A ccording to the records of the International Union of Soil Sciences, there are over 50,000 members of national soil science societies across the globe. Some of them are research scientists; others are practical scientists working as consultants, teachers, or managers of institutes or tracts of land. Only a portion of them work in soil science and actively publish. Currently, over 16,000 journal publications appear annually with soil in the title, keyword, or abstract (Thomson ISI data). If we assume an average of 3 authors per paper, then there are potentially 48,000 authors. If we estimate that 25% of them are non-soil scientists and of the remaining authors each publishes on average three papers per year (Minasny et al. 2007), then there are about 12,000 soil scientists that actively publish. The real figure is probably lower. Despite a reduced number of scientists since the mid-1970s (when the number was highest), the number of publications keeps increasing with about 500 per year.

Is a scientist’s publication record an overriding factor that reflects productivity, influence, and contribution, or is there more to it?

Publications have always been used to evaluate the impact of an individual scientist. Those that wrote books and articles in journals and newspapers were generally considered influential and leaders in their field. Students or junior scientists did not publishing (or were not supposed to publish) until the 1960s, after which publishing became emancipated and the number of publications grew exponentially (Hartemink 2001). One question is whether the increased number of publications can be used to evaluate the development and performance of soil science—is soil science advancing faster with the increased number of publications? That is hard to answer and perhaps therefore rarely asked. More frequently the question is asked whether publications can be used to evaluate an individual scientist. Is a scientist’s publication record an overriding factor that reflects productivity, influence, and contribution, or is there more to it? This paper discusses some guidelines how to evaluate soil scientists.

PAPERS

A simple and much used way to evaluate a person’s productivity has been to count the number of papers in peer-reviewed and international journals. Some journals were obviously valued more than others (e.g., Nature versus the Netherlands Journal of Agricultural Science), but that was not necessarily considered in the evaluation. All that counted was that the paper was published in an “international and peer-reviewed journal.” In the 1950s, the annual impact factor of a journal was introduced (Garfield 1955), which is the ratio between citations and recent citable items published in a particular journal. The impact factor of a journal is calculated by dividing the number of current-year citations to the source items published in that journal during the previous two years. For example, the 2006 impact factor of Geoderma is calculated as follows: The number of citations in 2006 to articles published in 2005 was 284, and the number of citations in 2006 to articles published in 2004 was 368, so the total number of citations was 652. The number of articles published in 2005 and 2004 was 163 and 144, respectively, so the total number of articles published was 307. The impact factor is the total number of citations in 2006 to articles published in 2005 and 2004 divided by total number of articles published in 2005 and 2004: 652 ÷ 307 = 2.124. This method has not changed since the 1960s and is commonly used as a proxy for the influence or impact of a scientific journal.

Since the journal impact factors were first published, a semi-quantitative evaluation was possible whereby the publications of an individual author were multiplied with the impact factor of a journal, and then summed up. Clearly, the impact factor of a journal provides no information on the article of the individual scientist. It only says something about the overall impact of the journal, with the underlying assumption that high-impact journals are harder to get published in and are thus better. Another problem is that the impact factor has a considerable interannual fluctuation, although the fluctuation decreases with the age of the journal—that is, older journals fluctuate less (Hartemink 1999). The fluctuation largely influences the evaluation of soil scientists if it were the sole criterion for evaluation.

In recent years, the h index has been used and it has quickly been applied to soil science (Minasny et al. 2007). Hirsch (2005) suggested the h index as a measure of scientific “output.” The index reflects both the number of publications and their impact as measured by the number of citations (quantity and quality). It uses more than just the number of publications and journal impact factors; it uses actual citations of the papers of an individual scientist. For the calculation of the individual scientist’s h index, we selected 228 soil scientists from all major subdisciplines. The average relationship between h index and scientific age for soil scientists is h = 0.7 t, where h is the h index and t is the number of years since the first publication. So if your first paper was in 1998, and you have kept publishing since 1998, then your h index should be about 7 in 2008. Since the h index is closely related to the total number of citations, it varies within subdisciplines of soil science; for example, it is smaller in pedology than in soil biology. The relationship h = 0.7 t is also different for other disciplines in which the factor is often much higher than 0.7 (e.g., over 1.0 in physics). The h index doesn’t take into account the role of the authors in a paper in case of multiple-authored papers. For example, someone can have a high number of papers and citations and thus a high
The information on the papers’ factors can be obtained from the Web (Thomson ISI, Scopus, Harzing, Google Scholar). Webometrics are increasingly used, although there has been little evidence that Harzing and Google Scholar are better than more traditional sources such as Thomson ISI (Garfield 2006). Web citations may occur a little earlier, but they are not the same as citations in Thomson ISI databases. There is also no clear link between downloads of an article and the number of citations, although some limited studies indicate that Web citation is a harbinger of future citation (Garfield 2006). In many cases, it seems easier to collect the data than to make unbiased interpretation.

OTHER PERFORMANCE INDICATORS
Different job positions require different types of evaluations. It makes no sense to consider the number of publications for someone who only teaches or to take into account student supervision for someone who only works in a research lab without any students. Yet in some universities and research centers, evaluations are fairly uniform and as a result there may be a mismatch between the evaluation criteria and the person’s activities or job description.

In soil science, papers (p), non-peer reviewed communications (e.g., books, newspaper articles, software development) (n), student supervision (s), teaching (t), administrative duties (a), consultancies and advisory (c), research grants applications (r), and policy impact (pi) are possible indicators against which the performance of a soil scientist can be evaluated:

\[ f(p, n, s, t, a, c, r, pi) \]

There are also other factors such as community outreach, patents, or contributions to radio and television programs. The criteria for each of these factors are to be established and will be different for each position and institute, university, or country. Some will be hard to measure if not impossible to quantify, but some such as the papers factor are straightforward. In many universities, nominal proportions are allocated to research, teaching, and administrative activities (something like 40%–40%–20%), but this says little about how good each of these three activities are being done. For peers, research and publications are obvious important activities, but the university administration may give higher values to consultancies and grant applications. Likewise, journal publications in prestigious journals may be valued much higher than the writing of a reference book or teaching software, whereas the unmeasured impact of such book or software may be higher and longer lasting than the journal article. Also, teaching is often valued much lower than publications or administrative duties that come with a head of department position. Valuing activities in an evaluation is difficult but needed when, for example, there is an application for promotion.

VALUING AND EVALUATING
The value of soil science is hardly measured and hard to measure. Somehow the same applies to the value of an individual soil scientist. Most soil scientists probably have recognized who is influential and valuable for the discipline. This is mostly based on papers and other publications, and these have influenced someone’s thinking, actions, and perhaps career path (i.e., opened the eyes, put on a research track, or inspired in other ways). As useful as such ranking and appreciation of other soil scientists may be, it is largely subjective and of little use to administrators and heads of research schools who wish to see independent, objective, and numerical measures and criteria to evaluate a soil scientist.

It is somewhat unrealistic, if not unfair, to think that excellent 100% scientists also should be excellent communicators, just like is unfair to think that excellent communicators ought to be excellent scientists, although we may strive for both.

The combination of the h index, the total number of publications, and the sum of all citations are factors that reflect a scientist’s publication productivity and impact. With these three criteria, no attention is given to non-peer reviewed journal papers, books, newspaper articles, reports, software development, and contributions to the popular press and Internet. The amount of weight or value of such contributions is hard to measure and largely determined by the job; for example, a 100% research scientist is employed to do 100% research. It is somewhat unrealistic, if not unfair, to think that excellent 100% scientists also should be excellent communicators, just like is unfair to think that excellent communicators ought to be excellent scientists, although we may strive for both.

The biggest resistance toward impact factors, citation analysis, and h indices often comes from colleagues who never or rarely publish. This is sometimes based on lack of knowledge, although there is an argument that these “metrics” don’t or can’t measure quality or scholarship. I have also noticed that administrators and evaluators are well aware and sometimes overfancy basic indicators such as impact factors, citation frequencies, or the h index.

REFERENCES