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Christian Walter, Jennifer Veenstra, Romain Melot, Yves Coquet

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SURVEY ARTICLE

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Identification of soil-related professional profiles for the future from a survey of European stakeholders

Christian Walter[1] | **Jennifer Veenstra**[2] | **Romain Melot**[3] | **Yves Coquet**[2]

[1]SAS, Institut Agro, INRAE, Rennes, France

[2]ECOSYS, INRAE, AgroParisTech, Palaiseau, France

[3]SADAPT, INRAE, AgroParisTech, Palaiseau, France

Correspondence

Christian Walter, SAS, Institut Agro, INRAE, F-35000 Rennes, France.
Email: christian.walter@agrocampus-ouest.fr

Yves Coquet, ECOSYS, INRAE, AgroParisTech, Palaiseau, France.
Email: yves.coquet@agroparistech.fr

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Abstract

Current and future stakeholders and decision-makers involved in agricultural soil management need to develop soil-related skills to meet the challenges of food security and global change in the coming decades. The aim of this study was to identify professional profiles related to the management, conservation and restoration of agricultural soils on the basis of a European stakeholder survey and to relate these profiles to specific and generic skills. Stakeholders from 24 European countries, selected by the national hubs of the European Joint Programme on agricultural soil management, were invited to propose soil-related professional profiles that they considered important to develop over the next 20 years. They were then asked to identify up to 15 specific or generic skills that they considered necessary for each profile. In total, 299 stakeholders proposed 1–3 professional profiles each, in 20 languages, for a total of 786 profiles ranging from the bachelor to doctoral level. After translation into English and grouping by expertise, 60 profiles were identified and classified as 'traditional', 'specialised' or 'innovative'. Innovative profiles were related to the inclusion of soil in fields that do not currently provide soil-related education (e.g., communication, mediation, economics, law, land-use planning, architecture, data science). Correspondence analysis based on the number of times a skill was considered necessary for a given profile led to the grouping of the 60 initial profiles into 10 clusters of profiles that required similar skills: these 10 clusters of profiles were described, and their necessary skills were identified. The clusters illustrate the need to broaden the scope of soil science and the variety of professions that can address soil-related issues and require knowledge about soils. Ultimately, this list of soil-related professional profiles and their necessary skills could help revise existing higher-education curricula or create new curricula.

KEYWORDS

foresight study, skill requirements, skills, soil education, soil science

1 | INTRODUCTION

In many fields of higher education, structural changes in economic activities and labour markets, as well as responses to environmental challenges, are leading to profound revisions in the content of curricula and associated teaching methods (Chan et al., 2017). The competency-based education approach was developed to identify the knowledge, skills, abilities and qualities that students need to acquire during their education to meet professional requirements and take on future challenges (OECD, 2016; Robinson et al., 2007).

The present study addressed higher education related to the knowledge and sustainable management of agricultural soils, which are increasingly recognised as a key resource for many issues, including food security, environmental protection and climate-change mitigation (European Parliament, 2021; FAO, 2015). The need to develop both specific and general soil literacy at multiple levels has been recognised, for example in the European Commission's recent Communication on Soil Strategy: 'Soil literacy combines broad awareness with specialised understanding across a range of disciplines through communication and education activities that bring soil closer to people's lives. To achieve this, all stakeholders must have access to both general soil education and targeted training for specific needs' (European Commission, 2021).

Despite this recognition of the importance of soils, the position of soil-related education seems to have decreased in recent decades. Baveye et al. (2006) noted that the number of students enrolled in soil-science courses had decreased by 40% since the early 1990s, which they attributed to the fact that existing curricula did not sufficiently consider emerging professional needs and students' aspirations. Subsequent surveys in several countries have confirmed this decrease in the number of students and ultimately in the number of soil-science courses (Diochon et al., 2017; Havlin et al., 2010). A recent European-wide survey of existing soil-science courses (Villa Solis et al., 2021) showed that while many higher-education institutions provide courses in soil science, only a few provide full degrees in soil science at the bachelor, master or doctoral levels.

Recognition of the importance of soils for addressing future challenges, but also of the relative weaknesses of existing curricula, has led to reflections about the need to revise soil-science education. Ideas about how to do so have been proposed (Brevik, Hannam, et al., 2022; Brevik, Krzic, et al., 2022; Diochon et al., 2017; Masse et al., 2019), but what has been lacking is a survey of decision-makers and current soil-related professionals on the skills, knowledge and professions that will be needed to manage agricultural soils in the coming decades. Such a survey appeared to be necessary to design curricula adapted to the future needs of the labour market in soil science, with professionals able to address the multiple dimensions of sustainable soil management.

Highlights

- 299 stakeholders from 24 European countries proposed bachelor to doctoral soil-related profiles.
- 60 profiles were identified and classified as traditional, specialised or innovative.
- 10 clusters of profiles with similar skill requirements were identified.
- These clusters could help develop new curricula.

As part of the Horizon 2020 European Joint Programme on agricultural soil management (EJP Soil), Veenstra et al. (2024) surveyed 669 stakeholders in 24 European countries to identify the soil-related skills they felt would be most useful to develop over the next 20 years. Their results highlight the importance of having basic scientific knowledge of soils and their functioning, especially soil biological and ecological functioning, but also of being able to implement agronomic drivers to manage and protect soils.

The aim of the present study was to identify professional profiles associated with the management, conservation and restoration of agricultural soils on the basis of a European survey of stakeholders, and to relate these profiles to specific and general skills. This article builds on the article of Veenstra et al. (2024) but differs in that it does not focus on individual skills, focusing instead on identifying groups of skills that appear to be important for the professional profiles proposed by stakeholders.

2 | MATERIALS AND METHODS

2.1 | Survey design and management

A foresight study of soil-science professional requirements was conducted using an online survey addressed to a closed panel of stakeholders (Veenstra et al., 2024). Stakeholders were recruited based on existing stakeholder panels established by the national hubs of the EJP Soil Programme which gathered together 26 partners from 24 European countries (ejpsoil.eu). However, efforts were made to balance participation among countries and stakeholder socio-professional categories.

To this end, we set a target for the number of respondents per country proportional to its number of territorial units, according to level 2 of the European Union (EU) *Nomenclature of Territorial Units for Statistics* (NUTS 2) (https://ec.europa.eu/eurostat/web/nuts/principles-and-characteristics). Furthermore, to attempt to ensure the representation of smaller countries, at least 18 invitations were sent per country (Veenstra et al., 2023). Subsequently, additional stakeholders were contacted directly by the research team or through the national hubs. Stakeholders were recruited who belonged to one of the following six socio-professional categories:

- farmers, advisers and farmer-organisation representatives (practitioners)
- national administrations
- local and regional public administrations
- the scientific community and educational institutions
- civil society and the general public, including NGOs
- industry and agri-business

The survey was hosted on the online platform LimeSurvey™, through which stakeholders were sent personal e-mail invitations to participate. To address stakeholders in their own language, the survey was translated into national languages under the supervision of the national hubs. Stakeholders could also choose the survey's display language, and the original English version was visible under each question. Respondents were asked to reply in their own language. Responses were anonymous, although participation was tracked using unique token codes. Additionally, reminders to complete the survey were sent to the stakeholders who had not declined but had not yet submitted their responses.

2.2 | The questionnaire about professional profiles and their necessary skills

In addition to general questions about the respondent, the questionnaire (Table S1) contained four parts: (1) open-ended proposal of 3–10 soil-science skills that the respondent thought would be important in the future (ca. 20 years from now) to manage agricultural soils sustainably; (2) scoring from 1 (useless) to 8 (essential) of 66 skills proposed by the questionnaire; (3) selection of the three most important skills among those considered essential and (4) proposal by the respondent of 1–3 professional profiles, as well as the level of education and up to 15 soil-related skills (from those scored at least five [important] necessary for each profile). Part 4 of the questionnaire served as the basis of the present study. See Veenstra et al. (2024) for more information about the questionnaire.

2.3 | Data analysis

Data were analysed by compiling a list of professional profiles from the proposals and then associating each profile with the proposed necessary skills. The list of profiles was compiled in three steps:

1. translating the proposals into English with the help of automatic translation software (DeepL™)
2. classifying the profiles qualitatively into three classes of originality: 'traditional' (e.g., agronomist), 'specialised' (e.g., soil microbiologist) or 'innovative' (e.g., architect), the last of which corresponded to professions that have not considered soil explicitly to date (e.g., architect), or when there was no soil-related education in this field
3. grouping proposals by expertise into professional profiles depending on the level of education required.

The profiles were classified and grouped by a single person (the first author of this article) and then discussed by the research team. Relations between the profiles and their necessary skills were analysed through correspondence analysis (CA) (Benzecri, 1992; Husson et al., 2017) of a contingency table (with profiles in rows and skills selected at least once in columns) using the *FactoMineR* package version 2.4 (Lê et al., 2008) of R software (R Core Team, 2023). CA is a geometric approach that helps identify underlying structures and investigate relations between categorical variables in a low-dimensional space. CA built a point cloud of the profiles and skills and then broke down the cloud's total inertia into a sequence of axes of decreasing importance. After analysing the CA's principal dimensions, hierarchical clustering on principal components (HCPC) (using the *HCPC* function based on the Manhattan distance in *FactomineR*) was applied to the first five dimensions to create clusters of profiles that required similar sets of skills. Cluster dendrograms of the profiles were constructed, each cluster was described by its most frequently proposed profile(s), and skills required by each cluster were identified using a chi-square test (*catdes* function in *FactomineR*).

3 | RESULTS

3.1 | Participation and response rate

The response rate to the survey was 45%, and 669 questionnaires were retained for use. Respondents came from 24 countries, ranging from 7 from Slovenia to 95 from France. Despite efforts to balance participation by the number of NUTS 2 regions, some countries were over-represented due to high response rates (i.e., Norway, Austria, Spain and Estonia), whereas others were under-represented (especially Germany, Hungary and Slovenia).

Regarding stakeholders' degree of knowledge about soils, their responses were 31% ‘expert’, 36% ‘advanced’, 31% ‘basic’ and 2% ‘none’. In total, 84% ($n = 561$) of the stakeholders had professions directly related to soils, mainly in the fields of agriculture and farmland management (86%), the environment (64%) and water management (28%), with only a few in urban planning (15.5%). Other professions related to soils (8%) lay in the fields of forestry, teaching, research, climate or soil mapping. Conversely, 13% of the stakeholders' professions were indirectly related to soils, in the fields of research, agricultural consulting, farming, water management, policy, land-use planning and lobbying, among others.

In total, 299 of the 669 respondents proposed 1–3 professional profiles and associated each with skills taken from among those that they had scored at least 5 in part 2 of the survey: 217, 54 and 28 respondents proposed 3, 2 and 1 profile, respectively. In total, 786 profiles were described in 20 languages, of which 166 were positioned at the bachelor's level or less, 450 at the master or engineering level and 170 at the doctoral level (Figure 1).

3.2 | Professional profiles suggested by the stakeholders

After translation into English and grouping of profiles by expertise, 60 profiles were identified (Table S2) (see Table 1 for the 25 proposed most frequently). The profiles proposed most frequently for all levels of education combined were ‘Researcher’ and ‘Soil (micro)biologist and ecologist’ (Table 1). The most common profile was ‘Farmer’ with a bachelor's degree or less, ‘Agronomist’ with a master's or engineering degree and ‘Researcher’ with a doctoral degree. To become a ‘Researcher’, most stakeholders considered a doctoral degree necessary, while to become a ‘Soil (micro)biologist and ecologist’, either a master's or doctoral degree would be necessary. To become an ‘Adviser’, a master's or bachelor's degree or less would be necessary.

3.3 | Innovative profiles

Only a few stakeholders proposed innovative profiles (2–7 per profile), which represented 67 of the 786 proposals (8%). The 20 most frequently suggested innovative profiles are listed in Table 2. At the bachelor level, they concerned communication and mediation, but also economic consulting and soil remediation. Innovative profiles were most common at the master or engineering level and concerned in particular information technology, data science, modelling, but also urban and land-use planning, architecture, economic consulting, environmental law applied to soils, decision-makers trained in soil-related issues and business managers. At the doctoral level, stakeholders proposed more specialised profiles of modellers, climate-change and carbon-sequestration specialists and policy officers.

3.4 | Skills required for the profiles

Of the 60 profiles identified (Table S2), two contrasting examples were the following:

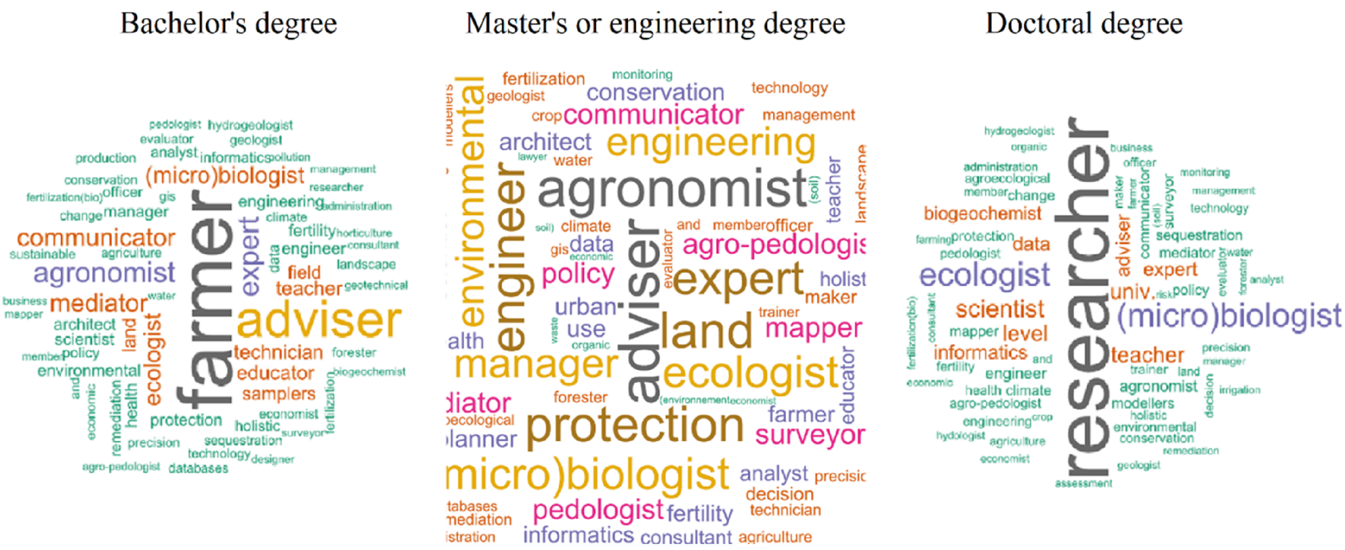

FIGURE 1 Word clouds for the proposed professional profiles translated into English as a function of the level of education (created using the *wordcloud* package of R software for words used at least twice).

TABLE 1 The 25 professional profiles proposed most frequently by the stakeholders, as a function of the proposed level of education.

Professional profile	Bachelor's degree or less	Master's or engineering degree	Doctoral degree	Total
Researcher	1	9	43	53
Soil (micro)biologist and ecologist	8	26	19	53
Adviser	22	25	3	50
Farmer	38	11	1	50
Agronomist	10	33	5	48
Agricultural engineer	3	28	5	36
Environmental protection engineer	4	23	3	30
Soil scientist	4	12	12	28
Communicator and mediator	9	15	4	28
Information technology and data specialist	3	11	8	22
Soil surveyor and mapper	1	15	4	20
Pedologist or agro-pedologist	1	15	3	19
Soil fertility and health specialist	4	11	3	18
Soil biogeochemist	1	10	7	18
Land manager	3	13	0	16
Teacher or educator	6	9	0	15
Holistic soil expert	3	9	2	14
Soil analyst	3	9	1	13
Urban or land-use planner	0	12	0	12
Policy officer	3	7	2	12
CC and C sequestration specialist	2	6	4	12
Business manager or consultant	1	9	1	11
Soil-remediation expert	3	6	1	10
University-level teacher and researcher	0	0	10	10
Policy and decision-maker	0	8	2	10
Total	133	332	143	608

Abbreviation: CC, climate change.

- The master-level profile 'Agronomist' was proposed 38 times, and 66 skills were required for it; the three mentioned most frequently were *Having scientific knowledge of soil physicochemical functioning* (e.g., *nutrients*) (28 times), *Having scientific knowledge of soil physical functioning* (e.g., *soil water*) (26 times) and *Knowing how to interpret soil analyses* (25 times).
- The profile 'Communicator and mediator' was proposed 28 times, and 66 skills were required for it; the three mentioned most frequently were *Knowing how to discuss soils with farmers* (28 times), *Knowing how to communicate about soils with non-experts* (19 times) and *Knowing how to interact with experts from other fields in projects involving soils* (18 times).

The first five principal dimensions of the CA represented 50% of the total inertia and had the following characteristics:

1. contrasting data skills (e.g., mastering databases, mastering statistics) to agronomic skills (e.g., designing cropping systems, managing crop fertilisation)
2. contrasting soft skills (e.g., summarising information, understanding and negotiating with others) to technical skills (e.g., mapping soils, sampling a soil)
3. contrasting assessment skills (e.g., assessing economic impacts of decisions, managing crop fertilisation) to soil-remediation skills (e.g., cleaning up contaminated soils, unsealing soils)
4. contrasting soil-restoration skills (e.g., designing functional engineered soils) to soil-conservation skills

TABLE 2 The 20 most frequently proposed innovative professional profiles related to soils.

Level of education	No. of times proposed
Bachelor's degree or less	
Communicator and mediator	6
Economic adviser or economist	2
Soil remediation expert	2
Master's or engineering degree	
Computer and data scientist	7
Urban or regional planner	6
Communicator and mediator	5
Landscape architect or architect	5
Policy and decision-maker	5
Business manager or consultant	3
GIS and database specialist	3
Modeller	3
Economic adviser or economist	2
Lawyer (environment and soil)	2
Soil health specialist	2
Doctoral degree	
Information technology and data specialist	5
Modeller	4
Climate-change and carbon-sequestration specialist	3
Communicator and mediator	2
Policy officer	2
Expert in risk assessment	1

Abbreviation: GIS, geographic information system.

(e.g., including soils in biodiversity conservation, ecological functioning)

5. contrasting data skills (e.g., artificial intelligence tools and methods) to field skills (e.g., describing a soil, sampling a soil)

The dendrogram of the HCPC applied to these five dimensions (Figure 2) identified profiles that required similar skills, creating 10 clusters that grouped the 60 profiles into larger sets (Figure 3).

In decreasing order (by the number of proposed profiles in each cluster), the 10 clusters were 'Soil ecologist' (123 proposals), 'Agronomist' (119), 'Manager/teacher' (78), 'Farmer/adviser' (77), 'Researcher' (77), 'Geoscientist/pedologist' (73), 'Environmental protection specialist' (71), 'Communication/mediation expert' (46), 'Information technology/data scientist' (41) and 'Mapping/GIS expert' (27). This ranking showed the importance that stakeholders placed on profiles that focused on soil ecological functioning and agronomy, which are the subjects of the top two profiles, respectively. It also showed that the stakeholders recognised the need for a range of profiles with strong soil-related skills, including teachers, researchers, agricultural advisers, soil scientists and environmental scientists. The farmer profile was also proposed frequently. Although they were proposed less frequently, the clusters 'Communication/mediation expert', 'Mapping/GIS expert' and 'Information technology/data scientist', which grouped innovative profiles, were also proposed for the near future, using communication, information and more technical expertise in data science and geographic information systems to manage soil sustainably.

Finally, the clustering also made it possible to identify the skills that appeared to be most necessary for each cluster, as well as those that appeared less useful. The relations between the clusters and their necessary skills

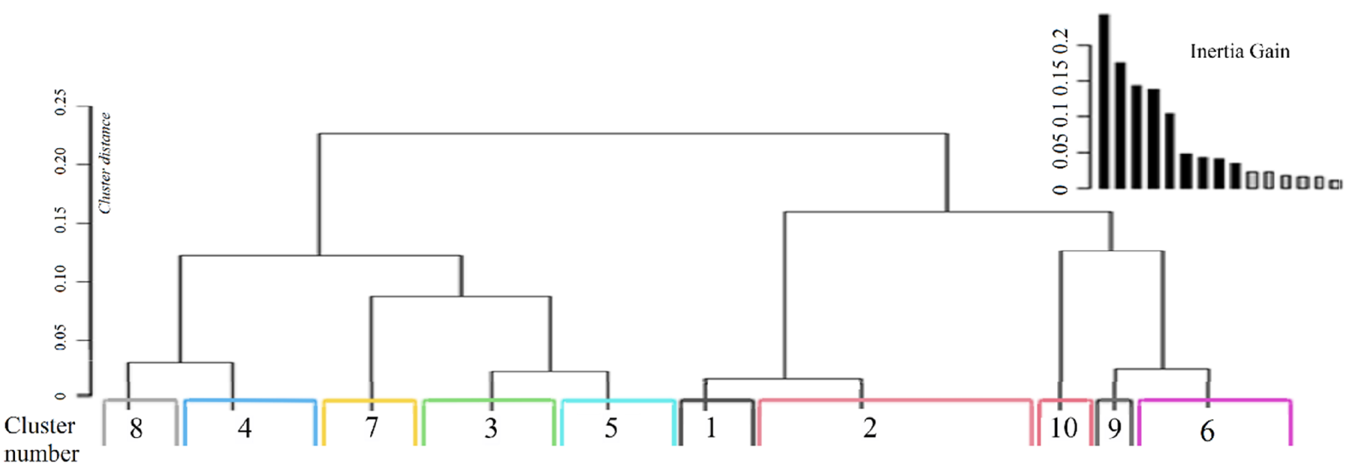

FIGURE 2 Dendrogram of the professional profiles grouped into 10 clusters with similar necessary skills using hierarchical clustering on principal components.

Cluster 1 (*n* = 77) *Farmer/adviser*	
Adviser at BL	22
Farmer	50
Soil pollution specialist	2
Sustainable production expert	3

Cluster 2 (*n* = 110) *Agronomist at ML*	
Adviser at ML	28
Agricultural engineer	33
Agricult. technician	5
Agronomist at BL	15
Agronomist at ML	38
Crop specialist	7
Fertilization specialist	9
Fertilization(bio) specialist	3
Irrigation specialist	2
Organic farming adviser	4
Recycling and waste manager	2
Researcher (applied)	1
Soil conservation expert	9
Soil fertility and health specialist	18

Cluster 3 (*n* = 78) *Manager/teacher*	
Administration member	8
Agroecological adviser and trainer	8
Business manager or consultant	11
Land manager	16
Policy officer	12
Soil protection specialist	8
Teacher or educator	15

Cluster 4 (*n* = 123) *Soil ecologist*	
Climate change and C sequest. specialist	12
Forester	9
Horticulture specialist	2
Soil (micro)biologist and ecologist	53
Soil biogeochemist	18
Holistic soil expert	14
Soil scientist or Pedologist at DL	15

Cluster 5 (*n* = 71) *Environ. Protection specialist*	
Environmental engineer	30
Geotechnical engineer	2
Landscape architect and architect	9
Soil remediation expert	10
Urban or land use planner	12
Water conservation and management expert	8

Cluster 6 (*n* = 73) *Geoscientist/pedologist*	
Geographer	4
Geologist and hydrogeologist	9
Monitoring (soil) specialist	5
Soil and land evaluator	9
Soil designer	2
Soil physicist	5
Soil sampler and field technician at BL	6
Soil scientist/Pedologist at ML	33

Cluster 7 (*n* = 46) *Communicator/consultant*	
Communicator and mediator	28
Econ. advisor or economist	5
Lawyer	2
Policy and decision maker	10
Social scientist Researcher	1

Cluster 8 (*n* = 77) *Researcher*	
Researcher at DL	53
Risk assessment expert	1
Soil analyst	13
University teacher and researcher	10

Cluster 9 (*n* = 27) *Mapping/GIS expert*	
GIS and database specialist	7
Soil surveyor and mapper	20

Cluster 10 (*n* = 41) *Information technology/Data scientist*	
Informatics and data specialist	22
Modeler	9
Precision agriculture or technology expert	10

FIGURE 3 The professional profiles in the 10 clusters defined by hierarchical clustering on principal components based on the necessary skills. Numbers indicate the number of times that stakeholders proposed a given profile, which is summed by cluster. BL, bachelor level; DL, doctoral level; GIS, geographic information system; ML, master level.

were assessed (Figures S1–S4) (see Figure 4 for the contrasting clusters 'Manager/teacher', 'Soil ecologist' and 'Environmental protection specialist').

4 | DISCUSSION

4.1 | Strengths and weaknesses of the survey

By asking stakeholders from several socio-professional categories to project themselves 20 years into the future, this study aimed to identify professional profiles in the near future that will require soil-science skills. The large-scale survey was therefore disseminated to 1500 stakeholders from 6 socio-professional categories pre-identified in the 24 European countries participating in the EJP Soil project. The 45% response rate was higher than those of similar studies (Bampa et al., 2019; Cimpoiasu et al., 2021; Key et al., 2016; Masse et al., 2019) (and thus higher than expected at the start of the survey), perhaps because EJP national hubs pre-recruited stakeholders (Manfreda et al., 2008). A common characteristic of the respondents was a high level

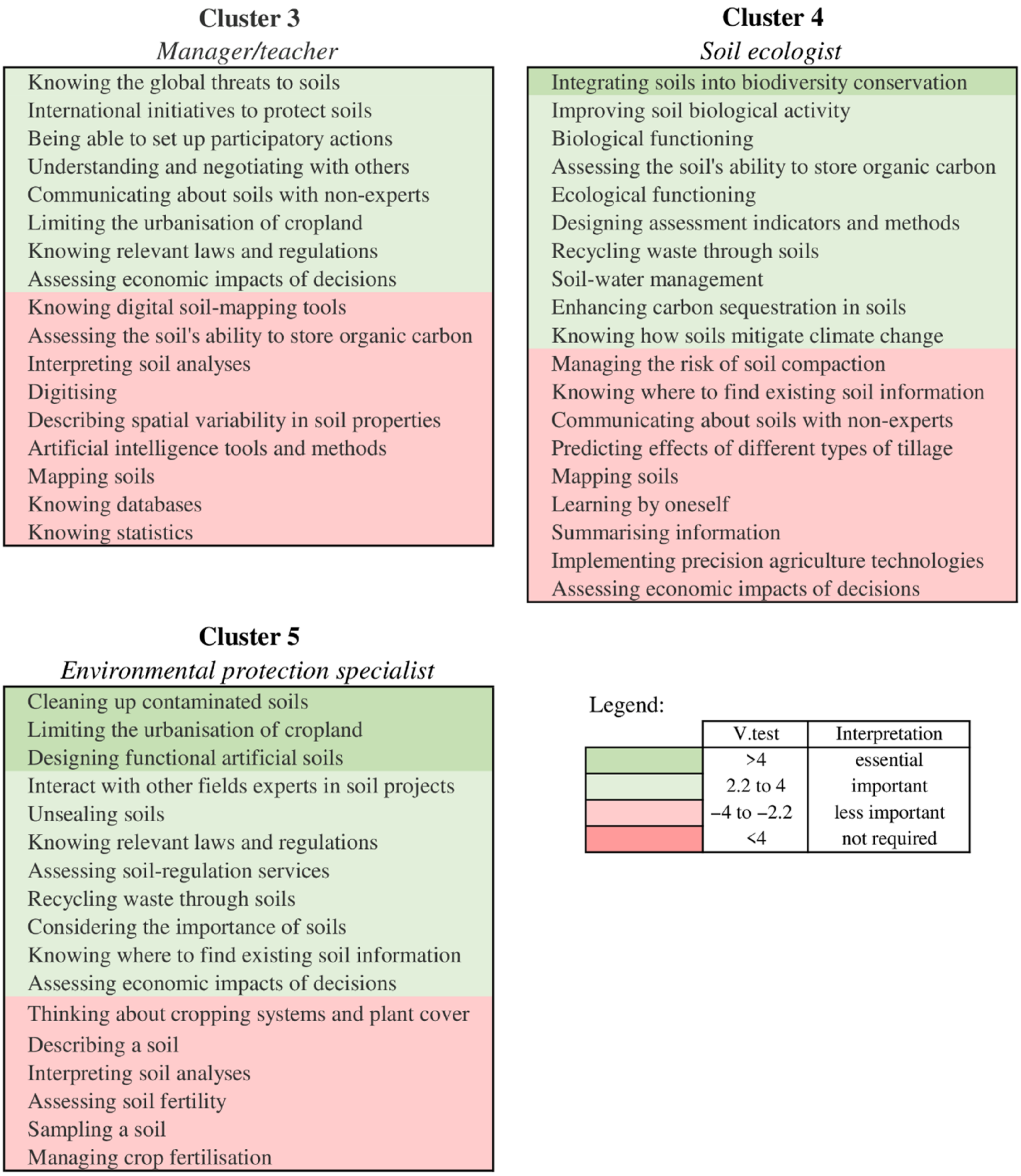

FIGURE 4 Skills significantly more important (in green) or less important (in red) for the clusters of professional profiles of 'Manager/teacher', 'Soil ecologist' and 'Environmental protection specialist' than for the general population of responses.

of education (i.e., 44% with a doctoral degree, 40% with a master's or engineering degree). This over-representation of highly educated stakeholders overall was also true for the farmer category, because the farmers pre-recruited by the national hubs often also served as representatives of farmers' organisations. Most of the respondents (67%) also had expert or advanced knowledge of soils, and the vast majority (84%) were active in soil-related fields. Thus, the survey respondents were decision-makers who were particularly well informed about soil-related issues, but who nevertheless belonged to different socio-professional categories and had different fields of activity, personal experiences and visions. The survey responses thus reflected the opinions of experts who were strongly aware of the importance of soils.

Relatively few respondents (i.e., only 299 of 669) proposed professional profiles and their necessary skills. The length of the survey may have discouraged some from doing so, and this task was also more demanding, as it involved comprehensive and prospective thinking. This suggests that the respondents who proposed profiles were more informed and motivated by soil-related issues than the panel as a whole. Nevertheless, the 786 profiles proposed provide a large and diverse base that has no equivalent in the literature. Indeed, the number of responses and the diversity of the profiles proposed were much higher in this survey than in surveys published in the last two decades on existing soil-related education programmes (Baveye et al., 2006; Diochon et al., 2017; Havlin et al., 2010; Villa Solis et al., 2021) or on learning outcomes (Masse et al., 2019).

4.2 | Profile categories

The vast majority of the profiles proposed most frequently were traditional soil-science profiles that focused on agricultural soil management or environmental protection (e.g., agricultural advisers, agronomists, environmental engineers, agro-pedologists), which shows that professionals in these fields are still greatly needed. Nevertheless, when analysing the scores given to skills in the survey, Veenstra et al. (2024) found that skills related to soil biology and functional ecology were considered particularly important. This was reflected by the proposal of many profiles for (micro)biologists or soil ecologists, mainly at the master or doctoral level. Farmer profiles were also proposed often, especially at the bachelor level or less and master level; thus, most stakeholders consider farmers as key actors in managing and protecting soils, and that improving their ability to manage soils sustainably requires improving their soil literacy.

Although innovative profiles were proposed less frequently, they show the broadening of soil science and the variety of professions that deal with soil-related issues and require soil knowledge. Indeed, soil professionals should respond to the increasing interest that soils have received from many areas, including the general public and policy spheres, as previously recommended (Hartemink & McBratney, 2008). It is a matter of spreading knowledge about soil and its problems to a wider public, which requires specialists in communication and social sciences. However, it is also a matter of generating new knowledge from a variety of experts to give soil a more important place in public policies, economic assessments and land-use planning, which implies training architects, economists or lawyers who can address these issues. Managing the increasing amount of soil data is another challenge, which requires specialists in data science and geographic information systems. Finally, soils not only need protection but often also need to be restored, to meet the European Commission's target of having 75% of soils in EU countries considered 'healthy' despite the pressure of climate change (European Commission, 2021); meeting this target requires training specialists in soil health, climate change and soil carbon sequestration.

4.3 | Profile clusters and their necessary skills

Like the initial 60 profiles, the 10 profile clusters also differed, with (i) traditional profiles such as agronomists, soil scientists, teachers and environmental scientists; (ii) more specialised profiles of soil ecologists and researchers; (iii) specific profiles of farmers and (iv) innovative profiles of experts in communication, information technology and data science. Importantly, the fact that a profile is considered traditional does not mean that the necessary skills have not been revised greatly: for example, agronomists now need to know how to discuss topics with farmers, increase carbon sequestration or improve biological activity in soils, none of which is necessarily covered by current curricula.

Comparing this spectrum of professional profiles needed for the future to existing soil curricula in Europe, as summarised by Villa Solis et al. (2021), the current educational offerings do not cover a wide diversity of professional profiles. Thus, there is a clear need not only to adapt existing programmes, but also to create new courses that certify new profiles. This may involve adding higher-education courses, but also increasing the number of continuing education modules and short courses for professionals whose work is not directly related to soil, but who need to improve their soil-related skills.

4.4 | Potential applications of the survey results

The results of this survey of European stakeholders can be applied at two levels. The first concerns developing a programmatic framework to analyse existing soil-related educational capacity, whether at the local level (e.g., educational centre, university) or a larger level (e.g., region, country, Europe). The 10 clusters of professional profiles identified in this study can be used to analyse what courses already exist and what needs to be developed: (i) Do existing courses cover the range of soil-related professional profiles that seem necessary to develop in the future? (ii) If not, should new courses be created to prepare for these future needs? Depending on the skills required for these missing profiles, should courses be created that focus on soil, or should soil skills be integrated into existing courses in other fields (e.g., law, communication, statistics)? (iii) In addition to higher-education courses, what continuing education programmes should be developed to enable existing professionals to adapt or improve their soil-related skills once they become involved in sustainable agricultural soil management?

The second level concerns revising existing courses or creating new courses. By noting which skills the European stakeholders considered most useful for different professional profiles, teaching teams working on a course can identify the most important skills that they must be able to certify that students have acquired and the skills that can be abandoned. For example, three French agricultural engineering schools analysed and considered the survey results as they developed an engineering specialisation: by targeting three profile clusters identified in the study (i.e., 'Agronomist', 'Soil ecologist', and 'Geoscientist/pedologist'), the teaching team identified 18 key skills that its new competency-based education programme will seek to certify. In general, making the raw and processed data from the survey results available on the EJP dataverse will facilitate detailed analysis of the skills associated with the profiles.

5 | CONCLUSION

The aim of this study was not to transfer these profiles directly into curricula, but to provide educational teams with stakeholders' visions of the professional needs likely to emerge in the next 20 years. It is up to these teams to analyse their needs in detail, depending on their educational context and environment, to decide which profiles they are able to address and to certify that the students have acquired the relevant skills.

The traditional or specialised profiles identified in this study can obviously be addressed by the higher-education institutions that already provide degrees in soil science, revising them by including the new skills that are considered necessary. Developing curricula for the innovative profiles is more difficult, as doing so would require introducing soil-related issues into fields in which they barely exist at present, few teachers are available to teach them and likely few students are aware of or motivated by them. For the future of sustainable soil management, public policies and authorities should make a special effort to encourage initiatives for cross-disciplinary curricula to emerge.

AUTHOR CONTRIBUTIONS

Christian Walter: Conceptualization; data curation; formal analysis; writing – original draft; writing – review and editing; methodology; visualization; software; supervision; resources. **Jennifer Veenstra:** Conceptualization; methodology; data curation; formal analysis; writing – review and editing. **Romain Melot:** Conceptualization; methodology; writing – review and editing; data curation; formal analysis; investigation; funding acquisition; supervision. **Yves Coquet:** Conceptualization; methodology; writing – review and editing; project administration; data curation; funding acquisition; supervision; resources.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could influence the work reported in this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Recherche Data Gouv, dataverse EJP SOIL at https://doi.org/10.57745/ISUOCW.

ORCID

Christian Walter https://orcid.org/0000-0002-4395-4942
Jennifer Veenstra https://orcid.org/0000-0002-4207-1646
Romain Melot https://orcid.org/0000-0002-7889-2833
Yves Coquet https://orcid.org/0000-0001-6458-5763

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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