Soil map of Denmark According to the Revised FAO Legend 1990

Henrik Breuning-Madsen & Niels Henrik Jensen

Abstract

In the first half of the 1990's, a comprehensive EU soil database was established comprising the EU soil map from 1985 published at scale 1:1.000.000, soil attributes and a soil analytical database. The EU soil map was based on a slightly revised FAO 1974 legend. In 1990 FAO published a revised legend to Soil Map of the World, and based on this system Central and Eastern Europe are now constructing soil maps at scale 1:1.000.000. In order to harmonize these soil maps, an updating of the EU soil map is necessary according to the FAO 1990 legend. The present paper describes the updating of the Danish part of the EU soil map.

Keywords

Soil database, FAO-legend.

Henrik Breuning-Madsen: Institute of Geography, University of Copenhagen, Øster Voldgade 10, 1350 Copenhagen K., Denmark.

Niels Henrik Jensen: Department of Geography and International Development Studies, Roskilde University Center, Postbox 260, 4000 Roskilde, Denmark.

Danish Journal of Geography 96: 51-59, 1996.

In 1974 a world-wide soil map at scale 1:5000000 was published using the FAO-soil classification nomenclature (FAO-Unesco 1974). In 1985 the Commission of the European Communities published a soil map at scale 1:1000000 covering the entire EC. The map was based on the same principles as the world-wide map but the nomenclature was expanded for some of the main soil types (Commission of the European Communities 1985). The Danish contribution to the map was based on information from few soil profiles and geological maps.

During the past twenty years, extensive soil investigations have been carried out in Denmark. In the late 1970s, a national soil mapping was carried out grouping the agricultural land into 8 soil classes according to the texture of the ploughlayer (Mathiesen 1980). This mapping was followed up by regional soil profile investigations during the 1980s. In the first half of the 1980s, most of the soil profile investigations were carried out along the trench of the gas pipeline, which was constructed across the country from the North Sea and the German border to Copenhagen (Madsen & Jensen 1985). In the second half of the 1980s, the soil profile investigations were carried out in a nationwide 7 km grid established by the Danish Agricultural Advisory Centre in order to predict the amount of nitrogen fertilization and manuring required by Danish agriculture (Østergård 1990, Jensen et al. 1994). In total, about 2000 soil profiles have been described and classified and soil samples collected for chemical and physical analyses.

The comprehensive soil profile investigations during the 1980s revealed that a revision of the Danish contribution to the EC soil map was necessary and a revised version of the Danish EC-map has been constructed by combining landscape maps, national soil maps and soil profile classifications from investigations in the 7 km-grid (Madsen & Jensen 1995).

In 1990 FAO published a revised legend to Soil Map of the World (FAO-Unesco 1990). Based on this system Central and Eastern Europe are now constructing nation-wide soil maps at scale 1:1000000. Soil analytical databases connected to these maps are under preparation using the same methodology as for the EU-countries (Breuning-Madsen & Jones 1995). In order to harmonize the soil maps of Europe, it is necessary to transform the EC soil map using the 1985-nomenclature to the FAO revised legend of 1990. This paper descibes the construction of a Danish soil map at scale 1:1000000 using the FAO 1990 legend.

Soils of Denmark

Denmark has a temperate, Atlantic climate with a winter mean of about 0°C and a summer mean of about 17°C. The mean annual precipitation ranges from more than 800 mm in central Jutland to below 500 mm in the Great Belt region. The annual potential evapotranspiration is about 550 mm and the annual actual evapotranspiration about 380 mm. In spring and early summer, the potential evapotranspiration exceeds precipitation, and vegetation utilizes water stored in the root zone, causing depletion of soil water. In late summer and early autumn, the soil water reserves are replenished due to a precipitation surplus. In late autumn, winter and early spring, leaching takes place. In central Jutland, the annual percolation exceeds 400 mm. In the Great Belt region it is about 150 mm (Aslyng 1978).

The natural vegetation is deciduous forest, the climax vegetation being beechwood. Today, about two-thirds of the country is agricultural land that is manured, limed and, to some extent, drained. Only about 12% is under forest, and a large part of this is spruce plantations.

Figure 1 shows the origin of the parent material of Danish soils. The major part of the country consists of Weichsel glacial deposits, mainly tills. In Western Jutland, old relic Saale glacial deposits and the younger Weichsel outwash plain deposits dominate, while in Northern Jutland marine deposits cover large areas. Along the west coast of Jutland, sand dune and saltmarsh deposits are dominant. Figure 2 shows where clayey (>15% clay) and sandy (<15% clay) parent material is situated and where extensive peatlands are located.

The Danish landscape is generally flat or slightly undulating. Only about 1% of the country has slopes with gradients exceeding 12°. Today, half of this area is afforested. Therefore, severe soil erosion due to water is not a big problem, but colluvial deposits at the feet of slopes occur frequently due to sheet and rill erosion.

The overall soil forming processes on well-drained sites

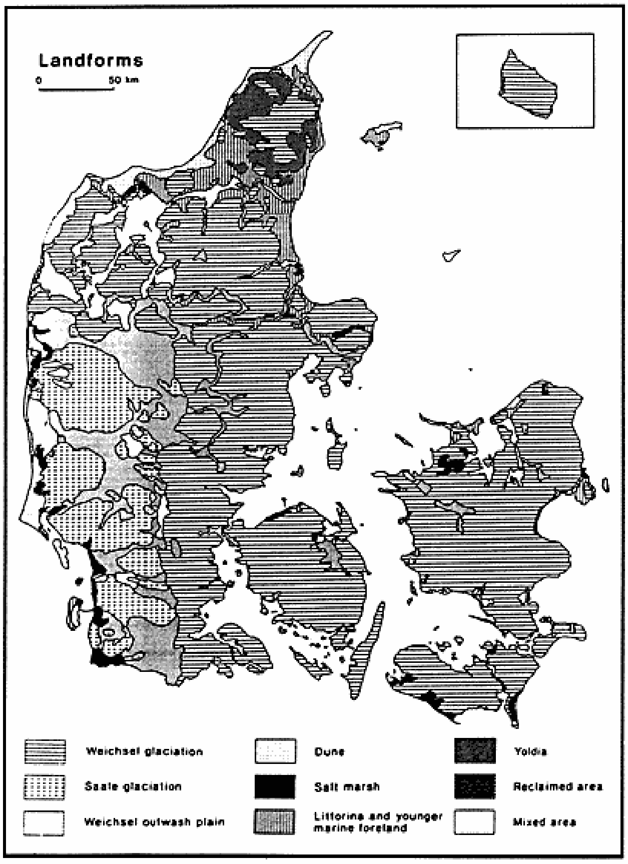

Figure 1: Denmark - A simplified computer-drawn landform map.

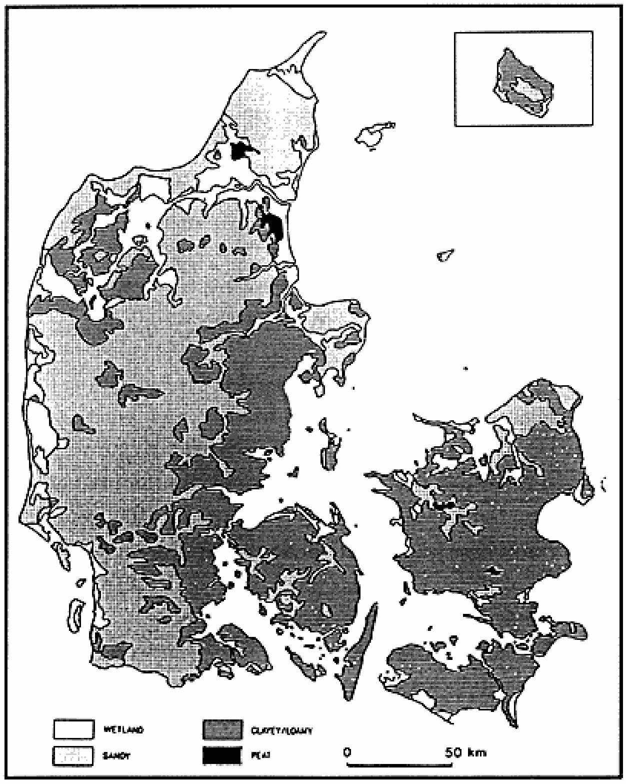

Figure 2: Denmark - The location of clayey/loamy and sandy parent material, wetlands and major moorlands. Clayey/loamy parent material (above 15% clay) sandy parent material (less than 15% clay).

reflecting the soil forming factors are; acidification due to the leaching of calcium carbonate and exchangeable bases, weathering of the different minerals, migration of clay particles on loamy or clayey soils, and podzolization of sandy soils involving translocation of humus, iron and aluminium (hydr)oxides from the A to the B horizon. In wetlands, gley processes and peat formations are the dominant soil forming processes.

Data Collection

The soil map is constructed by using different landscape maps and the national soil maps for deliniation of different mapping units. All the maps have been digitized and stored in a nation-wide comprehensive database sytem (Madsen et al 1992). The following maps have been used:

- The landscape map shown in Figure 1. (scale 1:100000).
- The texture map shown in Figure 2 (scale 1:500000).
- Map showing the location of wetlands in the first half part of this century (scale 1:20000).
- Textural information from the Danish soil classification including more than 36000 texture analyses (scale 1:50000).
- Maps showing potentially acid sulphate soils in Jutland (scale 1:100000).

The two first-mentioned maps (Figure 1 & 2) delineate the pedological mapping unit. The wetland maps are used for a percentage quantification of the wetland soils (Fluvisol, Gleysol, Histosol) on the level association and inclusion. The national soil map and 36000 texture analyses are used for delineation of different textures according to the 3 classes defined in FAO-Unesco (1990). Furthermore, it gives information on slope class. The potentially acid sulphate soil maps (Madsen et al. 1985) are used for delineation of thionic soil types.

The pedological assessment of the mapping units was mainly based on the soil classification of the soil profiles situated in the 7 km grid, but also results from other pedological investigations were taken into consideration when necessary.

Within the 7 km grid a soil profile was excavated at each intersection and described in detail according to a system based on FAO (1977) but adapted to Danish conditions. From each horizon, soil samples were taken for physical and chemical analyses, and undisturbed core samples were collected in tubes for determination of soil water retention and bulk density. For each of the excavations, an augering was made to a depth of 2 metres, from which a soil sample was collected.

All samples were analyzed for texture, pH, organic matter content and calcium carbonate content. All samples containing more than 0.5% organic carbon were analyzed for total nitrogen. Exchangeable bases, acidity, and cation exchange capacity were determined on half of the samples. Dithionite-citrate and pyrophosphate soluble iron and aluminium were determined on selected samples for classification purposes. Soil water retention was determined on all core samples. The analytical methods are described in Madsen & Jensen (1992).

Results and Discussions

All the soil profiles have been classified according to the FAO-Unesco legend (1974) and the names have been transformed to the FAO-Unesco (1990). This has been done in some cases by transforming soil names directly from the 1974-legend to the 1990-legend, while in other cases it has been necessary to make spot tests classifying soil profiles in the database according to the 1990-legend. Futhermore, information from other investigations has been used, e.g. for quantification of the area distribution of thionic soils. The sandy soils are mainly Arenosols or Podzols, while the more clayey soils are Cambisols, Phaeozems, Luvisols, Alisols or Podzoluvisols. The wetland soils are mainly Gleysols, Fluvisols or Histosols. Figure 3 shows the soils of the 7 km grid categorized into the eight groups defined below. As the sampling has been carried out in a fixed grid, it is possible statistically to make some simple estimations of the occurrence of different soils found within different geographical regions.

1) podzolized sandy soils
   FAO: *Podzols*.
2) non-podzolized sandy soils
   FAO: *Arenosols*.
3) acid loamy and clayey soils with clay illuviation
   FAO: *Alisols*, Podzoluvisols.
4) neutral or slighly acid loamy or clayey soils with clay illuviation.
   FAO: *Luvisols*, luvic and most gleyed Phaeozems.

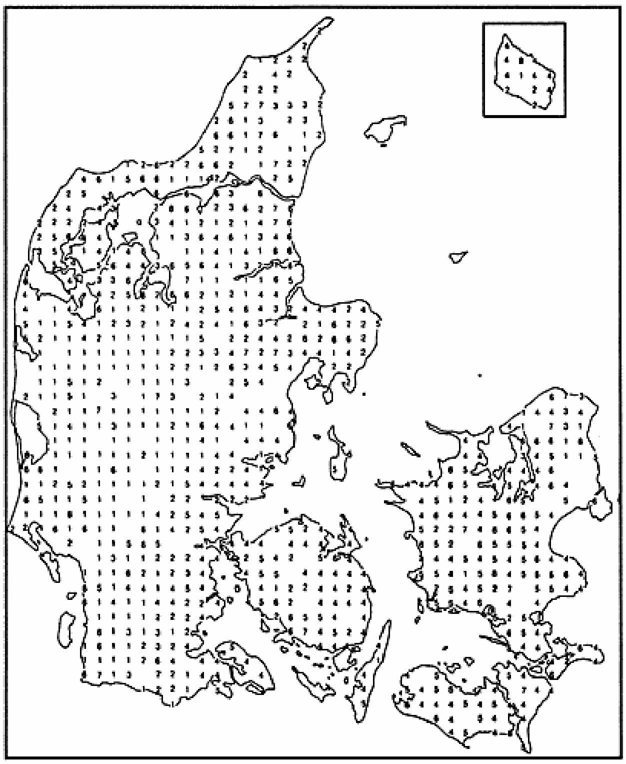

Figure 3: Denmark - Major soil groupings within the 7 km grid according to the FAO-Unesco soil Classification system 1990. 1) Podzol 2) Arenosol, 3) Alisol, Podzoluvisol 4) Luvisol, Phaeozem with Bt 5) Cambisol, Phaeozem without Bt 6) Gleysol, Fluvisol 7) Histosol 8) Leptosol.

5) loamy or clayey soils without clay illuviation
   FAO: *Cambisols*, Phaeozems except luvic and some gleyed ones.
6) wetland soils showing gley formation
   FAO: *Gleysols*, Fluvisols.
7) wetland soils showing deep peat formation
   FAO: *Histosols.*
8) shallow soils on limestone or gneis
   FAO: *Leptosols.*

In the following passage, the names in italic above indicate the eight major soil groups. The following comments should be made on the classification at first level. The base saturation of the ploughlayers vary due to liming and in some periods they might exceed 50% and in some periods drop below. In the first case the epipedon will often be mollic in the second umbric. This causes some classification and mapping problems because the soil types vary with time. A soil might e.g. be a Luvisol before liming and afterwards it will be a Phaeozem, after a few years it becomes a Luvisol again due to leaching. Furthermore, a spot test has revealed that about 2/3 of the Danish ploughlayers have more than 250 ppm citric acid P_2O_5, which excludes them from being a mollic or umbric epipedon. In nearly all investigated soil profiles, the epipedon is too shallow to be fimic, so they are considered as ochric for classification. It should, however, be noted that in the draft WRB handbook (ISSS et al. 1994) the citric-acid criterion is ignored and this will retain such horizons as mollic. According to the above-mentioned Phaeozems are present in Denmark but they are artificially made. They are unevenly distributed between Luvisols and Cambisols, but are not dominant. Because of the lack of systematical citric acid P_2O_5-analyses, it is not possible to estimate the percentage share of Phaeozems. Thus, Phaeozems are excluded in the definition of the 17 mapping units in table 4. They are categorized as Luvisol if an argic horizon is present elsewhere as Cambisol.

Soils of Different Landscapes

Table 1 shows the number and percentage share of the different soils in relation to the landforms shown in Figure 1. The landforms, reclaimed sea areas and salt marshes, have been excluded as the number of soils investigated in these areas was very small. However, most of the soils of these two landforms are Fluvisols or Gleysols. Areas with mixed landforms where the soils cannot be related to a definite landform have been excluded.

In the littorina areas, wet soils dominate: About 60% are Gleysols or Fluvisols, while about 10% are Histosols. On the more elevated parts, Arenosols are most common while Podzols are rare. On the Yoldia plateau, well-drained, non-podzolized, sandy soils dominate, while loamy soils are rare. The wetlands are mainly situated in deep narrow valleys. In these valleys, Histosols dominate. The dune landscapes show Arenosols and Podzols on the well-drained parts, while the wetlands are characterized by Gleysols, some of which have thin histic epipedons. In the Saale glacial landscape and on the Weichsel glacial outwash plains, Podzols dominate, accounting for about two-thirds of the profiles investigated, while Arenosols cover less than 20% of the area. Among the loamy soils, no specific soil type dominates. The wetland soils, mainly Gleysols and Fluvisols, cover about 10% of the area. Histosols are very rare. In the Weichsel glacial landscape, Luvisols are the dominant soil type, accounting for about 40% of the

Table 1: Soil types in relation to landforms. PZ: Podzol. AR: Arenosol. AL,PD: Alisol and Podzoluvisol. LV: Luvisol and Phaeozems with clay illuviation. CM: Cambisol, all Phaeozems without clay illuviation. LP: Leptosol. GFH: Gleysol, Fluvisol, Histosol.

			<---	*percent %*		*--->*		
Landform	*Number*	*PZ*	*AR*	*AL,PD*	*LV*	*CM*	*GFH*	*LP*
Littorina	43	0-10	20-30	0	0-10	0-10	60-70	0
Yoldia	24	10-20	40-50	0-10	0-10	0-10	10-20	0
Dune	22	30-40	40-50	0	0	0	10-20	0
Saale glaciation	87	60-70	10-20	0-10	0-10	0-10	0-10	0
Outwash plain	100	60-70	10-20	0-10	0-10	0-10	10-20	0
Weichsel glaciation	481	10-20	10-20	0-10	40-50	10-20	10-20	0-10
Total #	781	20-30	10-20	0-10	20-30	10-20	10-20	0-10

 # including salt marsh, reclaimed and mixed areas.

investigated profiles. Cambisols occupy 10% to 20% of the area, while Alisols cover less than 10%. Among the sandy soils, Arenosols seem to be a little more common than Podzols. The wetland soils account for about 10% of the investigated profiles, most of these are Gleysols/Fluvisols. The four Leptosols, mentioned earlier, were also found in these areas.

In the country as a whole Podzols and Luvisols are the most common soils. Each accounts for about 25% of the investigated area. Arenosols, Cambisols and Gleysols each cover 10% to 20% of the investigated area, while Alisols, Histosols and Leptosols are rare, making up 5% or less. The well-drained soils cover about 85% of the area, and the wetland soils about 15%.

Some landscapes like salt marsh, littorina, reclaimed marine areas, yoldia and coastal dunes cover relatively small areas and the soil profiles are developed under special soil forming conditions. There is no systematical regional variation in the complex of soil types within these areas and thus there is no need for a subdivision of them. Each can therefore be appointed one set of dominant soil, association and inclusion.

The pedological development within the landforms Weichsel, Saale, outwash plains and inland dunes are more complex and they had to be split up into several different mapping units because other factors like climate, parent material, vegetation history and the Pre-Quaternary substratum play an important role for the soil development (Madsen & Jensen 1992). In the following the location of different soil types developed on well-drained clayey and sandy parent material will be discussed.

Figure 4 shows the dominant soils, and hence the dominant soil forming processes, for well-drained loamy and clayey soils in different parts of the country. Five major regions have been identified. Two major geomorphological features can be recognized on the map; the Main Terminal Moraine and the East Jutland Terminal Moraine. Table 2 shows the percentage share of the different soil types within the various regions.

Region 1 (Cambisol>Luvisol) includes the southwestern part of Zealand and the northern part of Lolland. The parent material in this region is mainly loamy calcareous till. The dominant soil forming processes are weathering and structure formation. The soils are classified as Cambisols. Clay illuviation leading to the formation of Luvisols was only apparent in one-quarter of the profiles. Acid soils with clay illuviation are very rare in this part of the region.

Region 2 (Luvisol>>Cambisol) covers almost the entire remaining area east of the East Jutland Terminal Moraine. In this region, about 80% of the soil profiles are Luvisols. These are neutral or slighly acid soils with clay illuviation.

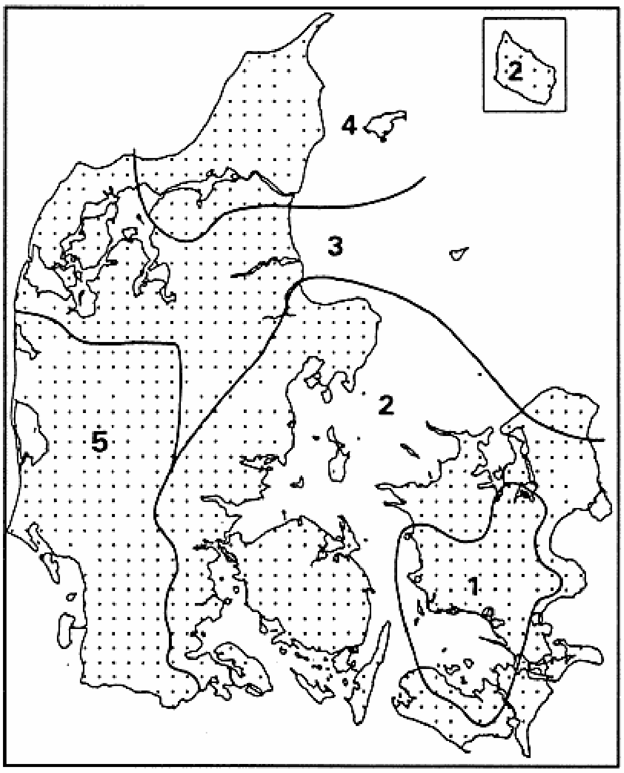

Figure 4: Denmark - Soil regions based on soils on loamy or clayey parent materials.
1: Cambisol > Luvisol; Alisol absent 2: Luvisol >> Cambisol; Alisol nearly absent 3: Luvisol > Alisol = Cambisol 4: Alisol >> Luvisol = Cambisol 5: Alisol = Cambisol > Luvisol. Ratio: >> higher than 3, > 1.5 to 3, = less than 1.5.
For detailed definition of the major group, see Table 2.

Only about 20% of the soils are Cambisols, and Alisols are rare.

Region 3 (Luvisol>Alisol=Cambisol) has a ratio of soils with and without clay illuviation similar to that found in Region 2, but acid soils with clay illuviation, Alisols, are more common, making up about one-quarter of the soils investigated. Luvisols are still dominant, covering more than half of the area.

Region 4 (Alisol>>Luvisol=Cambisol) covers Vendsyssel and the northern part of Himmerland. The area is mainly sandy and only few soil profiles have developed on loamy or clayey parent material. Among these, Alisols dominate, making up about 3/4 of the profiles. The loamy and clayey soils in the northern part are more acid than in the south, but soils with a loamy and clayey texture are rare in this region.

Region 5 (Alisol=Cambisol>Luvisol) includes most of

Table 2: The regional variation in the pedological development of loamy and clayey non-wetland soils. AL,PD: Alisol and Podzoluvisol. LV : Luvisol and Phaeozems with clay illuviation. CM: Cambisol, Phaeozem without clay illuviation and Leptosol.

	Percentage share		
Region	*AL, PD*	*LV*	*CM*
1	*0-10*	*20-30*	*70-80*
2	*0-10*	*80-90*	*10-20*
3	*20-30*	*50-60*	*10-20*
4	*70-80*	*10-20*	*10-20*
5	*30-40*	*20-30*	*40-50*
Total	*10-20*	*60-70*	*20-30*

the loamy and clayey parts of the Saale glacial landscape. There is more or less the same areal extent of Alisols and Cambisols (about 40% each), while Luvisols are nearly absent.

Figure 5 shows Denmark divided into three regions according to the frequency of podzolized sandy soils. Table 3 shows the percentage share of the different soil types within the various regions. Region A, (Podzol>> Arenosol), covers the area west of the Main Terminal Moraine of central Jutland and some parts of central Eastern Jutland. Furthermore, Northeastern Zealand belongs to this soil group. There is a clear dominance of Podzols making up about 90% of the sandy profiles. In Region B, (Podzol>Arenosol), about two-thirds of the sandy soils are Podzols, while in Region C, (Arenosol>> Podzol), the non-podzolized soils dominate, making up more than 80% of the sandy soils. In total, about 60% of the sandy soils are Podzols.

Soil Texture and Slope Class

According to FAO-Unesco (1990) the soils should be divided into one of three texture classes. Based on 36000 soil texture analyses, a texture map showing the 3 classes according to FAO-Unesco (1974) has been elaborated in scale 1:100,000. This map has been used unrevised, because only minor changes have been made in the revised legend of 1990. The major part of the country was texture class 1 but a significant part of the Weichsel glaciation

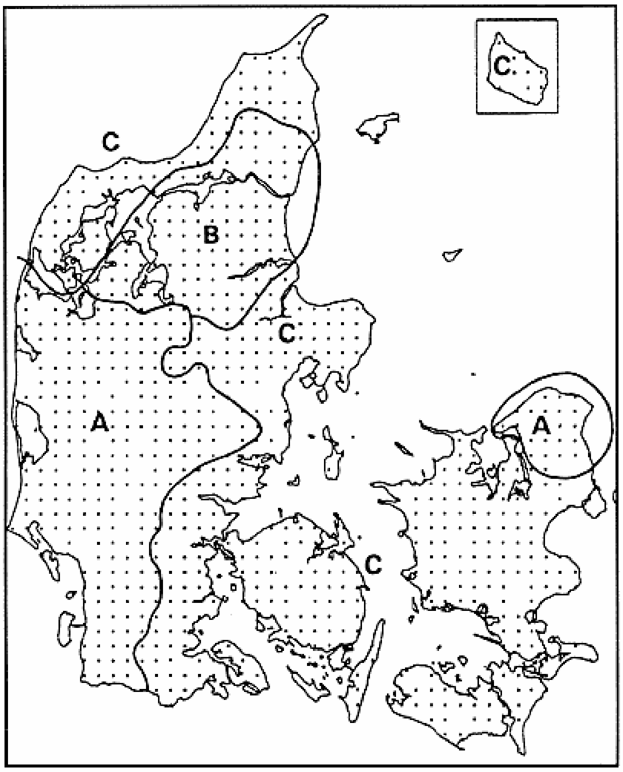

Figure 5: Denmark - Soil regions based on soils on sandy parent material.
A: Podzols >> Arenosols. B: Podzols > Arenosols. C: Arenosols >> Podzols. Ratio: >> higher than 3, > 1.5 to 3, = less than 1.5. For detailed definition of the major groups, see Table 3.

landscape was texture class 2. Only in the salt marsh area were more heavy textures found, and some minor areas are classified as texture class 3. The texture map has been combined with the pedological map when constructing the mapping units.

As previous mentioned the Danish landscape is generally flat or slightly undulating. Only about 1% of the country has slopes with gradients exceeding 12°. Thus the country as a whole is classified as slope class a. Thus, there is no indication of slope classes in Table 4 "The definition of the 17 different mapping units on the revised FAO-soil map of Denmark".

Table 3: The regional variation in the podzolization of sandy non-wetland soils. PZ: Podzol. AR: Arenosol.

	Percentage share	
Region	***PZ***	***AR***
A	*80-90*	*10-20*
B	*60-70*	*30-40*
C	*10-20*	*80-90*
Total	*55-65*	*45-55*

The Soil Map

By combining the different computerized maps and the above-mentioned statements about the pedological development of the Danish soils and the regional soil variation, it is possible to define the following 17 different mapping units in table 4 and to elaborate a revised FAO-Unesco soil map for Denmark, Figure 6.

Mapping unit 1 is the peatland from Figure 2. Mapping unit 2 and 3 are the salt marsh, and mapping unit 4 covers the younger marine forelands (Littorina) and reclaimed marine areas on Figure 1. Mapping units 5 to 11 are the relatively well-drained clayey mapping units in the Weichsel glaciation landscape and Rødding Bakkeø in the Saale glaciation landscape, while mapping unit 12 is the same but in remaining part of the Saale glaciation landscape. Mapping units 13 to 15 are the sandy well-drained soils. Mapping unit 13 is mainly situated on the outwash plains west of the terminal moraine, mapping unit 14 covers part of Northern Jutland, while mapping unit 15 is mainly located on the islands. Mapping unit 16 is coastal dunes and mapping unit 17 is the yoldia plateau in the north.

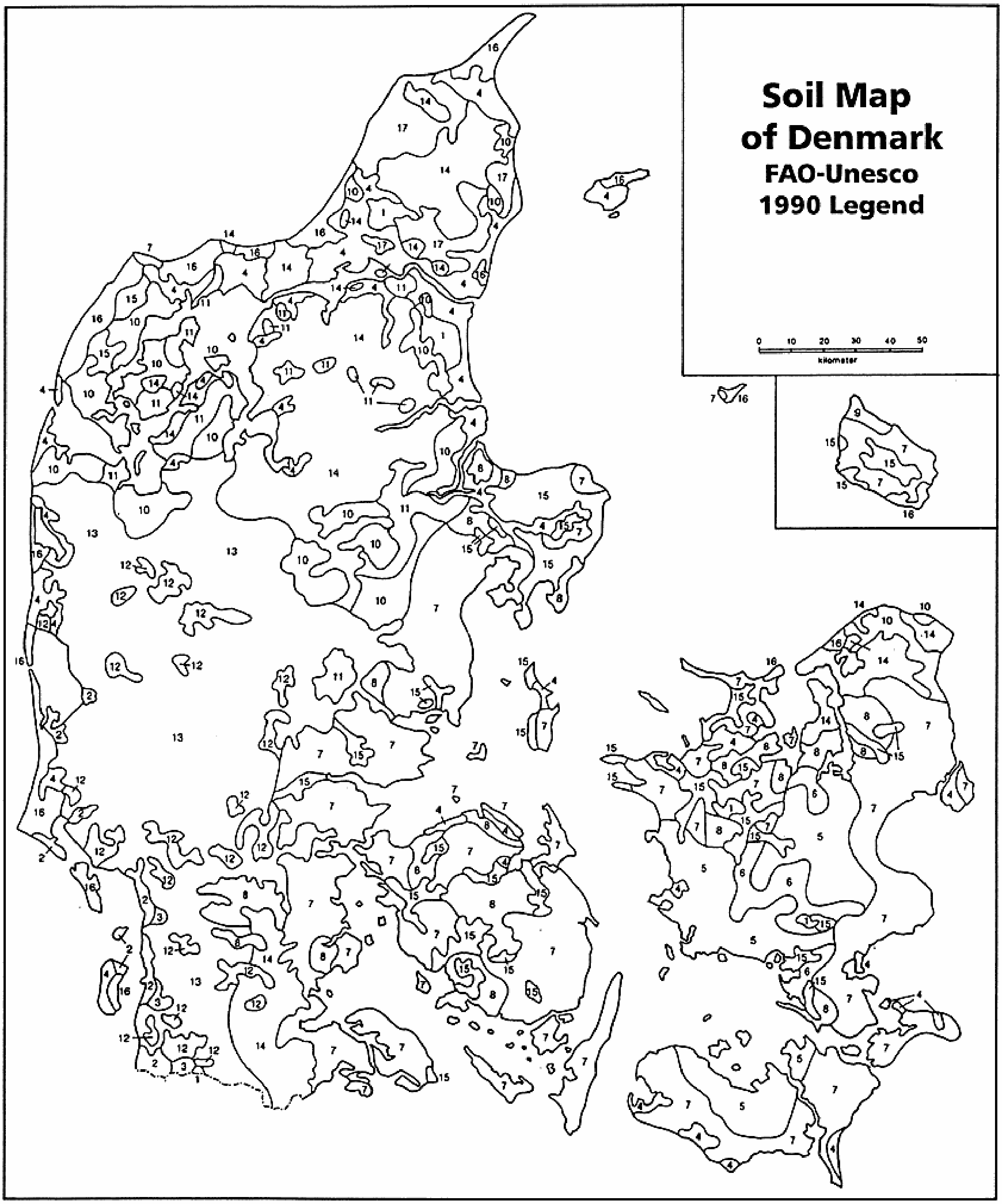

Figure 6: Soil map of Denmark according to FAO-Unesco 1990. Definition of the mapping units, see Table 4.

Table 4: *Definition of the 17 soil mapping units building up the FAO-soil map of Denmark based on FAO-Unesco (1990).*

1: HSf (70%); HSt (20%); HSs (10%)
2: FLe-2 (70%); FLt-2 (30%)
3: FLt-3 (70%); FLe-3 (30%)
4: GLe-1 (40%); GLm-1 (20%); GLd-1 (20%); GLt-1 (10%); ARa-1 (10%)
5: CMe-2 (40%); CMg-2 (20%);; LVg-2 (10%); LVh-2 (10%); CMk-2 (10%); ARb-1 (5%); GLm-2 (5%)
6: CMe-1 (60%); Lo-1 (10%);; Lg-1 (10%); CMg-1 (10%); ARb-1 (5%); GLm-1 (5%)
7: LVh-2 (50%); LVg-2 (25%); CMe-2 (10%); CMg-2 (5%); ARb-1 (5%); GLm-2 (5%)
8: LVh-1 (60%); LVg-1 (15%); CMe-1 (15%); ARb-1 (5%); GLm-1 (5%)
9: LVh-2 (50%); LVg-2 (15%); LPq-1 (10%); LPd-1 (10%); ARb-1 (5%); GLd-2 (5%); CMd-2 (5%)
10: LVg-2 (25%); LVh-2 (20%); ALh-2 (15%); PDd-2 (15%); CMe-2 (10%); GLd-2 (10%); PZh-1 (5%)
11: LVh-1 (25%); LVg-1 (20%); ALh-1 (15%); PDd-1 (15%); CMe-1 (10%); GLd-1 (5%); ARb-1 (5%); PZh-1 (5%)
12: ALh-1 (25%); PDd-1 (25%); CMd-1 (20%); CMg-1 (10%); GLd-1 (10%); PZh-1 (10%)
13: PZh-1 (75%); PZg-1 (10%); ARb-1 (10%); HSs (5%)
14: PZh-1 (50%); ARb-1 (25%); PZg-1 (10%); ARg-1 (5%); GLd-1 (5%); HSs (5%)
15: ARb-1 (80%); PZh-1 (15%); GLe-1 (5%)
16: ARa-1 (90%); ARg (10%)
17: ARb-1 (50%); PZh-1 (15%); GLd-1 (15%); CMd-1 (10%); PDd-1 (5%); HSs (5%)

References

Aslyng H.C. (1978): Miljø og jordbrug. DSR, København.

Breuning-Madsen H. & R.J.A. Jones (1995): Soil Profile Analytical Database for the European Union. Danish Journal of Geography 95: 49-58.

Commission of the European Communities (1985): Soil map of the European Communities, 1:1000000. Office for official publications of the European Communities, Luxembourg.

FAO (1977): Guidelines for Soil Profile Descrip. FAO, Rome.

FAO-Unesco (1974): Soil Map of the World, Legend. FAO, Rome.

FAO-Unesco (1990): Soil Map of the World, Revised legend. FAO Rome.

ISSS, ISRIC & FAO (1994): World Reference base for world resources, draft. Wageningen & Rome.

Jensen C., Stougaard B. & Østergård H.C. (1989): Simulation of Nitrogen Dynamics in Farmland Areas of Denmark 1989-93. Soil Use and Management 10: 111-118.

Madsen H. Breuning & Jensen N.H. (1985): The Establishment of Pedological Soil Databases in Denmark. Geografisk Tidsskrift 85: 1-8.

Madsen H. Breuning & N.H. Jensen (1992): Pedological Regional Variations in Well-drained Soils, Denmark. Geografisk Tidsskrift 92: 61-69.

Madsen H. Breuning & N.H. Jensen (1995): The elaboration of a revised EU soil map of Denmark: 221-234. In: D. King, R.J.A. Jones & A.J. Thomasson (eds.): European Land Information Systems for Agro-Environmental Monitoring. Joint Research Centre, European Commission, EUR 16232 EN.

Madsen H. Breuning, N.H. Jensen, B.H. Jakobsen & S.W. Platou (1985): A Method for identification and mapping potentially acid sulfate soils in Jutland, Denmark. Catena 12: 363-371.

Madsen H. Breuning, A.H. Nørr & K.Aa Holst (1992): The Danish Soil Classification. Atlas of Denmark I,3. Reitzel, Copenhagen.

Mathiesen F.D. (1980): Soil classification in Denmark. Its result and applicability. EEC-seminar on Land Resource Evaluation, Wexford, Ireland 1978.

Østergård H.S. (1990): Kvadratnet for nitratundersøgelser i Danmark 1986-1989. Landbrugets Rådgivningscenter, Landskontoret for Planteavl, Skejby, Århus.

Table 4: *Definition of the 17 soil mapping units building up the FAO-soil map of Denmark based on FAO-Unesco (1990).*

1: HSf (70%); HSt (20%); HSs (10%)
2: FLe-2 (70%); FLt-2 (30%)
3: FLt-3 (70%); FLe-3 (30%)
4: GLe-1 (40%); GLm-1 (20%); GLd-1 (20%); GLt-1 (10%); ARa-1 (10%)
5: CMe-2 (40%); CMg-2 (20%);; LVg-2 (10%); LVh-2 (10%); CMk-2 (10%); ARb-1 (5%); GLm-2 (5%)
6: CMe-1 (60%); Lo-1 (10%);; Lg-1 (10%); CMg-1 (10%); ARb-1 (5%); GLm-1 (5%)
7: LVh-2 (50%); LVg-2 (25%); CMe-2 (10%); CMg-2 (5%); ARb-1 (5%); GLm-2 (5%)
8: LVh-1 (60%); LVg-1 (15%); CMe-1 (15%); ARb-1 (5%); GLm-1 (5%)
9: LVh-2 (50%); LVg-2 (15%); LPq-1 (10%); LPd-1 (10%); ARb-1 (5%); GLd-2 (5%); CMd-2 (5%)
10: LVg-2 (25%); LVh-2 (20%); ALh-2 (15%); PDd-2 (15%); CMe-2 (10%); GLd-2 (10%); PZh-1 (5%)
11: LVh-1 (25%); LVg-1 (20%); ALh-1 (15%); PDd-1 (15%); CMe-1 (10%); GLd-1 (5%); ARb-1 (5%); PZh-1 (5%)
12: ALh-1 (25%); PDd-1 (25%); CMd-1 (20%); CMg-1 (10%); GLd-1 (10%); PZh-1 (10%)
13: PZh-1 (75%); PZg-1 (10%); ARb-1 (10%); HSs (5%)
14: PZh-1 (50%); ARb-1 (25%); PZg-1 (10%); ARg-1 (5%); GLd-1 (5%); HSs (5%)
15: ARb-1 (80%); PZh-1 (15%); GLe-1 (5%)
16: ARa-1 (90%); ARg (10%)
17: ARb-1 (50%); PZh-1 (15%); GLd-1 (15%); CMd-1 (10%); PDd-1 (5%); HSs (5%)

References

Aslyng H.C. (1978): Miljø og jordbrug. DSR, København.

Breuning-Madsen H. & R.J.A. Jones (1995): Soil Profile Analytical Database for the European Union. Danish Journal of Geography 95: 49-58.

Commission of the European Communities (1985): Soil map of the European Communities, 1:1000000. Office for official publications of the European Communities, Luxembourg.

FAO (1977): Guidelines for Soil Profile Descrip. FAO, Rome.

FAO-Unesco (1974): Soil Map of the World, Legend. FAO, Rome.

FAO-Unesco (1990): Soil Map of the World, Revised legend. FAO Rome.

ISSS, ISRIC & FAO (1994): World Reference base for world resources, draft. Wageningen & Rome.

Jensen C., Stougaard B. & Østergård H.C. (1989): Simulation of Nitrogen Dynamics in Farmland Areas of Denmark 1989-93. Soil Use and Management 10: 111-118.

Madsen H. Breuning & Jensen N.H. (1985): The Establishment of Pedological Soil Databases in Denmark. Geografisk Tidsskrift 85: 1-8.

Madsen H. Breuning & N.H. Jensen (1992): Pedological Regional Variations in Well-drained Soils, Denmark. Geografisk Tidsskrift 92: 61-69.

Madsen H. Breuning & N.H. Jensen (1995): The elaboration of a revised EU soil map of Denmark: 221-234. In: D. King, R.J.A. Jones & A.J. Thomasson (eds.): European Land Information Systems for Agro-Environmental Monitoring. Joint Research Centre, European Commission, EUR 16232 EN.

Madsen H. Breuning, N.H. Jensen, B.H. Jakobsen & S.W. Platou (1985): A Method for identification and mapping potentially acid sulfate soils in Jutland, Denmark. Catena 12: 363-371.

Madsen H. Breuning, A.H. Nørr & K.Aa Holst (1992): The Danish Soil Classification. Atlas of Denmark I,3. Reitzel, Copenhagen.

Mathiesen F.D. (1980): Soil classification in Denmark. Its result and applicability. EEC-seminar on Land Resource Evaluation, Wexford, Ireland 1978.

Østergård H.S. (1990): Kvadratnet for nitratundersøgelser i Danmark 1986-1989. Landbrugets Rådgivningscenter, Landskontoret for Planteavl, Skejby, Århus.