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Soil maps of The Netherlands

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ABSTRACT

The Netherlands has a long history of soil research. Over the past 150 years, seven national soil maps have been produced at scales ranging from 1:50,000 to 1:1,000,000. The maps were based on different conceptual models which reflected advances in soil science as well as societal demands. There are four phases in the development of soil mapping in The Netherlands. The first three are: (i) the geological phase (1837–1937), (ii) the physiographic phase (1937–1962) and (iii) the morphometric phase (1962–1995). The earliest soil maps, made in the mid-1800s, were largely based on surface geology. In 1950 the first national soil map was published based on physiographic soil mapping. From the 1960s onwards, mapping followed a pedogenetic–morphometric approach and these maps have been widely used in land use planning, hydrologic studies, re-allotments, and agricultural land evaluations. An increase in environmental awareness with the need to assess environmental impacts and developments in information technology induced the digital soil information phase (1995–present). New technologies have improved the collection, storage, analysis and presentation of soil geographic information. It is concluded that initial soil mapping in The Netherlands had a strong agricultural focus but that the current maps are used in a wide range of applications.

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1. Introduction

The Netherlands has a number of distinct soil geographic regions (Edelman, 1950; Jongmans et al., 2013). About half of the country is below sea level and would be inundated in the absence of dikes, dunes and pumping plants. It is also a wet country and more than 90% of the soils have groundwater within 140 cm of the soil surface during the winter. As a result, most Dutch soils have hydromorphic properties and require artificial drainage when taken in use. There is hardly soil derived from consolidated rock. Non-urban areas are dominant by sandy soils (43%), marine clays (24%), fluvial clays and loams (8%) or organic soils (14%). Soils developed in loess deposits (1.4%) occur mainly in the southern part of the country. This unique trait of soil geographic regions in combination with high population densities has led to characteristic soil research and mapping approaches.

The Netherlands has a long history in soil research. Initially, most of the soil research was focused on improving soil conditions for agriculture and horticulture. There was a great need to improve soil productivity, and to include new insights from chemistry, physics and mechanics into Dutch agriculture. The first publications on the spatial distribution of Dutch soils and their properties are from the beginning of the 19th century (Felix, 1995). Until the 1930s, there was little activity in soil surveying in The Netherlands although much work was done in the Dutch East Indies by E.C.J. Mohr (1873–1970) and there was mapping in reclaimed polders by D.J. Hissink (1874–1956) and A.J. Zuur (Bouma and Hartemink, 2002). Systematic soil mapping became institutionalized in August 1945 with the establishment of the Dutch Soil Survey institute (StiBoKa). StiBoKa produced several national soil maps (Table 1). Large scale soil mapping ended in 1995 when the final sheets of the 1:50,000 soil survey were published. It was felt, as in other countries, that soil survey and mapping were finished in the 1990s. The question of what next steps to be taken was formulated by Bouma (1988) as: "when the mapping is over, then what?" Soil survey institutes merged, closed and were seeking new grounds for existence (Young, 1991). As a result some considered soil surveyors an endangered species (Nachtergaele, 1990) and pedology dead and buried (Basher, 1997). This changed in the 1990s when new technologies were developed to satisfy the increasing demand for soil information. These technologies combining GIS, spatial statistics, existing soil maps and a whole range of covariates were dubbed digital soil mapping (McBratney et al., 2003). As a result, a continued use and production of spatial soil information can be seen in many parts of the world—including The Netherlands.

Here, we review the history of soil mapping in The Netherlands from the mid-19th century to the present. We focus on the rationale behind soil maps and the conceptual models that have been used in the past with respect to soil forming processes, soil survey and soil classification, and synthesized the information in four periods or phases that are linked to international soil mapping developments. The objectives of this paper are to (i) present an inventory of soil

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Table 1
Overview of national soil maps and their use in The Netherlands.

Phase	Year	Map	Number of sheets	Scale	Mapping concept	Use, reference
I	1858–1867	Geological soil map	28	1:200,000	Lithology	Agriculture, education (simplified versions) Staring (1860)
I	1915	Geological soil map	1	1:800,000	Lithology	van Baren (1915)
II	1950	Provisional soil map	1	1:400,000	Physiography	Edelman (1950)
II	1961	NeBo soil map	9	1:200,000	Physiography	Stiboka (1965)
II/III	1966	Generalized soil map	1	1:1,000,000	Physiography/pedogenesis/morphometry	Appendix in De Bakker and Schelling (1966)
III	1964–1995	1:50,000 soil maps	89	1:50,000	Pedogenesis/morphometry	Regional land use planning, land evaluation, selecting sites for mining soil materials, pipeline constructions, informati on on water table depths from the maps 1:50,000 used in manure applications policy
III	1985	Generalized map	4	1:250,000	Pedogenesis/morphometry	Regional planning, national planning
III	1986	Generalized map	1	1:1,000,000	Pedogenesis/morphometry	EU soil map
III/IV	1990–present	Thematic maps, soil property maps	(digital)	Various scales and resolution	Quantitative	Environmental assessments, model inputs (phosphate leaching, nitrate leaching, organic matter)
IV	Present	Digital soil maps	(digital)	Updating of soil geographical data	Quantitative	Update maps in regions with organic soils

Phase I = Geologic phase; II = Physiographic phase; III = Pedogenetic/morphometric phase; IV: Digital information phase.

maps of The Netherlands which in the 19th and 20th century to present, (ii) unravel the mapping concepts from those maps, (iii) discuss how the maps have been used in research and planning and (iv) highlight some challenges for soil survey in the digital soil mapping era. We limit ourselves to The Netherlands sensu strictu and not to the kingdom of The Netherlands which in the 20th century also included several colonies.

2. The geologic phase 1800–1937

In 1822, a first national geological map of The Netherlands was published (d'Omalius d'Halloy, 1823) which had two legend units for the entire country: one for Southern Limburg (Cretaceous), and one for the rest of the country (post-Cretaceous). The need to produce a more detailed map describing the earth conditions in The Netherlands was expressed at a Dutch agricultural congress in 1846 (van der Poel and Wessels, 1953; Veldink, 1970). This congress was organized to address the question why agriculture in The Netherlands lagged behind that of surrounding countries and in comparison to other Dutch industries (Floor, 2012). It was concluded that a thorough overview of agriculture was required, and the need was expressed to create a geological map and a geological description of The Netherlands, including a description of crops that were typical for the various geological conditions.

A committee was formed consisting of six members that were assigned the task of producing the map. The committee member W.C.H. Staring (1808–1877) was familiar with the subject since he had published a 1:800,000 scale geological map in 1844 (Staring, 1844). Due to personal conflicts, the committee broke up and Staring solely published the book *De Bodem van Nederland* in two volumes in 1856 and 1860 (Staring, 1856 en 1860). The maps appeared between 1858 and 1867 and were printed onto 28 different sheets at a scale of 1:200,000. The maps contained 8 soil units. Reprints of the map were made in 1888 and 1889 in which the topography was improved (de Bakker et al., 1981).

The main distinction on Staring's map was between (i) alluvial (Holocene) soils, (ii) diluvial (Pleistocene) soils and (iii) tertiary soils. The distinction between Alluvium and Diluvium was based on biblical perceptions and not uncommon in the mid-19th century (Hartemink, 2009). The concept of Diluvium was introduced in 1815 by the English theologian and geologist W. Buckland (1784–1856). He used the term to distinguish between Alluvium layers, deposited by rivers and wind, and Diluvium layers resulting from a large flood. The younger Alluvium period was the period when all post-flood sediments were deposited. An early user of these terms in the Northern Netherlands was G. Acker Stratingh (1804–1877) who published a first geological soil map of the Dutch province of Groningen in 1837, which legend influenced Staring (Acker Stratingh, 1837; Floor, 2012).

The first volume of Staring's work, on alluvial soils, mainly covered organic soils, marine soils, dunes, river deposits and drift sands. The second volume described soils developed in older deposits such as loess and Pleistocene fluvial deposits. The map contained 60 legend units, mainly distinguished on the basis of (unconsolidated) lithology. Although Staring's map was essentially a geological map, he also considered human activities in the landscape that had produced soils as anthropogenic or plaggen soils (Pape, 1970). Staring's map distinctions within the young Holocene soils yielded him an award at the World Exposition in London in 1862.

At the request of a teacher's society a simplified version of Staring's map was published in 1860 and this map contained 19 legend units (Fig. 1) (Staring, 1860). Another simplified version of the geological map was published in 1877 and contained seven legend units (Felix, 1995). It was used in education on basic schools for over a century. Colors used for sand (yellow), clay (blue), brook sediments (green) and peat (purple) have been used for legends of all Dutch soil maps ever since.

Although the maps appeared to be not directly useful for agricultural use, Staring believed that "… geological knowledge should precede agronomic knowledge, agronomic knowledge being in essence the practical application of it" Staring (1860). A new version of Staring's map was published in 1915 at a scale of 1:800,000 (van Baren, 1915). The agrogeologist Prof. J. van Baren (1875–1933) published revised versions of Staring's book between 1908 and 1927 (van Baren, 1920–1927). The first revised version was published commemorating the 100th birthday of W.C.H. Staring. van Baren incorporated new insights on processes during the Pleistocene, and the role of glaciers in the transportation and deposition of northern rocks and boulders.

A governmental decision to produce a 1:50,000 scale geological map of The Netherlands was taken in 1918 and these maps were used by a co-worker of van Baren, W.A.J. Oosting (1898–1942), to create a 1:800,000 scale geological map of The Netherlands on the occasion of the International Agricultural Congress in 1937 (Oosting, 1937). The publication of the 1:800,000 scale geological map marks the end of the first geologic phase.

3. The physiographic phase 1937–1962

Prof. J. van Baren was succeeded by C.H. Edelman (1903–1964) in 1933. Edelman intended to make a new soil map of The Netherlands and he was inspired by W.A.J. Oosting whose PhD-thesis combined principles from geology, geomorphology, topography, hydrology and archeology (Oosting, 1936). His principles and focus on agricultural use of soil maps influenced the production of soil maps in the decades to come (de Bakker, 1995; Sonneveld, 2010).

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