P/S was harvested/used.

3. Open the Access program
4. Repeat the steps 2-15 in earlier chapter (or open an existing DB)

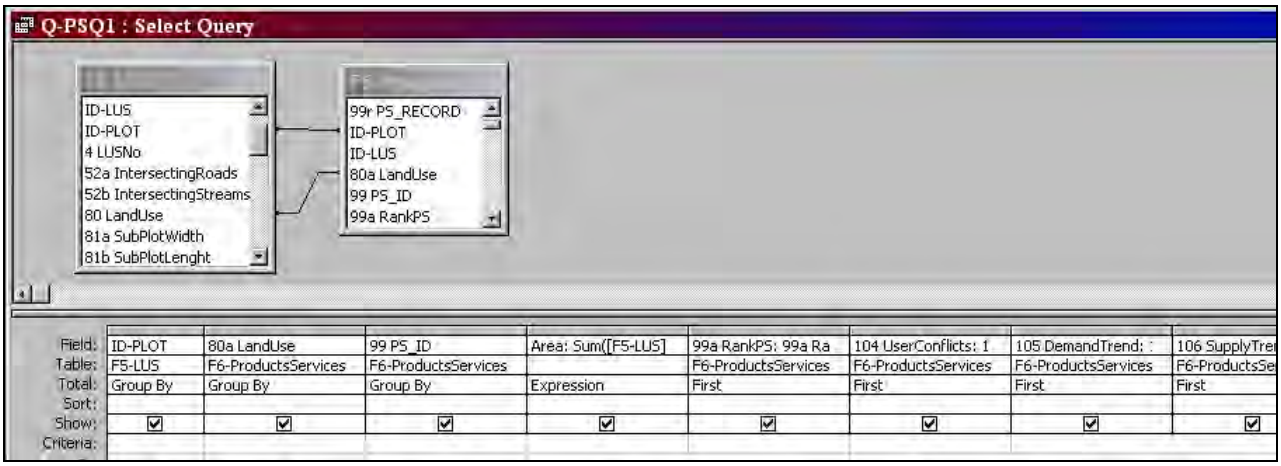

Figure 78: Design view of the Products/Services query "PSQ1". The area of the Land Use corresponding to where the P/S are harvested/used is assigned as reference to the P/S data

Q-PSQ1 : Select Query

ID-PLOT	80a LandUse	99 PS_ID	Area	99a RankPS	104 UserConflicts	105 DemandTrend	106 SupplyTrend
3110971	332002	201	0,32	1	1	3	3
3110972	321001	101	0,418	1	1	3	1
3110972	321001	102	0,418	3	1	3	1
3110972	321001	201	0,418	2	1	3	1
3110972	332001	101	0,082	2	1	3	1
3110972	332001	102	0,082	3	1	3	1
3110972	332001	201	0,082	1	1	3	1
3110973	332002	102	0,364	2	1	3	1
3110973	332002	105	0,364	3	1	3	1
3110973	332002	201	0,364	1	1	1	1
3110974	321001	101	0,5	3	1	3	3
3110974	321001	102	0,5	1	1	3	1
3110974	321001	201	0,5	2	1	3	1
3110991	114000	101	0,366	2	1	3	1
3110991	114000	102	0,366	1	1	3	1
3110991	114000	209	0,366	3	1	3	1
3110992	114000	101	0,42	1	1	3	1
3110994	111000	101	0,04	1	1	3	2
3110994	111000	102	0,04	2	1	3	2
3110994	321001	105	0,414	3	1	3	2
3110994	321001	201	0,414	1	1	3	1

Record: 89 of 256

Table 15: Table view of the Products/Services query "PSQ1", showing the P/S reference areas for each land use and Plot

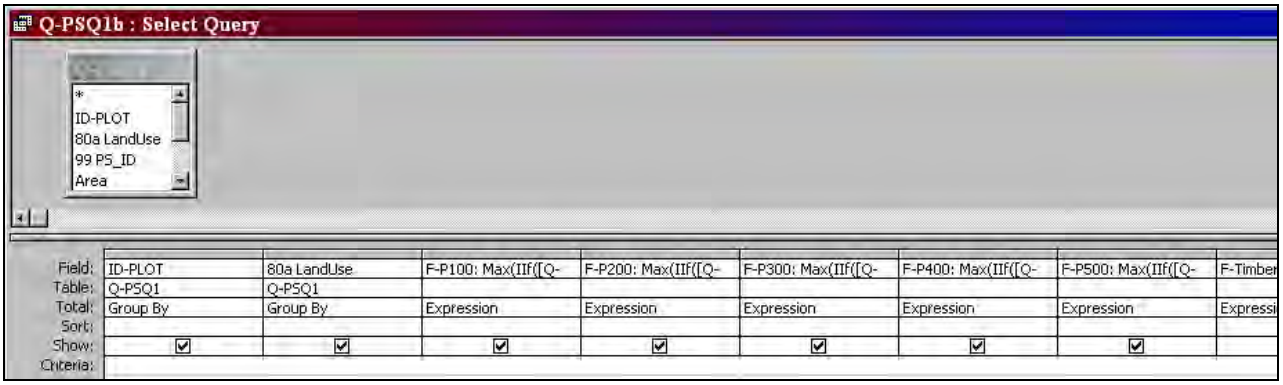

Figure 79: Design View of the Products/Services query "PSQ1b". The query "PSQ1" is used as source data and the P/S reference areas are grouped by Plot and Land Use applying "Max" for the reference areas to avoid that areas are double counted

Q-PSQ1b : Select Query

ID-PLOT	80a LandUs	F-P100	F-P200	F-P300	F-P400	F-P500	F-Timber	F-Timber_H	F-Timber_M	F-Timber_L	F-Fuelwood	F-Fuelwood_H	F-Fuelwoo
3110971	321001												
3110971	332002												
3110972	321001												
3110972	332001												
3110973	332002												
3110974	321001												
3110991	114000	0,366	0,366	0	0	0	0,366	0	0,366	0	0,366	0,366	
3110992	114000	0,42	0	0	0	0	0,42	0,42	0	0	0	0	
3110994	111000	0,04	0	0	0	0	0,04	0,04	0	0	0,04	0	
3110994	321001												
3111081	321001												
3111081	332001												
3111083	321001												
3111083	332001												

Record: 1 of 94

Table 16: Table View of the Products/Services query "PSQ1b" showing P/S reference areas by Plot and Land Use

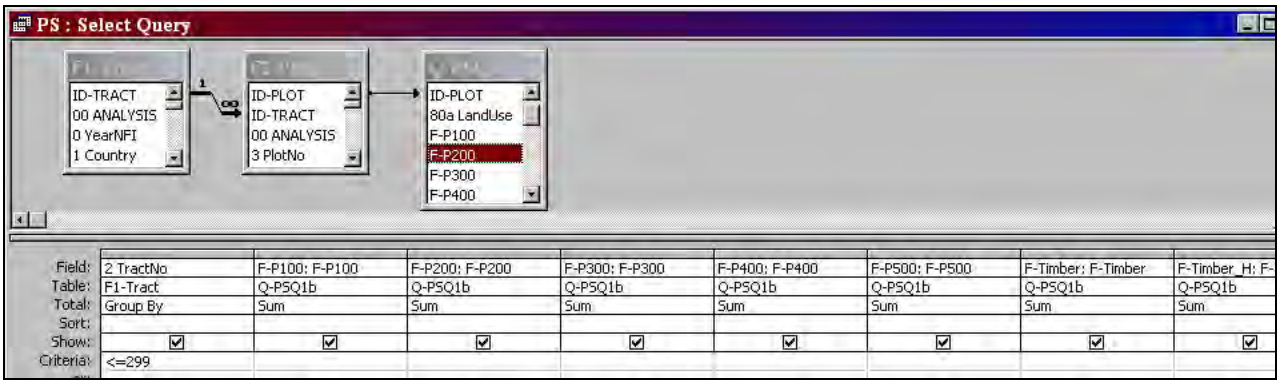

Figure 80: Design View of the Products/Services query "PS". The query "PSQ1b" is used as source data together with the tables "F1-Tract" and "F2-Plot" and to prepare the dataset the P/S reference areas are summarized by Tract and Land Use

PS : Select Query

2 TractNo	F-P100	F-P200	F-P300	F-P400	F-P500	F-Timber	F-Timber_H	F-Timber_M	F-Timber_L	F-Fuel	F-Fuelwood_H	F-Fuelwood_M	F-Fuelwood
87													
88													
89													
90													
91													
92													
93													
94													
95													
96													
97													
98													
99	0,826	0,366	0	0	0	0,826	0,46	0,366	0	0,406	0,366	0,04	
100													

Record: 1 of 299

Table 17: Table View of the Products/Services query “PS” showing the dataset of P/S reference areas by Tract and Land Use

Annex III
LINKS TO WEB SITES WITH INFORMATION ON GIS APPLICATION

GIS in Decision Making:

1999 FAO *Aquaculture Study and Lagoon Management. Pilot study in Morocco*.
http://www.fao.org/sd/EIdirect/EIre0068.htm

1999 FAO *Forest Management, Pilot study in Morocco.*
http://www.fao.org/sd/EIdirect/EIre0069.htm

1999 FAO *Rangeland Assessment and Monitoring Pilot Study in Morocco.*
http://www.fao.org/sd/EIdirect/EIre0071.htm

1999 FAO *Groundwater Exploration. Pilot Study in the Syrian Arab Republic.*
http://www.fao.org/sd/EIdirect/EIre0070.htm

1999 FAO *Forest Fire Management. Pilot Study in Poland.*
http://www.fao.org/sd/EIdirect/EIre0074.htm

1999 FAO *Forest Decline Assessment and Monitoring. Pilot Sstudy in Poland.*
http://www.fao.org/sd/EIdirect/EIre0075.htm

1999 FAO *Crop Information Systems. Pilot study in Romania.*
http://www.fao.org/sd/EIdirect/EIre0078.htm

2002 FAO *Assessment of Priority Areas for Trypanosomiasis Control Actions by Ssatellite Data and Fuzzy Logic: Pilot study in Togo*. Series N.20
http://www.fao.org/sd/2002/EN0202_en.htm

Forestry:

ASEAN-UNEP Cooperation on the Establishment of a GIS Database and Improvement of Communications for Forest Fire Management. Nairobi.
http://www.rrcap.unep.org/issues/forestfi/gisdatabase.cfm

Arcnews Online 2003 *For Douglas County Forestry in Wisconsin, GIS Is the Primary Tool.* http://www.esri.com/news/arcnews/summer03articles/for-douglas-county.html

Arcnews Online 2004 *Virginia Department of Forestry Uses Internet GIS to Reach Landowners.* http://www.esri.com/news/arcnews/fall04articles/virginia-dof.html

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