SOIL, 10, 887–911, 2024
https://doi.org/10.5194/soil-10-887-2024

SOIL Open Access EGU

Trapnell's Upper Valley soils of Zambia: the production of an integrated understanding of geomorphology, pedology, ecology, and land use

Nalumino L. Namwanyi[1], **Maurice J. Hutton**[2], **Ikabongo Mukumbuta**[3], **Lydia M. Chabala**[3], **Clarence Chongo**[1], **Stalin Sichinga**[4], and **R. Murray Lark**[5]

[1]Department of Historical and Archaeological Studies, University of Zambia, Great East Road Campus, Lusaka, Zambia
[2]Department of History, University of Nottingham, University Park Campus, Nottingham, NG7 2RD, UK
[3]Department of Soil Science, University of Zambia, Great East Road Campus, Lusaka, Zambia
[4]Soil Survey Unit, Zambia Agriculture Research Institute, Mt Makulu Central Research Station, Chilanga, Lusaka, Zambia
[5]School of Biosciences, University of Nottingham, Sutton Bonington Campus, Loughborough, LE12 5RD, UK

Correspondence: R. Murray Lark (murray.lark@nottingham.ac.uk)

Received: 1 February 2024 – Discussion started: 12 February 2024
Revised: 20 September 2024 – Accepted: 17 October 2024 – Published: 9 December 2024

Abstract. The Ecological Survey of Northern Rhodesia (now Zambia), undertaken in the 1930s under the leadership of Colin G. Trapnell, was a seminal exercise to relate soil, vegetation, and agricultural practices through intensive field observation. In this article, we examine early activities of the survey in the Upper Valley region around the Kafue Flats and the neighbouring plateau, where Trapnell recognized how geomorphological processes of normal erosion gave rise to distinctive soils with associated vegetation communities and considerable potential for crop production. We consider how Trapnell's approach to fieldwork gave him a particular insight into how soil conditions constrained agriculture in the Zambian environment; the adaptive value of traditional practices; and how these were developed as communities moved and responded to social, economic, and environmental change. We argue that Trapnell's work was innovative and that distinctions must be drawn between his understanding and what has been called the ecological theory of development. Close attention to Trapnell's experience could inform modern efforts to understand indigenous knowledge of African soils and their agricultural potential.

1 Introduction

The pursuit of food security in sub-Saharan Africa requires an understanding of soil resources. Two sources of understanding, superficially rather different, are indigenous or traditional soil knowledge and legacy soil information from surveys undertaken in colonial or early post-colonial periods. In this article, we examine one such legacy survey and the information it provides, including what was recorded about traditional agricultural practices.

The Ecological Survey of Northern Rhodesia (now Zambia), which Colin G. Trapnell led through the 1930s (Trapnell et al., 1947), has been cited by scientists because of its detailed treatment of agricultural practices such as the *chitemene* systems of shifting cultivation (e.g. Mielke and Mielke, 1982) and wetland (dambo) farming (e.g. Wood and Thawe, 2013). Its value as an early "baseline" observation of the vegetation of Zambia has also been recognized (e.g. Lloyd et al., 2008), along with its pioneering observations on the soil variations of the country and region (Webster, 1960). It has also been studied as an example of colonial science (e.g. Tilley, 2011) and used as a resource for studies on agricultural and social change (e.g. Moore and Vaughan, 1994). In the immediate aftermath of the survey, its methodology and findings were applied in locally focused surveys in the country (Allan et al., 1948; Allan, 1949), and it subsequently provided the basis for the Zambian contribution to the Soil Map of Africa (D'Hoore, 1964). The significance and novelty of Trapnell's work, using an ecological model to support inferences about soils and agricultural practices in extensive surveys, has been recognized (e.g. Young, 2017), and the wider significance of an ecological survey as a basis for a certain understanding of colonial development has been explored by Bowman (2011) and Speek (2014). However, Trapnell's work has been treated as something of a curiosity in the history of pedology in tropical Africa, receiving less attention than A Provisional Soil Map of East Africa (Milne, 1936), referred to for brevity in what follows as the East African Soil Map (Milne, 1936). A review of soil surveys in Africa by Dalal-Clayton (1988), while recognizing the pioneering ecological structure of Trapnell's map units, does not attribute any originality to his treatment of soil and land forms.

Our contention is that Trapnell's work is very relevant to questions about the soil and food security in contemporary Africa, and some of the studies cited above demonstrate this. However, we also maintain that the evaluation of such information requires cross-disciplinary collaboration between natural scientists and historians to evaluate the original surveys in their context. The published transcripts of Trapnell's field records (Smith and Trapnell, 2001) are an invaluable source which can be read systematically to examine the practice of the survey, the interactions of the survey team with local communities in Zambia, and the relationship between the survey as practised and colonial policy at the time. However, to date, historians (e.g. Moore and Vaughan, 1994; Tilley, 2011; Hodge, 2007; Speek, 2014; Bowman, 2011) have focused their attention on published outputs of the Ecological Survey (Trapnell and Clothier, 1937; Trapnell, 1943; Trapnell et al., 1947). On examining the citations of Smith and Trapnell (2001) returned from searches on the Web of Science and Google Scholar (16 September 2024), we found that they are used to provide general evidence for past biodiversity of the Kafue Flats (Pawlowicz et al., 2020), to provide biographical information about Trapnell (Speek, 2014; Bowman, 2011), as a source of plant names in one of the languages of Zambia (Fowler, 2002), as base mapping for a study of wetlands in Zambia (Shaw et al., 2022), and as evidence for traditional management practices in the *miombo* woodland of central Africa (Ribeiro et al., 2020). Their potential value for the close study of survey practices remains to be fully realized.

This article offers a reading of Trapnell's traverse notes as the record of the production of integrated knowledge of soils, vegetation, and land use. The team undertaking this reading comprised scientists (Ikabongo Mukumbuta, Lydia M. Chabala, Stalin Sichinga, R. Murray Lark) and historians (Nalumino L. Namwanyi, Maurice J. Hutton, Clarence Chongo). We evaluate Trapnell's work critically, considering how his field methods, in their colonial context, shape his findings, as well as their value and lasting significance. We also examine the distinctive methods of ecological surveys considering soils in their geomorphological setting and the expression of their properties in the vegetation and the new and traditional agricultural practices they supported (or failed to support). The early work in the Upper Valley is particularly instructive for this because the role of geomorphological processes in controlling the spatial pattern of soil variation – and so the capability of the land – was particularly clear. At the same time, economic factors (notably the development of the railway line from Livingstone to Lusaka, which opened up new markets) and the politics of colonialism, with the expropriation of land from African farmers for commercial use by Europeans, were major drivers of rapid change, the sustainability of which was moot.

We undertook a close reading of Trapnell's traverse records from the Upper Valley, as published by Smith and Trapnell (2001) in volume 1 (1932–1934), along with Trapnell's correspondence held in the archive at the Royal Botanic Garden, Kew, London. In addition to these, we examined reports of the Northern Rhodesian Department of Agriculture held in the National Archives of Zambia (NAZ), Ridgeway, Lusaka, concerning the Ecological Survey and its activities. Published materials from the survey and other unpublished syntheses were also examined, including the two Ecological Survey reports by Trapnell and Clothier (1937) and Trapnell (1943) and the final Vegetation–Soil Map. We also examined the proceedings of the 1932 and 1934 meetings of East African soil scientists as context for Trapnell's work and the first published account of his findings and methods (Milne, 1932, 1935).

In Sect. 2 of this paper, we give an overview of geomorphology in Trapnell's account. Section 3 summarizes the colonial perspective on African farming practices and the commissioning of the Ecological Survey. In Sect. 4, we present our account of Trapnell's activities in the Upper Valley based on close reading of the field records and other unpublished reports. Sections 5 and 6 examine the presentation of the Upper Valley environment in, respectively, early syntheses of the Ecological Survey's outputs and its published reports.

2 Overview: geomorphology in Trapnell's classification

Webster (1960), writing on the basis of field experience of the soil surveys in late-colonial Northern Rhodesia in the 1950s, suggests that climatic soil zones did not become a dominant model in Africa because of the widespread influence of geomorphological processes and the age of the land surface on the soil distribution there. He notes that, in the Zambian setting, uplift since the Karroo System deposition, peneplanation and faulting, and the consequent variations in the "age of the land surface or the alterations which have taken place in its relief" (Trapnell and Clothier, 1937, quoted by Webster) are key to understanding soil variation. Webster (1960) notes that these geomorphological influences on soil properties were recognized by Trapnell and Clothier (1937) and cites the use of Plateau and Upper Valley (Trapnell's mapping units) as topographical terms to denote contrasting soil environments. In an overview of the soils of Zambia, Webster (1960) refers to the Upper Valley where normal erosion of the old plateau surface leaves residual or colluvial soil material with a reserve of weatherable minerals, contrasting with the deeply weathered Plateau surface. It is this physical process which underlies the ecological differences on which Trapnell first distinguished the Upper Valley unit from the surrounding Plateau and which also accounts for the fertility of the Upper Valley soils, their importance in traditional agricultural systems, and their significance in relation to agriculture in Zambia when Trapnell was doing his fieldwork.

Trapnell was primarily an ecologist, and his approach was strongly influenced by the vegetation survey completed by Henkel (1931) in what was then Southern Rhodesia. The Upper Valley environment was initially recognized on the basis of its distinctive vegetation (Trapnell and Clothier, 1937), but Trapnell identified the importance of erosional processes from the onset; see Trapnell (1935). Cole (1963) states that Trapnell was "concerned primarily with the coincidence of physiographic types and climate regimes", but this does not bear examination. The first published output from the Ecological Survey (Trapnell and Clothier, 1937) introduces the Upper Valley on the basis of its geomorphological origin and links this explicitly to its ecological and agricultural significance. Further, Trapnell and Clothier (1937) observe that, in a region like the Upper Valley, undergoing normal erosion, soil formation takes place under a climate regime that is very different to that in which the genesis of Plateau soils was initiated.

Little was known about the geomorphology of Zambia at the time of Trapnell's fieldwork. The first synthesis of the geomorphology of Northern Rhodesia was by Dixey (1944). Earlier work focused on the Copperbelt in the northwest of the country. The first edition of Lester King's *South African Scenery* (King, 1942), which gives a synoptic account of the regional landscape, was not published until Trapnell's fieldwork was complete. Topographic mapping outside areas of particular economic importance, mainly the Copperbelt, was sparse at the time of Trapnell's fieldwork (Haines, 2015). The first map with 500 ft contours was published in 1939 (Dixey, 1944), and so, at least during the period of the fieldwork we examined, Trapnell did not have access to this information. His interpretation of geomorphological processes was therefore limited to what he could see on foot and from limited air photo cover, which was not stereoscopic.

3 Overview: "native agriculture", contrasting views, and the genesis of the Ecological Survey

> The acquaintance of the Ba-Ila with the principles of agriculture is very slight; of fallowing, rotation of crops, manuring, seed selection, they know nothing. ... Their present methods are extremely wasteful, both of labour and land. (Smith and Dale, 1920, p. 135)

This colonial assessment of African agriculture, the first author of which was a missionary, had been challenged before Trapnell's fieldwork (Tilley, 2011). Homer Shantz, from the US Department of Agriculture (see Sect. 4.2), participated in the 1923–1924 African Education Commission tour of eastern and central Africa and reported his findings (Shantz, 1925). He wrote "The agricultural methods of the Natives in Africa have often been condemned as shiftless, wasteful, and destined to decrease the productivity of the country ... but there are many testimonies in the literature to the effect that the Native is an excellent agriculturist." He went on to note that practices such as shifting cultivation were routinely condemned but argued that they were adaptive and more effective at the restoration of fertility and soil physical quality than any alternative. He pointed to the effectiveness of African soil selection methods for matching crops to sites.

Shantz recognized that, at the time of writing, there was a widespread shift in focus among colonial administrators from European to African agriculture and that many had a genuine interest in understanding traditional practices. Tilley (2011) notes that Shantz's views were regarded sympathetically by some British scientists and politicians, including the Undersecretary for the Colonies, William Ormsby-Gore. She highlights the work of Faulkner, director of the Department of Agriculture in Nigeria from 1922, who prioritized the study of African farming.

In 1924, the administration of Northern Rhodesia was transferred from the British South Africa Company to the Colonial Office. The overall record of European settler farmers in the colony was not good. While there had been short-lived successes with some crops (such as cotton), sustained production had not been achieved, which Thomas C. McEwen, the colony's chief agricultural research officer, attributed to a lack of knowledge regarding the plant ecology in the Zambian environment (Speek, 2014). The acting director of agriculture in the new colony, John Smith, reflecting the changing focus to African farming, initiated two linked research projects in 1927: field experiments on African shifting cultivation methods led by Unwin Moffat and a programme of ethno-agrobotany undertaken by T. C. Moore, whose team collected seeds and information on agronomic practices from across the country (Tilley, 2011).

It was in this context of new thinking about agriculture and its role in the future of the colony that the plans for the Ecological Survey were developed (1927–1928). Key to this were recommendations by Ray Bourne of the Imperial Forestry Institute at Oxford University that a multidisciplinary team of geologists, foresters, and agriculturalists with good knowledge of the local flora undertake an ecological survey aided by air photography. There was general support in Northern Rhodesia for the survey, but this concealed divergent understandings of its purpose and the general shape of the policy it would enable (Speek, 2014). Bourne was of the view that European cultivation should be discouraged and that Africans would be the main agents in the development of land resources. Smith, in contrast, wanted research to support sound subsistence farming by Africans but not competition with Europeans in commercial production. According to Baldwin (1966), a widespread view among Northern Rhodesian officials was that food supply for the mines could be sustained by domestic production only if this was undertaken by European farmers, requiring further immigration. This was one reason for the policy of resettling African communities who lived on productive land close to the railway. This particular conflict over agricultural policy paralleled broader unease within the settler community provoked by the Passfield Memorandum, asserting "native paramountcy" as a key principle of Britain's colonial policy (Wetherell, 1979). The Northern Rhodesia (NR) legislative council responded that "the British Empire is primarily concerned with the furtherance of the interests of British subjects of British race and only thereafter with other British subjects, protected races, [etc.]" (Colonial Office, 1930).

In this context, Smith forwarded the proposal for the Ecological Survey to the Empire Marketing Board (EMB) with the suggestion that it would support improved livestock production by Europeans. Nonetheless, as Speek (2014) notes, the governor of the colony ensured that further settlement schemes for European farmers would wait on the results of the survey.

The bid for EMB support was unsuccessful, but the proposal was developed with technical input from the Royal Botanic Gardens at Kew, which emphasized the potential to both identify land for export crops and base development in a young colony on a scientific survey undertaken before the widespread impact of the settlement of or change in African farming methods (Speek, 2014). H. C. Sampson, an economic botanist at Kew, stated that the survey should entail "enquiry into indigenous agricultural practice such as crops, varieties, soils, seasons, and their association one with the other and with the natural vegetation" (Sampson, 1928). Funding was provided by the Colonial Development Fund, but it was not until 1931 that Trapnell was appointed as an ecologist to lead the work, and the survey was eventually inaugurated in 1932.

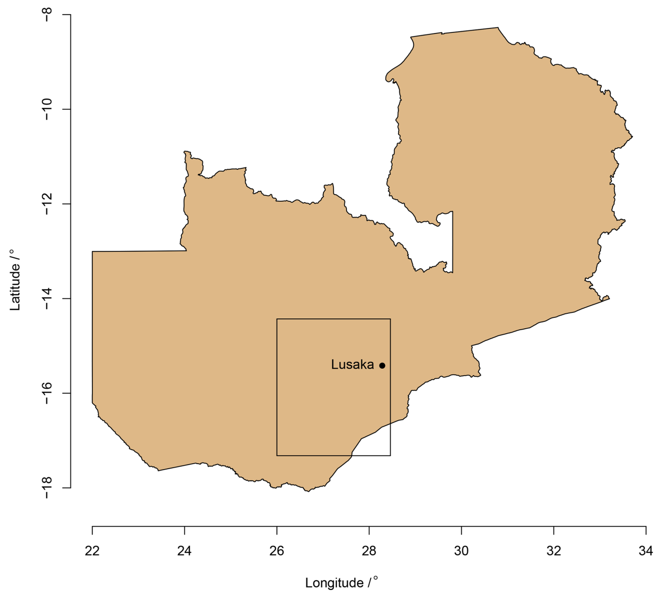

Figure 1. Map of Zambia; the black rectangle shows the study area. Map produced de novo by the authors.

4 Fieldwork in the Upper Valley

In this section, we examine the survey activities which took place in the Upper Valley environment from 1932 to 1934. The primary source is the set of Trapnell's field traverse records (Smith and Trapnell, 2001), but we also refer to reports from the Ecological Survey contributed to the Department of Agriculture annual reports and to other reports by Trapnell and Clothier available in the National Archive of Zambia.

We outline the itinerary of fieldwork in the Upper Valley area. We then review the information available to characterize Trapnell's field survey methods and highlight some aspects of these that emerge from a close reading of the field records for the Upper Valley. We then discuss what these records show Trapnell to have observed in the Upper Valley and associated Plateau and how this contributed to the emergence of the model of the Upper Valley as a distinctive environment created by geomorphological processes, developing a distinctive vegetation with, consequently, distinctive potential and challenges for agricultural use in Trapnell's time.

4.1 Reading the traverse records

Trapnell's traverse observations recorded in field notebooks in Zambia between 1932 and 1943 were transcribed by Paul Smith with Trapnell's assistance and were published by the Royal Botanic Gardens, Kew (Smith and Trapnell, 2001). The original notebooks are held in the Royal Botanic Garden's archive. In this study, we used the records for the survey activities listed in Sect. 4.2. These comprised the traverses for June–July 1932 and August–October 1932, recorded as the

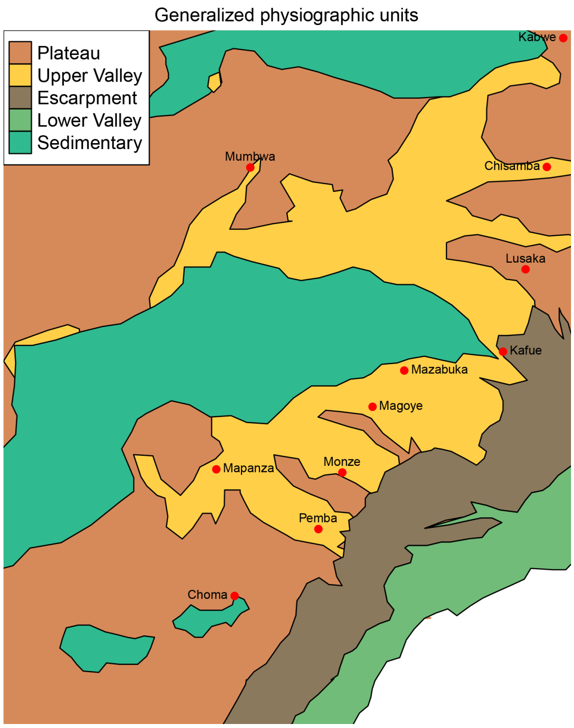

Figure 2. Generalized boundaries of the physiographic units from the 1947 soil vegetation map within the study area. Map produced de novo by the authors.

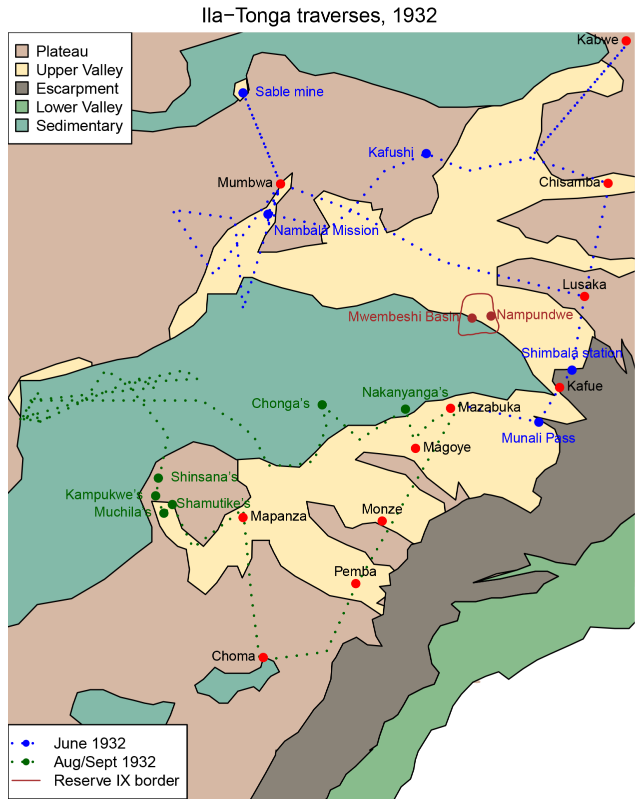

Figure 3. Ila–Tonga traverses of 1932 and the boundaries of the Sala Reserve. Note that the dotted lines join waypoints with known locations and so generalize the actual route. Map produced de novo by the authors.

"Ila–Tonga traverses 1932" in part 3 of volume 1 – "Western, southern and central Zambia" – of Smith and Trapnell (2001). Some sections of the traverses lying on the sedimentary land of the Kafue Flats were excluded. Some key sites and a generalization of the route based on coordinates of some recorded sites are shown in Fig. 3, with blue symbols for sites other than major towns on the traverse and dotted blue lines generalizing the route for the initial days of the inaugural survey in which Trapnell participated. Trapnell's and Clothier's visits to land south of the Kafue River in August and September 1932 are represented in the same figure (see sites represented with purple symbols and the route generalized by the dotted purple line in Fig. 3).

In addition, the records for the survey listed as "Road Traverses, Southern and Central Provinces 1933–1934", also in part 3 of volume 1, were examined. These covered land south of the Kafue River (1933, Fig. 4) and on both sides of the river (1934, Fig 5).

At this stage, in the study, we undertook close readings of the traverse records listed above. By referring to locations listed in the traverses and their coordinates, where provided, we were generally able to situate the observations on the soil and vegetation map (Trapnell et al., 1947) using a scanned and georeferenced version (Mukumbuta et al., 2022b). The close reading of the records was done with two objectives: first, to examine Trapnell's general methodology as it was developed during field work in the Upper Valley and, second, to identify limitations which should be considered alongside his innovative approach to using vegetation cover as an integrating principle for information on soils and land use. Second, we identified locations at which information on soil conditions and agricultural practices was recorded along with the vegetation. These observations were summarized in tabular form, and the tables for the Ila–Tonga traverses, Reserve IX (Sala), and the road traverses (1933, 1934) are presented in the Supplement (Tables S1–S3).

Two further summaries of this material were produced. Table S4 puts together observations of farming practices at Plateau or Upper Valley sites with notes on the vegetation, characterization of the rotation practices and shifting cultivation, and any comments recorded on farming. Table S5 draws together observations recorded by Trapnell about changes in farming practices which his informants told him about or which he inferred from observations.

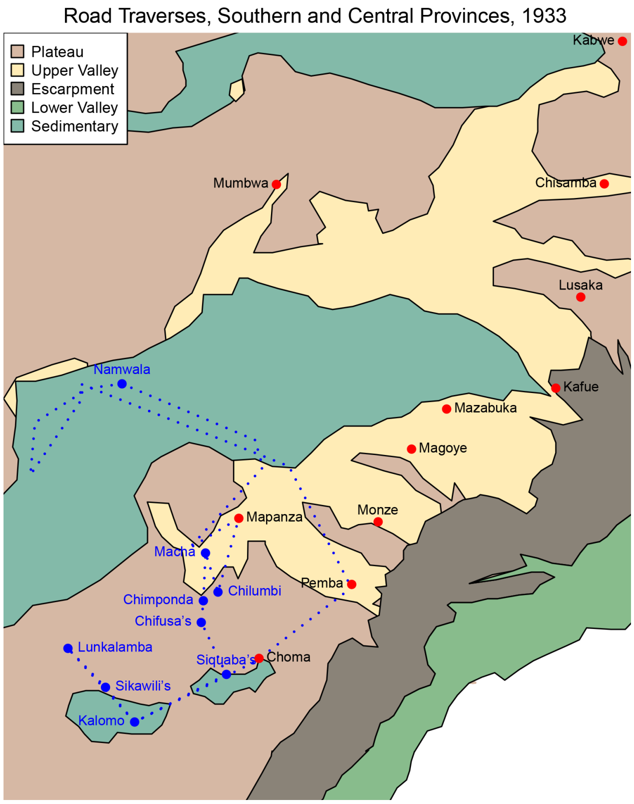

Figure 4. Road traverses of 1933 in Southern and Central provinces. Note that the dotted lines join waypoints with known locations and so generalize the actual route. Map produced de novo by the authors.

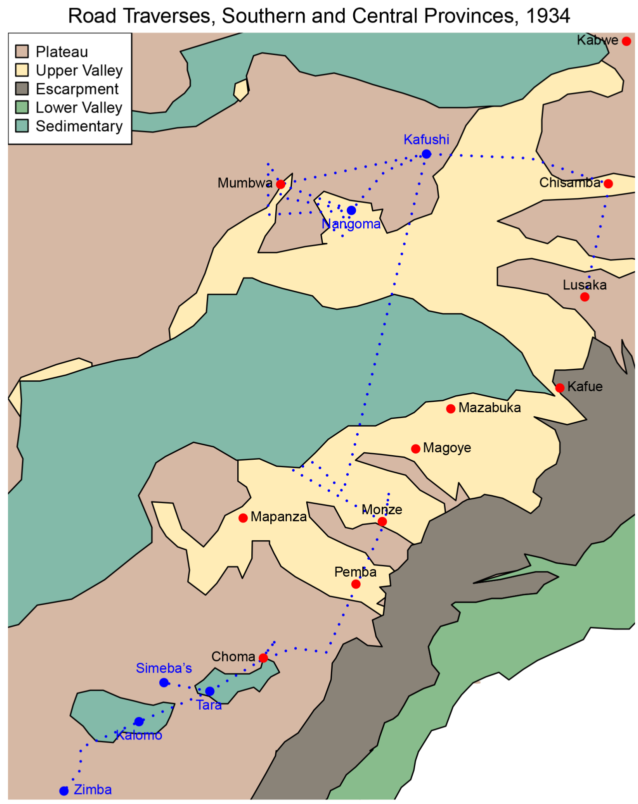

Figure 5. Road traverses of 1934 in Southern and Central provinces. Note that the dotted lines join waypoints with known locations and so generalize the actual route. Map produced de novo by the authors.

4.2 Field activities undertaken in the Upper Valley and associated Plateau environments

The Ecological Survey was inaugurated in June 1932 by Robert S. Adamson from the University of Cape Town. Adamson wrote a report on his visit, which included an itinerary, a summary of methods, and a summary of findings discussed in more detail below (Sect. 4.3). Trapnell (Trapnell, 1932a) provided a resumé of survey activities subsequently to the inaugural survey in later 1932. Trapnell's traverse records (Smith and Trapnell, 2001) provide information on further road traverses in 1933 and 1934. These are the sources for the summary below.

The inaugural survey began in Mazabuka on 13 June and initially covered land north of the Kafue River. Adamson was accompanied by Trapnell and J. Neil Clothier, agricultural officer to the Ecological Survey. After the first fortnight in the field, Trapnell was taken ill, and his traverse records ceased until August 1932.

The team continued to Kafue. In the second phase of the inaugural survey (13 to 23 July), Adamson was accompanied by T. C. Moore and C. E. Duff, agricultural and forest officers, respectively. This second phase examined land south of Kafue. It is not clear whether, beyond Adamson's summary (Adamson, 1932), this second phase of fieldwork contributed substantially to Ecological Survey outputs, and from 30 August to 20 September 1932, Trapnell and Clothier visited sites south of Mazabuka and on the Kafue Flats, which cover much of the same ground.

From 6 October 1932, Trapnell and Clothier visited the Mwembeshi basin region, specifically to examine the Sala Reserve (Reserve IX); see the region outlined by a solid red line in Fig. 3. This study produced similar descriptions of soil, vegetation, and agricultural practices to the Ecological Survey but with observations concentrated in a smaller area.

The activity listed above, between April and October 1932, is described in the "Ila–Tonga traverses" section in volume 1 of Smith and Trapnell (2001). That volume also contains records of road traverses in the Southern and Central provinces from 1933 and 1934 (the precise dates are not always clear). These covered Plateau and Upper Valley environments north and south of the Kafue River.

4.3 Survey methods: external evidence

Formal methodological statements about the Ecological Survey and its practices are few. Perhaps the only contemporaneous account is a terse summary provided by Adamson (1932) regarding methods used in the inaugural traverses in his report to the Northern Rhodesian government. According to Adamson (1932), the team travelled primarily by vehicle, noting vegetation along the route and recording it relative to the mileometer. At selected locations, more detailed studies were made by foot or bicycle traverse. The ecologists were concerned with soil and indigenous vegetation, and the agricultural officer collected information on farming practices. Soil samples were collected from both cultivated and uncultivated soils and sent on to central laboratories for analysis, although, as noted by Trapnell and Clothier (1937), very little soil analysis was to be completed because of financial constraints.

Tilley (2011), reporting from an interview with Trapnell, gives some limited information on later practices by Trapnell and Clothier, which contrasts with the description given by Adamson (1932). Travel was primarily on foot, with the assistance of a team of porters and one or more translators. In a village, they would meet with elders and ask questions described as "routine" about key practices – land selection, clearing, planting, the duration of cultivation, and extent of rest periods. However, Smith and Trapnell (2001) state that the settled practice of the Ecological Survey emerged in the course of the survey of Barotseland undertaken from May to August 1933; thus, the procedure was only emerging at the time of the first traverses in the Upper Valley and of the account given to Tilley.

Allan (1965) describes field survey procedures for land capability evaluation explicitly based on the Ecological Survey methods, in which Allan participated. But, as these included the survey of endpoints of traverses and the use of prismatic compasses to mark them up, with clearance of ground to facilitate the passage of the teams for more intensive surveys of smaller areas than the Ecological Survey covered, it is clear that they tell us little about the original Ecological Survey itself.

Trapnell's (1937) article is ostensibly on the method of the ecological survey but is rather a higher-level account of the hypotheses which early stages of the survey (principally of the Kafue basin) were held to validate, thus justifying later practices. Trapnell (1937) presents the Ecological Survey as a new kind of field study explicitly tied to two linked hypotheses: first, that vegetation type is directly correlated with the agricultural capability of land – and so with successful farming practices on that land – and, second, that vegetation is correlated with soil type or soil properties – and so with the agricultural capability of land. On this basis, the Ecological Survey, primarily structured by the observation of vegetation classes, provides a basis to test this hypothesis. Trapnell treats the lower Kafue basin stages of the Ecological Survey as a test of these hypotheses, the first one being validated because African cultivators who were interviewed by the surveyors recognized the same vegetation classes as the surveyors; used these classes in the selection of cultivation sites; employed different practices and crops on land under these classes; and, to varying extents, had a concept of vegetation type as an indicator of fertility. The second hypothesis could not be tested in terms of particular soil properties related to fertility, requiring laboratory analyses. However, Trapnell (1937) observes that the vegetation classes related to classes of the underlying soil, primarily defined with respect to physiography, and thus were comparable to classes used in the East African Soil Map (Milne, 1936).

4.4 Survey methods: air photography

Air photography began in Northern Rhodesia in a campaign (1927–1929) focused on the northwest to facilitate the accurate mapping of mining concessions and the planning of infrastructure to support the mines and, more speculatively, to aid in mineral exploration. Air photography and its conversion to topographic mapping were undertaken by the Aircraft Operating Company (AOC), with the initial photography paid for by the Rhodesia Congo Border Concession Ltd and the cartography paid for by the Colonial Office (Haines, 2015). Subsequently (1931), the Northern Rhodesian government paid for some additional air photography in the Copperbelt and 15 miles (24 km) either side of the railway line south of Mazabuka. This latter work was in collaboration with the Agricultural Survey Commission to facilitate the distribution of land to European farmers. The AOC, with a view to promoting the use of air photography in the colony, undertook an independent air survey of land in a block centred roughly on Lusaka and bordered at the south by the Kafue River. This photography was interpreted in terms of the vegetation types and the agricultural potential of land by the AOC's C. R. Robbins, who provided a report to the Department of Agriculture. He described the use of parallel strips of vertical photography, supplemented by oblique views, for the delineation of different vegetation types by visual interpretation. Comments on the report, including specific comments from Trapnell, were forwarded to the Chief Secretary at Livingstone in June 1932 and January 1933 (Robbins, 1932). In the first set, Trapnell, who had not yet undertaken substantial fieldwork in the country, commented that the photography clearly distinguished certain bush types but not all (including the agriculturally important thorn country), but he was positive about the use of air photography as part of an overall survey procedure. Robbins's report was subsequently published (Robbins, 1934), and Trapnell's contribution to the description of some of the units is acknowledged. When the original report and the paper are compared, it is apparent that Trapnell added more botanical and ecological detail, as well as geomorphological information on colluvial and alluvial parent material and dambos. Trapnell's comments, forwarded to the Chief Secretary at Livingstone on 17 June, just 4 d after the commencement of the inaugural traverse of the Ecological Survey, show that he had already familiarized himself not only with the vegetation of the plateau and Upper Valley but also, at least to some extent, with knowledge about the ecological potential of land under contrasting vegetation. There is no evidence that air photographs were used in the field by Trapnell, but Trapnell and Clothier (1937) state that Robbins's photography was used to produce the map that accompanies that report (paragraph 68).

Robbins's report, with comments from Trapnell explaining his approach to the survey, was shared with R. Bourne at the Imperial Forestry Institute in Oxford. Recall (Sect. 3) that Bourne's enthusiasm for the potential of ecological surveys supported by air photography had been an important factor in the initiation of the Ecological Survey. However, Bourne was not impressed. His comments on the report (Robbins, 1932) made clear that he did not regard the procedures described to be adequate, particularly the lack of the substantial and interdisciplinary team which he had envisaged. He was sceptical about the general validity of the proposed connections between soil conditions, vegetation, and agricultural potential on which the Ecological Survey was to be based. Although he acknowledged that the Ecological Survey activities were in an early stage of development, he was prepared to make the statement "I cannot help thinking that Mr Trapnell's, as well as Captain Robbins's, investigations have not been sufficiently thorough" (minute forwarded from the Imperial Forestry Institute in Oxford by the director on 2 September 1933, in Robbins, 1932). However, Bourne did state that if Trapnell had the evidence to back up claims about the "mappable" regions then "his final report will be very valuable." Trapnell was clearly concerned about this negative judgement. In a minute (Trapnell, 1933), he stated the need to publish intermediate results to support his interpretation of African selection rules and their value for ecological survey. Lewin forwarded this minute to the chief secretary at Livingstone with a covering letter which stated his strong support for what Trapnell was doing (Lewin, 1933). In this, he stated "I must confess that I read the final portion of Mr Bourne's memorandum with amazement. It is well known that Mr Bourne holds very decided views on the subject of surveys of this nature. ... [O]ne cannot but feel that he is somewhat prejudiced against a survey which is obtaining results by slightly different methods. ... The alternative organisation suggested by Mr Bourne is probably the ideal, but it would be expensive; cumbersome; and in practice, unless its personnel were of exceptionable calibre both technically and socially, might well fail where a survey organised on the lines of the one now in operation would succeed." He went on to state "I have no hesitation in saying that I consider the Ecological Survey to be the most important and useful activity which has yet been inaugurated for the benefit of agriculture in Northern Rhodesia."

The Ecological Survey was not derailed by Bourne's negative judgement. However, in the light of the comments of Trapnell (1933), it seems that this criticism motivated the framing of the early phases of the ecological survey in terms of the testing of a hypothesis of the general ecological value of African land selection rules. This was presented in a paper on the Ecological Survey's methods (Trapnell, 1937). It may also explain why Trapnell, in the reports of the Ecological Survey, always emphasized the consistency of his topographically defined soil classes with those of the East African Soil Map as independent validation of his method. It does, however, underplay the originality of Trapnell's own work.

4.5 Survey methods: evidence in the traverse records

In this study, we explore the potential of an extended close reading of Trapnell's traverse records as a source for understanding his interpretation of one Zambian environment of particular interest for pedology and the emergence of soil survey methods. Close reading of field records to elucidate the production of knowledge, the environment, the role of field assistants and interlocutors, and the realities of fieldwork practice has been undertaken in African historical studies, e.g. Weintroub (2015) on Dorothea Bleek's ethnological and linguistic fieldwork in the Kalahari, Namibia, Angola, and Tanzania. Here, we focus on the routine methodology used in the Upper Valley; protocols (or lack of them) for describing soil, vegetation, and agricultural systems; Trapnell's sources and his approach to them; and the particular focus of his interests.

We have relied primarily on the published version of Trapnell's records (Smith and Trapnell, 2001) for reasons of accessibility (much of this work was done in Zambia during the COVID-19 pandemic when access to archives was, at best, restricted). We (RML) have, however, been able to make a direct comparison between some of Trapnell's notebooks in the Archive of the Royal Botanical Gardens at Kew (e.g. Trapnell, 1932b) and the publication. Trapnell collaborated with Smith in the publication, including the transcription of the original notes, which are not always very legible in the original. In places, Trapnell's later comments on observations in the field notes are included, but these are footnotes rather than interpolations and so can be distinguished from the original material. Where the published records and the originals do differ is that, in the latter, Trapnell used vernacular names to refer to plant species, whereas in the published version these are usually rendered as the botanical names as used in the published reports of the Ecological Survey (a table of synonymies with current botanical names is provided, as well as lists of the vernacular names for plant species, ecological assemblages, and cultivation systems). This is helpful because the vernacular names for particular species change throughout the survey as Trapnell encountered speakers of different languages. In this paper, we use the same botanical names as used in Smith and Trapnell (2001) and give modern synonyms in Table S10 of the Supplement. The published records also include clear reproductions of Trapnell's field sketches, an important part of his methodology, as we note below.

4.5.1 Daily practice of the survey

The traverse records provide a narrative of fieldwork, indicating, typically, the start and end of each day's route, the time at which locations were reached, and the distance along the route at which changes in vegetation cover occurred. Locations may be settlements, often named for the headman. Trapnell often made sketches in his notebook: maps, panoramic diagrams, and topographical cross-sections showing vegetation and land use in different slope positions. These are reproduced in Smith and Trapnell (2001). The cross-section sketches, now commonplace in textbooks of pedology to illustrate catenas or other soil landscape patterns, put particular emphasis on general relationships between relief, soil conditions, and land use practices, reflecting an emerging model of how these were linked. The panoramas show specific local topography with arrangements of geology, drainage, and vegetation and are reminiscent of the oblique air photography produced by Robbins (1934) for interpretative rather than cartographic use.

Observations on vegetation, geology, soils, crops, and agricultural practices are included in the records, often within the daily itinerary but sometimes as a separate block of notes at the end. Comments are comprehensive and reflect wide-ranging conversations with local informants. In addition to information about the crops in the ground, descriptions are given of the rotations, the shifts (how long cleared land was cultivated, how long land was fallowed), indicator species used for site selection, social observations (how much land a family cultivates, what land is cultivated for the chief), prices obtained for local products, foods resorted to in famine periods, and changes in farming practices.

Adamson (1932) states explicitly that ecologists and agricultural officers concentrated on their specialities, recording soil and vegetation and cropping practices, respectively, during the inaugural survey. This is reflected in Trapnell's traverse notes for the inaugural traverse, where observations on cultivation are relatively sparse. On 16 June 1932, Trapnell commented that cultivation was proceeded by the lopping and burning of trees, and he speculated that shifts between cultivation sites were probably fairly frequent. However, there is no evidence that this information was provided by local informants. Otherwise, Trapnell's observations on farm practices in June 1932 were limited to noting where there was evidence of cultivation, past or present, and some observations of the crops under cultivation. From August 1932, however, the observations on farming become more frequent and systematic, with observations on rotation practices which clearly reflect engagement with informants. We do not have access to field notes made by Clothier or other agricultural officers engaged in the survey, but it is clear from Trapnell's field notes, summarized in Tables A1–A4 in the Supplement, that he soon began a more cross-disciplinary approach to his task than Adamson (1932) describes, and his observations in Reserve IX and on the road traverses provide the kind of information on agricultural systems and their setting under different vegetation types which was set out in Clothier's report on African farming practices (Clothier, 1933). As noted in Sect. 4.3 above, the settled field protocol emerged after the Barotseland survey (May–August 1933), but there is no apparent change in emphasis or approach from the initial Ila–Tonga traverses of 1932 to those recorded in and around the Upper Valley in 1933 and 1934, although these were road traverses and so were somewhat atypical.

4.5.2 A paucity of protocols

Modern soil surveys, vegetation surveys, and descriptions of agricultural systems use defined protocols to ensure that information is collected in a consistent, comprehensive manner. It becomes apparent on reading Trapnell's field notes that the Ecological Survey did not use formal protocols to record soil properties, vegetation, or farming practices. While Adamson (1932) reports observed plant species using taxonomic names, Clothier (1933) reported on the vegetation of the Kafue basin using primarily English vernacular names. While Trapnell, in his original traverse records, typically referred to plants by the vernacular names used by his African informants, taxonomic names are used as substitutes in Smith and Trapnell (2001). Trapnell's original practice of using vernacular names may reflect his dependence, at least in part, on informants for the identification of species, and specimens were sent to Kew for identification (Trapnell, 1934b).

Similarly, there was no consistent way to record cropping practices. We are grateful to Paul Smith for an email exchange on the following examples (Paul Smith, personal communication, 2020). In some cases, a crop might be listed in a rotation sequence with an integer subscript, interpreted as the number of successive seasons in which it appears (e.g. at "Chifusa's" on the Kalomo to Macha mission traverse leg in 1933; Smith and Trapnell, 2001, p. 531, vol. 1), but this convention is not used everywhere. As Mukumbuta et al. (2022b) note, a hyphen and a solidus were each used to denote a rotation in some records and intercropping or mixed cropping elsewhere (or possibly alternative crops at some point in the sequence), and at some locations (e.g. near Lwidi River; Smith and Trapnell, 2001, p. 531, vol. 1) a cropping sequence is given as an enumerated list. The description of rotations and shifting cultivation practices by Clothier (1933) is generally easier to interpret than the accounts in Trapnell's traverse records, which may be a result of Clothier's formal education in agricultural science (Young, 2017).

At least as far as soil surveying is concerned, the lack of standard protocols reflects the fact that procedures for the field description of soils were still emerging and unstandardized at the time (see comments by Mukumbuta et al., 2022b). The first edition of *The study of the soil in the field* (Clarke, 1936) was not published when the Ecological Survey began. Clarke's book provided the foundation for field manuals used subsequently in England and Wales, as well as elsewhere.

The *Soil Survey Manual* of the US Department of Agriculture was first published in 1937 (Soil Survey Staff, 1937).

Furthermore, as Trapnell explicitly recognizes in a later formal account of the survey methods (Trapnell, 1937), the brief and the resources available for the survey did not permit an approach based on a soil survey with extensive sampling or profile description. Indeed, due to retrenchments in spending within the Agriculture Department of Northern Rhodesia and the loss of the soil chemist's post (Trapnell and Clothier, 1937), very few analytical data on soils were available when the survey formally reported on the central and western regions (Trapnell and Clothier, 1937).

4.5.3 Sources of information

With whom did Trapnell speak? In the interview recorded by Tilley (2011), he states that "elders" were his principal informants, but Trapnell did not systematically record the source of his information in the traverse records. In the traverse records, villages are referred to by the name of the headman, e.g. "Chonga's" (31 August 1932, p. 381). It is not clear here whether Chonga himself was the principal or sole informant. Trapnell was told, for example, that shifts on this land (where agriculture was described as semi-permanent) would happen when a son moved to a new area, which he would then cultivate until he died or chose to move on. It was not clear whether this would apply to all "sons" in the village or just to the headman's sons. Among the Tonga, settlement might be patrilocal or matrilocal, with a newly married couple settling either near family or near the man's mother (Jaspan, 2017). It is therefore likely that major shifts under Tonga semi-permanent agriculture might involve single cultivators moving longer or shorter distances according to choice. Because Ila settlement was typically patrilocal (Jaspan, 2017), shifts might be over smaller distances. The records for this village, however, are not clear.

At Muchila's in the Upper Valley (18 September 1932, pp. 419–420), it is made explicit that Muchila was the informant: "Muchila's people ... cultivate in *Afrormosia* bush. For cultivation, he chooses by *Afrormosia* with *Acacia campylacantha* mixed in." It is not clear whether the information we are given about Muchila's soil selection reflects a general practice of selecting land in *Afrormosia* bush or perhaps a privilege for the headman to select a superior class of land. Elsewhere, there was evidence that such privileges were exercised. For example, at Mantanyani's (6 March 1934, pp. 566–567), where bush and dambo head cultivation was undertaken, it was recorded that the "Chief has a separate, large (dambo head) *Acacia woodii* garden on the best land." Here, Trapnell's record gives us a picture of social stratification of land use practices. Elsewhere, we cannot always be sure whether the records refer to land use in just one social stratum, whether there is no such stratification, or whether the description is a generalized account of farming within which there might be some variation.

How did Trapnell speak with his informants? In the interview with Tilley (2011) referred to above, it was stated that he travelled with one or more interpreters. Interpreters are not named in the traverse records, and so these individuals' roles and linguistic specialisms (and possible limitations in some settings, given the many languages to which Trapnell refers) remain unknown. Trapnell certainly recorded names for crops, wild plants, and ecological units in a wide range of vernaculars. For example, the notes to volume 1 of Smith and Trapnell (2001) record 15 names for sorghum (*Sorghum bicolor*) in 11 language groups; 7 names for *Acacia campylacantha* used in 8 language groups; and 3 words for "dambo" in 2 language groups, including words distinguishing those with or without streams. A total of 46 agricultural terms were recorded describing agricultural systems such as anthill gardens, manured "home" gardens near the village, and various systems on dambos. The collection of this detailed vocabulary clearly required considerable linguistic expertise on the part of the interpreter and a capacity to grasp the importance of the nice distinctions based on ecological setting, drainage conditions, and cultivation methods. However, we do not know anything about the background of these individuals or the education or experience that equipped them for the task.

At only one place in the traverse records read for this study do we find any attempt to transcribe the speech of an informant, Siabasuni, who describes the shrub *Phyllanthus engleri*, which has very toxic bark and roots, as "*meninge skellem mouti*" (p. 380). The language used here is Cikabanga, originating from Fanagalo, the lingua franca used in the mines of South Africa. We have here a glimpse of Trapnell and colleagues communicating with informants in a pidgin, but the ethno-botanical and linguistic depth of the records as a whole clearly did not depend on this.

Trapnell used ethno-linguistic names in the traverse records to refer to territory; for example, on 3 September 1932 (p. 386), he notes the survey's change of direction at a store by Nalubamba's: "turn north into Ila country" . Similarly, he notes in the record for a road traverse in 1933 (pp. 529–530) that the survey was passing through "millet country" and comments that the "Matotela stop at Machili". The significance of this comment is clarified in part II of the report of the Ecological Survey for Northern and Western Rhodesia (Trapnell and Clothier, 1937), where (paragraph 95) he refers to the Matotela as "a backward people who cultivate bullrush millet on poorer upland sands". Ethno-linguistic groups provide a framework in the report to describe the variation in agricultural systems (paragraphs 89–97) and the map which shows that the distribution of agricultural systems has "tribal" names, as well as the names used to describe particular systems of cultivation. The "Tribal index" to volume 1 of Smith and Trapnell (2001) contains 81 separate entries, not including recorded variant names. There are 13 entries in this index for the traverse descriptions examined in this study (excluding references to photograph captions or entries in itineraries). Table S6a shows these entries by group and the associated language group. There are 28 entries in which the name is used to describe a village or some part of a village where the occurrence of two or more ethnic groups is noted. The next largest set (16) is made up of plant names, with an additional seven records of wild or famine foods eaten. Other entries refer to soil selection and cropping practices and so transfer across to the description of agricultural systems by Trapnell and Clothier (1937). There are also entries on particular trading specialisms (the Bambala, for example, specialized in tobacco processing) and where groups might transfer cattle to graze under the oversight of another during certain seasons. There are also comparisons or comments made between ethnic groups by members of those groups or by Trapnell. For example, Trapnell met an Ila community which stated they did not make gardens in Phragmites on the river banks "because they are true Ba-Ila, not Batwa who have them" (p. 411, Trapnell's quotation marks).

How far the tribal labels used by administrators, missionaries, and others in colonial Africa reflected the self-understanding of the people themselves has been challenged in various studies (e.g. Ranger, 1989). The robustness of Trapnell's ethno-linguistic framework therefore requires examination. Posner (2003) notes that missionary programmes to standardize languages for Bible translation and later policy on languages for instruction in secular colonial schools, along with the homogenizing effect of the mass movement of workers to mines, lie behind the replacement of the linguistic diversity of precolonial Zambia with the contemporary situation in which four languages dominate (Bemba, Lozi, Tonga, and Nyanja). The emerging dominance of these four was recognized as early as the 1940s by administrators and anthropologists (Posner, 2003), although estimates based on observations from 1930 suggest, that in the pre-colonial period, there had been 17 principal languages, among many more, with any one being spoken by less than 10 % percent of the population.

The ethno-linguistic information in Trapnell's traverse records does not reflect this emerging homogenization. Table S6b shows a simplified form of the classification of 19 languages or dialects in the Glottolog classification (Hammarström et al., 2023) which appear in Trapnell's 10 principal language groups. Trapnell's largest group is IT (Ila–Tonga), with six principal languages or dialects. Four of these are in the Kafue subfamily of the Greater Eastern Botatwe group in the classification of Hammarström et al. (2023). The fifth remaining of the Kafue languages, Lenje, was treated by Trapnell as a separate language group. The Toka dialect in Trapnell's IT group is in the Toka–Leya–Dombe subfamily, closely allied with the Kafue languages. This comparison shows Trapnell paying close attention to the linguistic diversity of his informants, at least in so far as this provides what we would now call ethno-pedological or ethnobotanical information. Indeed, when he encountered distinct Ila and Tonga names for particular species, he recorded these as such (e.g. the Ila name *Mukamba* and the Tonga name *Mupapa* for the pod mahogany tree *Afzelia quanzensis*, p. 400).

4.5.4 The information that Trapnell collected

Trapnell's interlocutors provided a wide range of information relevant to his interests. In particular, they described the plant species, namely trees or grass, used to select land for cultivation. Figure 7 shows a list of 28 distinct vegetation descriptions (species, genera, associations, and one structural group of "tall grass"). All of these were recorded at least once as an indicator for soil selection (in one case, *Brachystegia flagristipulata* was indicated as a counter-indicator), either for general cropping (the 22 indicators and 1 counter-indicator with symbols on the plot) or for a particular crop – for example, *A. campylacantha* in association with *Setaria phragmatoides* was never given as a general indicator, but there are three cases where it was named as an indicator of land for sorghum. In some cases (three for the general indicators in Fig. 7), an indicator is proposed for land which is the second or third choice for cultivation (e.g. *Afrormosia angolensis* and one out of two records for *Setaria* sp., indicated in the figure by a light-green symbol).

Trapnell was also informed about plant species or the general form of vegetation whose appearance in a secondary succession indicated that fallowed land could be cultivated again. For example, land might be cultivated again if *Hyparrhenia* grass regrows or if "the bush is high" (Nangoma's in the Upper Valley, p. 542). Practices described to Trapnell included shifts; rotations; and the susceptibility of the local systems to drought, pests, and damage by wild animals.

Trapnell also recorded wild species that were eaten, including those which were important in poor-cropping seasons, which he referred to as "famine foods". For example, at Muchila's in the Upper Valley (18 September 1932, pp. 419–420), he recorded that *Bunkulu*, the flowers of *Muyinga*, for which no taxonomic name is given but which he described as "a bushy, yellow-flowered papilionaceous herb", were cooked with groundnuts in a porridge in famine years. The fruits of *Parinari* and *Uapaca nitida* were eaten regularly.

Trapnell's interlocutors also informed him about trading activities. For example, Muchila himself sold poultry (a shilling each) and cassava. Goats were sold at the neighbouring Kalomo (European and African customers), and groundnuts were sold to nearby missions. Other non-agricultural economic activities were recorded, such as the manufacture and sale of canoes and paddles (p. 449), the processing and sale of tobacco (p. 398), and the manufacture and sale of iron hoes (p. 439).

Trapnell described the vegetation as he saw it on the traverse but also recorded information from informants about the lateral extent of particular formations. For example, at Kafushi on the inaugural traverse, he was informed that the *Isoberlinia paniculata* country extended 1.5 d north, followed by 4 h of grass on sandy soil; 4 d northwest; and 1.5 to 2 d south. Trapnell estimated that 1 d of travel was equivalent to 15 miles (24 km). While not stated explicitly, it would appear that this information was used to delineate vegetation map units in the map accompanying Trapnell and Clothier (1937) and in the final Vegetation–Soil Map, perhaps with the cross-hatching rather than solid pattern to indicate the uncertainty.

4.6 Soil, vegetation, and land use in the traverse records

Having considered Trapnell's methods thematically, we now focus on his observations in some of the fieldwork undertaken in the Upper Valley and adjoining Plateau in 1932. We then present summaries of observations in tabular and graphical form and then examine what the traverse records show about relationships between soil and farming practices and changes in the latter during the time of the Ecological Survey.

The distinct units of land which the Soil and Vegetation Map (SVM, Trapnell et al., 1947) delineated as Plateau soils (P7: southern *Isoberlinia globiflora–Brachystegia* woodland, P5: central *Isoberlinia paniculata–Brachystegia* woodland) and Upper Valley soils (U2: *Combretum–Afrormosia* and *Pterocarpus–Combretum* transitional grass–woodland, U3: *Acacia–Combretum* thorn) were traversed early in the inaugural survey. For example, on 14 June 1932, the route from Lusaka to Broken Hill (now Kabwe) started over yellowish soils under *Brachystegia flagristipulata* and *Brachystegia hockii* (P7). African cultivation was observed in a valley with some fig trees. Later on that route, "buff" topsoil over deeper orange subsoil was observed under transitional woodland (*Afrormosia, Combretum, Albizzia, and Terminalia* (U2) before passing into *Acacia campylacantha* (U3) thorn. Again, cultivation was observed in the transitional woodland, but no details were recorded by Trapnell.

The route the next day from Kabwe to Kafushi passed onto *Isoberlinia paniculata* plateau soils, with some *Brachystegia* species and *Uapaca*. The soil varied from pure white sand to "buffish" clay, and the laterite blocks and underlying laterite, characteristic of the plateau, were observed. After 10 miles (16 km) or so on the Plateau, the route passed onto dense *Combretum* with tall grass and then *A. campylacantha* before moving into more open *Combretum–Terminalia* country and then *Acacia woodii* with *Hyparrhenia* grass and *A. woodii* grass cover before an *A. campylacantha* belt.

Both these routes cut across the Plateau and Upper Valley environments and showed the distribution of characteristic transitional vegetation before the thorn soils of the latter. This is not commented on in the notes at this stage, and the term "transitional" is not used. Although Trapnell observed some cultivation on the thorn soils, no detail is recorded.

The third day out of Lusaka (16 June 1932) was spent in a cycle reconnaissance around Kafushi on Plateau soils under "remarkably pure and uniform" cover of *I. paniculata*. Some variation was seen with *B. flagristipulata* near dambos and *Uapaca kirkiana* on shallow soils over laterite. Trapnell also observed the vegetation characteristic of the Upper Valley thorn soils (*A. campylacantha, Hyparrhenia rufa*) on "sweet" dambos with good grazing and the transitional vegetation (*Combretum, Terminalia*) over the poorer "sour" dambo.

Trapnell's observations on the area around Kafushi included his first reference to farming practices on the Plateau, but these are rather sparse and are not suggestive of detailed discussion with informants. He noted that trees were lopped and burned and inferred that shifts of the cultivated site were "probably fairly frequent". He also noted that the dambo slopes were cultivated but not to the waterside, in contrast with dambos under *Brachystegia longifolia*. This tree cover had been observed on previous days, although without observations on dambo cultivation in Trapnell's notes.

The continued Ila–Tonga traverses in August–September 1932 after Adamson's departure and Trapnell's period of illness were south of the Kafue (Fig. 3). These covered Plateau and Upper Valley environments, as well as routes across the sedimentary soils of the Kafue Flats. As noted above, Trapnell's descriptions of agricultural systems, alongside the ecological descriptions and comments on soil, become more detailed. For example, at Shinsana's village, visited on 17 September 1932, he described a Plateau setting under *Brachystegia flagristipulata* and some *B. hockii* over gravelly or old cultivated soils. There were species of *Hyparrhenia* grass, including *H. rufa* on dambos. He noted a fine sandy loam soil, chestnut to brown in colour and relatively shallow, with an underlying layer of ironstone nodules and quartzitic gravel, which is characteristic of the old plateau soils, with the layer being thicker near the dambo. Within this ecological setting, he noted that the community was engaged in bush cultivation. Sites were selected based on the presence of *Hyparrhenia filipendula* and *B. flagristipulata*. Opened land was cultivated for 5 years, with new land opened each year for the cultivation of groundnuts. They returned after a 4-year-long fallow, and the site was then abandoned. In addition, he noted that the community was vulnerable to famine in dry years.

The next day, on 18 September 1932, Trapnell made a similarly detailed set of observations at a site, Muchila's, on the Upper Valley. The dominant vegetation was what Trapnell referred to as transitional, specifically *Afrormosia–Combretum* over soil derived from granite, and some of the sites under cultivation were under *Acacia campylacantha*, characteristic of the thorn soils of the Upper valley beyond the transitional fringe. This community cultivated *Afrormosia* bush, selecting sites with *Afrormosia* and *H. filipendula* for groundnut crops. Sites under *H. filipendula*, *A. campylacantha*, and *Combretum* were selected for growing maize and sorghum. Land was cultivated for 4 years, with millet grown in the third year. After a 4-year-long fallow, the community returned to

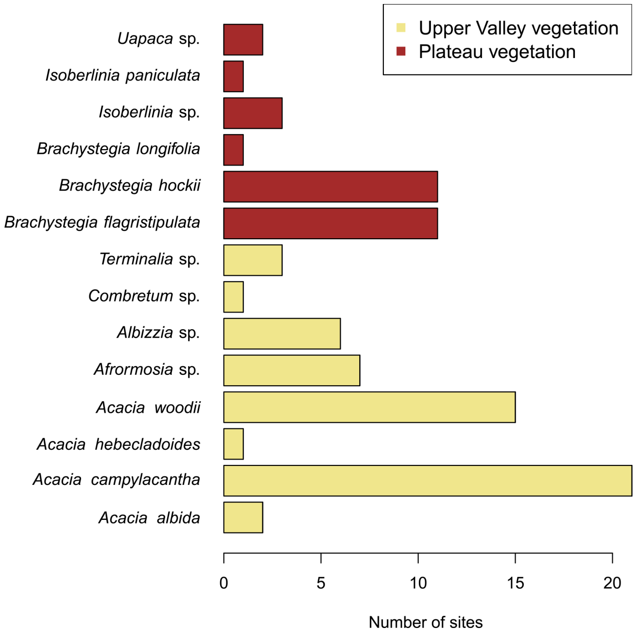

Figure 6. Dominant tree species recorded at cultivated sites (Sala Reserve excluded).

the site for a further 4 years, after which the site was abandoned.

A similar level of detail was provided for many sites in the remaining traverses in the vicinity of the Upper Valley. The observations are summarized in two figures. The vegetation species named at cultivated sites (excluding the observations in Reserve IX) are shown in Fig. 6. Because of the purposive nature of sampling on the transect, the relative proportions of these species should not be treated as evidence of the vegetation species associated with cultivation in the Kafue basin at the time of the surveys, but they do show the picture provided by the traverse records as subsequently interpreted by the survey team. Figure 7 shows the number of references to particular species or associations of species as indicators of the suitability of a site for selection for cultivation, as recorded by Trapnell from discussions with informants.

Trapnell's observations of agricultural systems in these traverses are compiled in Table S4. These and similar observations, along with those made by Clothier across the Kafue basin (Clothier, 1933), are generalized in the descriptions of agricultural systems provided by Trapnell and Clothier (1937) and subsequent reports. We have noted above some of the challenges in the interpretation of the accounts of farm systems in the traverse records. Nonetheless, they contain a wealth of detail on practices following site selection with respect to land preparation (for example, the burning of tree branches and other biomass), cropping sequences, the extension of cultivated land in successive seasons (e.g. by planting groundnuts in extensions on the plateau), the variations in the size of cultivated areas (reflecting soil quality), and the spatial complexity of cultivation (with certain crops being grown in ash heaps, some on garden margins, and some on dambo margins).

One notable feature of Trapnell's observations of agricultural systems is the information he inferred or gathered directly from informants about recent changes in farming practice. Observations on these changes are compiled from the Upper Valley traverse records in Table S5. At three locations in the vicinity of Monze south of the Kafue River, visited in February 1934, Trapnell was told how maize as a crop had supplanted sorghum. Sorghum itself appeared to have replaced millets as the dominant crop. At one site, bullrush millet had preceded sorghum, and at sites, bullrush millet and finger millet had preceded sorghum. At one site, Benzu's (23 February 1934), the demise of sorghum was linked explicitly to the arrival of Europeans. At two sites on the adjoining Plateau, maize was the dominant crop at the time of surveying; in some cases, this was in combination with sorghum. At one site, this was linked explicitly to the railway, where the maize was taken for sale. At a third site, maize, sorghum, and finger millet were planted, the latter on anthills. Note that, by "anthills", most if not all of the time, Trapnell means termite mounds. It was stated that, previously, the crops had been bullrush millet and sorghum. Trapnell noticed that the practice of growing bullrush millet and sorghum had changed where ploughs were used, with alternate rows of the crops being grown rather than having separate gardens. He also noted that bullrush millet had spread as a crop onto sandier soils in the Zambezi catchment.

The introduction of the plough was a critical technological change which was taking place at the time of the Ecological Survey. As noted in the previous paragraph, Trapnell observed changes in the farming of millet and sorghum through the use of ploughing, but the plough also facilitated increased cultivation areas and extended periods of cultivation of land for maize production in response to markets opened by the railway (see observations in the Pemba–Kalomo road traverse of 1933, p. 528 et seq.) The traverse records, however, provide rather limited detail about the use of the plough in comparison with, for example, traditional technologies such as soil selection or burning for ash fertilization. There is one incidental reference in the Ila–Tonga series (p. 525), where it was noted that certain soils under *Acacia* could be ploughed before the rain, and one reference in the Sala Reserve field notes (p. 449) with regard to a site where black clay soil in alluvium was ploughed only at higher (better-drained) locations. There were more (four) references in the notes of road traverses, where ploughing downslope was observed (p. 529) and where Trapnell noted that the introduction of the plough at a Plateau site had resulted in intercropping of sorghum and bullrush millet in alternate rows where, previously, they had been grown in separate adjacent gardens (p. 529). This seems to be the only observation involving ploughing in these particular traverse records that notes specific technical information as to how the plough was used in the system. In the Up-

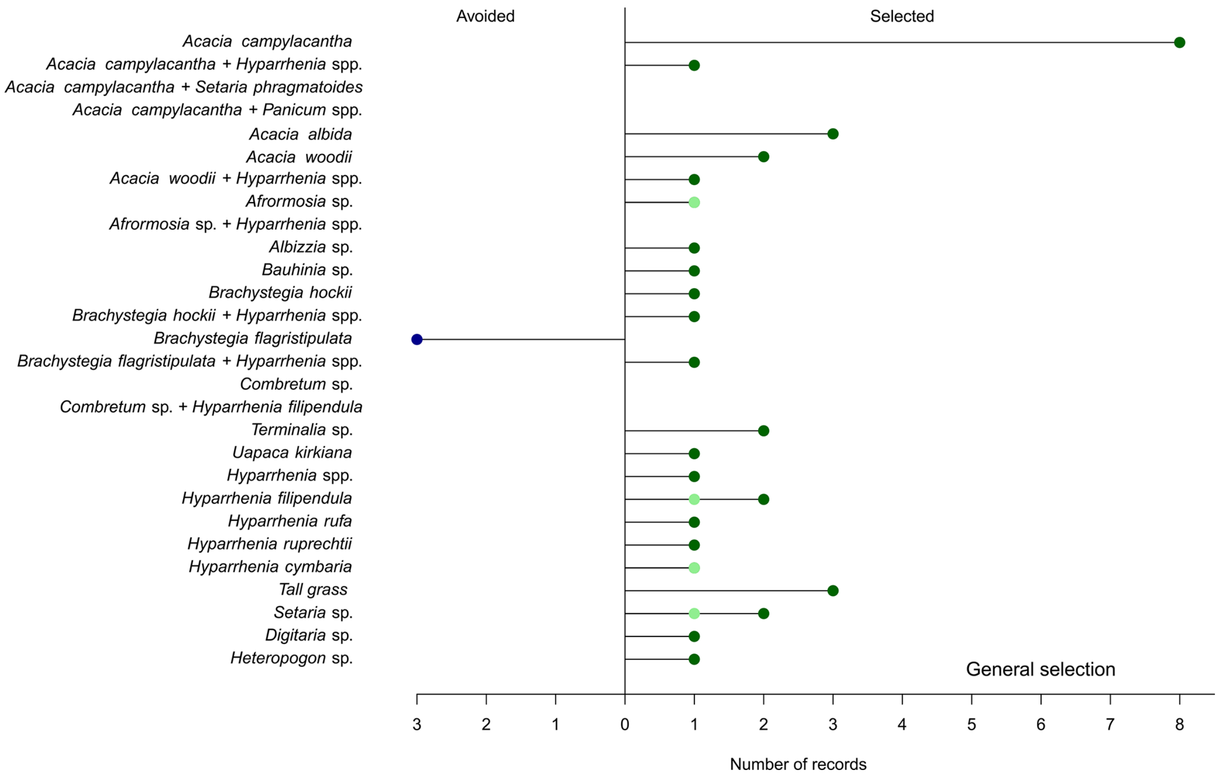

Figure 7. Number of references to particular species or associations of species as indicators in soil selection for general cultivation. Selection references for particular crops are shown in Figs. S1, S2, and S3 in the Supplement. Light-green symbols show cases where the selection is not the first preference.

per Valley at Mapanza mission, he noted that the Balundwe people had moved from cultivated transitional bush sites to the riverbank, using ploughing, which he associated with the "breakdown of soil", noting that erosion was general.

4.7 Trapnell's field observations and the "ecological concept of development"

Speek (2014) treats Trapnell as a key figure in the emergence of an "ecological" theory of development in Zambia. Under this account, the developmental trajectory of a local ecosystem, incorporating an African "tribal" group of cultivators, was either adapting towards some stable "climax" state, analogously with a primary vegetation succession, or degrading. The African cultivator was not granted conscious agency in this model. Ideally the cultivator is operating in harmony with nature, in contrast with the "defeat of nature" by European cultivators. This theory was seen as a reason for separating African and European cultivators, for example, through maize control regulations, to avoid direct competition for grain markets.

Moore and Vaughan (1994) note that the variations to be found within agricultural systems in the Zambian setting were often interpreted in ethnic and evolutionary terms in which a particular group had developed a system along some trajectory, often with an additional narrative of a contemporary breakdown of the system, for example, as a result of large-scale labour emigration. However, they comment that Trapnell (1943) was sceptical about such interpretation. Does our reading of Trapnell's fieldwork support the interpretation of Speek (2014), or does it accord more with the observations of Moore and Vaughan?

The traverse records in the Upper Valley show Trapnell identifying communities as "backward" if they were found to be cultivating poor soils or undertaking soil selection in ways which fell short of a paradigmatic ecological principle. At Benzu's village (p. 552), Trapnell noted that the community selected land with long grass but concluded that they were "unconscious of their practices". Similarly, he noted that Munampelo's people (p. 467), while selecting sites with tall grass, where Sorghum would grow well, did not know names for the grasses and compared them with "true Ba-Ila", who know the grass names. Here, the degree of "consciousness" of an African cultivator seems to be measured by how far they approximate to a scientific ecologist, although it is not clear that Munampelo's structural classification of vegetation is any less effective for the cultivator than a taxonomic one. In this respect and in his idea that even the successful African cultivator was selecting soils from plant species or vegetation types "intuitively and without conscious thought" (Trapnell, 1937), Speek's identification of Trapnell with the ecological theory of development has some force. However, Trapnell's observations, particularly his field records, do show a more nuanced understanding, as we now show.

Trapnell knew that the state of affairs in the Upper Valley and surrounding landscape was more complex than a picture of different ethnic groups having adapted, to differing degrees, to their local environments and of a part of the local ecosystems, either stabilizing or degrading. First, he understood that particular villages or wider communities, following a common set of soil selection practices, might comprise more than one ethnicity. At one site, with *Acacia albida* as the dominant tree, he noted that "People here mixed: Batonga and Balundwe" (p. 385). He was also aware that communities moved on the Plateau and Upper Valley in response to varied factors. He encountered one Tonga community at a site they had occupied for 7 years after leaving a reserve (p. 560). He also identified cultivation practices which were not accommodated by a simple classification, noting types " intermediate between the Tonga "circle" cultivation of the plateau bush and the differentiated bush/dambo head or associated dambo cultivation of Transitional bush" (p. 566). Trapnell was aware of the contingencies that cause communities and people to move and recognized cases where cultivation practices changed when a community moved to a new environment – in the central and western report (Trapnell and Clothier, 1937), they noted that Lamba–Kaonde people on the northern Plateau had changed their agricultural practices where they had penetrated the southern Plateau (paragraph 90). Furthermore, Trapnell and Clothier (1937) observed, in the final report for central and western Zambia, that the movement of "tribal" groups led to a change in agricultural practices independently of any European intervention (paragraph 188). These changes in practices might be through direct adoption of the methods of new neighbours or through the adaptation of neighbouring systems to create a new one (e.g. a groundnut–maize–millet rotation developed by Ila cultivators on sandy soils).

The account of the Ecological Survey by Speek (2014) is based on the published reports, and these do offer some support for his interpretation. For example, Trapnell and Clothier (1937) describe the Lamba–Kaonde as "backward ... lacking in crafts and primitive in diet, sowing [sorghum] broadcast in ash-fertilised land". In contrast (paragraph 91), the Ila and Tonga "tend generally to a higher level of agricultural development", by which they appear to refer to features of the southern Plateau system and cultivation of maize on the thorn soils of the Upper Valley; they are not necessarily criticizing ash cultivation as such, which was known to counteract soil acidity and provide plant nutrients.

It has been noted that the Lamba people, with their origins in the Copperbelt region, were widely held in low regard from the 1930s colony to post-independence Zambia (Siegel, 1989). This has been ascribed to their resistance to colonial models of development, not least in preferring agricultural activity to paid work in the mines. Siegel (1989) shows that, for some, this was a deliberate ideological choice. The African Watch Tower movement, based among the Lamba, actively rejected urban life as a colonial innovation. Others were simply happy to engage with this new order from the margins by selling agricultural produce or engaging in mine work for short periods only. From the colonial perspective, reflected in the text of Trapnell and Clothier (1937), the Lamba appeared unambitious and therefore backward. Siegel (1989) notes the difficulty of reconstructing the Lamba perspective, but their disengagement, or minimal engagement, with the colonial economy appears to have had roots in a strong sense of grievance at the loss of land to mining activity, a suspicion that the colonial authority's schemes aimed to dispossess them further, and the perception that the colony's administrators had interfered unjustifiably in the role of their traditional leaders.

The Ila–Tonga, in general, receive a positive assessment from Trapnell, and their use of the thorn soils of the Upper Valley enabled rapid agricultural development, which he observed, along with emerging problems in the Sala Reserve and the vicinity of Pemba. Mobility in space facilitated this development, particularly in taking up land with access to the railway line and the maize markets which it served. Colson (1962) was to note in fieldwork in the mid-1940s that Tonga communities showed particular mobility on the southern Plateau, with a minority of the individuals she recorded living in the village of their birth and with a general tendency to move westward over the lifetime. This mobility was facilitated, in part, by distinctive historical and social factors in Tonga life, which meant that the Tonga could transfer their allegiance between traditional headmen with relative ease. Cultic considerations were also important. For the Ila, ancestral spirits were associated with sacred funeral groves on particular areas of land which therefore held an ongoing meaning and a tie to the location, but, for the Tonga, obligations to ancestral spirits were met at domestic shrines, either at the doorway or central pole of the hut (Jaspan, 2017).

Thus, some observations in the published reports of the Ecological Survey, such as the above examples from Trapnell and Clothier (1937), do reflect a colonial perspective on different ethnic groups that misses political, ideological, and cultic factors that influence decisions and options for land use and agricultural development. However, as we note above, and as also highlighted by Moore and Vaughan (1994) and Tilley (2011), the reports also reflect a more subtle understanding of the factors at play in the distribution of practices that Trapnell observed. The field records reinforce this. Paul Smith (personal communication, 2020) has drawn our attention to entries from late 1934 (pp. 325–326) in the Solwezi district (northwestern Zambia, adjoining the border with the Democratic Republic of Congo). Here, Trapnell observed Lamba communities which he described as "advancing to at least stage 2" (see Table 1) of agricultural development beyond broadcast sowing in ash. The notion of "back-

Table 1. Trapnell's stages of agricultural development in the Pemba district (Trapnell, 1934a).

Stage	Management	
1	Original dense-scrub cultivation[1]	
	Dense scrub cut and burned Year 1: fm grown in ash, small annual extensions; gn/gb may be grown in small unburned patches Year 2–4: mz and sg interplanted with cp	
2	(a) Open-bush fringe cultivation[2]	(b) Dambo cultivation
	Fm in small patches only with dense bush Land elsewhere broken with gn/gb Separate sp gardens Larger extensions than in (1) 4–8 years under mz, some sg for 2–3 years	Sp/legumes in separate dambo margin gardens Sg/mz in dambo grass Sg preferred in clay soil at centre 2–4 ac for 4–5 years Can exceed 7 years
3	Extensive open-bush cultivation	
	Larger areas of open bush are cleared, including poor and stony ground Some land is broken with gn, most directly in relation to mz Small gn gardens are ploughed on neighbouring sites; abandoned after 1 year only No sg or fm grown; if sp planted, not in traditional mounds At the time of observation, enlargement was in process; more advanced clearances had stopped at about 25 acres Manuring undertaken with the objective of cultivating permanently	

Crops are denoted as fm (finger millet), mz (maize), sorghum (sg), cp (cow pea), sp (sweet potato), gn (groundnut), gb (ground bean). [1] The labour requirement to clear scrub means that plots are limited to 2–4 acres. Over time, return to land under secondary vegetation results in expansion of cleared land and the transition to stage 2. [2] There is a tendency to move to dambo cultivation to increase available land and reduce the labour demand for removing tree stumps.

ward" or "advanced" is applied to particular villages rather than to an ethnic group. Further, he observed there the Lamba practice of the cassava test (p. 227, 326, 340), an empirical rather than ecological approach to soil selection by which a single row of cassava was planted at a site under consideration for cultivation and settlement to assess the potential of the soil.

In summary, while the reports of the Ecological Survey (Trapnell and Clothier, 1937; Trapnell, 1943) might be regarded as trying to advance some sort of "ecological concept of development", we conclude that Speek's (2014) account of Trapnell's understanding is too reductive. Both Trapnell's field records and their synthesis in the final reports suggest a more nuanced understanding of the development, sharing, and adoption of cultivation strategies. Still less is Trapnell's understanding being consistent with the account of ecological surveys given by Anker (2002) in his discussion of Bourne's contribution to air photography as a survey tool in the Fifth International Botanical Congress in Cambridge. Anker (2002, p. 134) states "The political aim of ecological sampling in a grand survey of the empire was thus to find environmental solutions to social unrest among diverse human ecological groups in the colonies. The idea was to divide different races according to their corresponding ecological zones." This is hardly reflected in Trapnell's understanding of how peoples moved between environments and adapted to them. Nonetheless, Trapnell's perspective on African cultivators, while sympathetic, also shared the limited colonial understanding of the factors other than agronomic and economic, including cultic, ideological, and political concerns, that might motivate the peoples' decisions on what crops to grow and where to grow them.

5 Early syntheses

In this section, we consider the early outputs from the Ecological Survey and the syntheses which they present on the soils of the Upper Valley and surrounding Plateau, the traditional practices of cultivation, and the challenges for development.

5.1 Clothier's report on the Kafue basin

The first output from the Ecological Survey was a report by Clothier on observations from the period 1932–1933 (Clothier, 1933). Unlike Trapnell, Clothier was an agriculturalist and a recent graduate from the Imperial College of Agriculture in Trinidad (Tilley, 2011), but the report sets the agricultural observations in an ecological context that is entirely consistent with both Trapnell's field notes and the subsequent published reports detailed in Sect. 6. Although consistent, Clothier's ecological terminology is somewhat different from that of the final reports. He identified three "bush types": the plateau bush predominantly on the old peneplain with *Brachystegia–Isoberlinia* vegetation and fringing of *Combretum–Terminalia* trees and/or grassland; transitional bush on residual sandy soils, i.e. at the margins of the plateau where rejuvenation increases the relief and soil fertility and with *Combretum–Afrormosia or Combretum–Albizzia* scrubland; sweet bush on colluvium and in the lower plains of drainage basins with *Acacia* tree grasslands and tall *Hyparrhenia* grasses. "Sweet bush" denotes pasture land over soils with a large nutrient supply relative to the rate of primary production – *soetveld* in Afrikaans in contrast to *sourveld* (Ellery et al., 1995).

Clothier (1933) uses this framework to describe a set of "cultivation systems". These are set out in some detail in Table S6. Certain systems are characteristic of particular bush types. For example, residual cap cultivation was found in Plateau bush where communities had limited or no opportunities to cultivate in dambos. This system was limited by the nutrient supply from cut and burned vegetation, and continuous cultivation was limited to 2 or 3 years, with millets and gourds being the principal crops. Similar systems, though typically with longer cultivation periods, were found in transitional bush (dense-scrub system) mainly cultivated for maize. In the sweet bush, sites were cultivated for substantially longer (up to 10 years in *Acacia woodii* belts and *A. woodii–A. campylacantha* transitions. Dambo heads and sweet dambo sites in Plateau bush, with *A. campylacantha* and *H. rufa* or *H. filipendula*, were fertile and productive sites in contrast to the dominant local soil and vegetation. Sweet dambo cultivation was also found in the transitional bush.

Clothier also noted that choices on cultivation often depended on the range of soil and bush types available to a community. Residual cap cultivation, for example, would be found in Plateau bush only where a community did not have the option of dambo cultivation. Similarly, colluvial belt cultivation would be practised only for subsidiary gardens in transitional bush where communities had the option of cultivating in sweet dambos. Furthermore, communities near the railway line had the opportunity to sell maize into larger markets for cash, and this influenced decisions on land use. For example, on thorn fringe sites with *A. woodii* in transitional bush, large maize gardens could be found where communities had market access. Otherwise, maize was grown on smaller plots in such sites, along with groundnuts, cowpeas, and gourds. In short, Clothier's overview emphasizes that a community's decisions about cultivation took account of ecological conditions over a range of accessible sites, as well as opportunities beyond subsistence production.

5.2 Trapnell's contribution to the second meeting of African soil chemists, Zanzibar

On the initiative of William Nowell, director of the Amani Research Station, Tanganyika, the soil chemists from British East African territories convened in Amani in 1932 to discuss, primarily, the production of a soil map of the region (Milne, 1932). A second meeting to discuss progress was held in Zanzibar in 1934 (Milne, 1935). Trapnell had just begun his fieldwork in Zambia when the East African soil chemists met at Amani. By the time of the meeting in Zanzibar, he had begun a correspondence with Milne, had submitted three abstracts to the meeting, and had been engaged to open a discussion entitled "Ecological survey in its relation to soil survey". However, Trapnell did not attend. A letter from Milne to Trapnell after the meeting (Milne, 1934) shows that this was a decision of the Department of Agriculture in Northern Rhodesia made on financial grounds. Nonetheless, Trapnell's contributions appear in print in the proceedings (Milne, 1935), and an abstract entitled "A vegetational grouping of soils in Northern Rhodesia south of latitude 15°30′" is his first printed account of the principal soil groups of central and western Zambia and their relation to vegetation outside the pages of reports of the Northern Rhodesian government. Additional notes received from Trapnell during the meeting, accompanying draft map sheets, were read out.

As Trapnell did not present this in person, there is no amplification of a fairly terse abstract, and there is not any reported discussion. The abstract's stated aim was to describe "the main visible characters of soils grouped according to the principal vegetation formations, using, as far as possible, the groupings of Henkel's vegetation map of Southern Rhodesia [Henkel (1931)] together with what has been recorded of the vegetation of Nyasaland and Tanganyika." Trapnell set out four "main groups" of soils, with subgroups, stating that "main groups answer approximately to soil groups of different history, the sub-divisions answer to fertility distinctions." Trapnell indicated that this classification should allow comparisons with East Africa and postulated that similar soil–vegetation relations might be found elsewhere at comparable altitudes and where the rainfall is similarly unimodal.

Trapnell's main groups, as presented at the Zanzibar meeting, are shown in the first column of Table 2, with the corresponding units from the subsequent survey reports and the Vegetation–Soil Map (Trapnell et al., 1947). Here, we focus on the Plateau and Upper Valley groups and their subgroups.

The Plateau group of soils was characterized by *Brachystegia–Isoberlinia–Uapaca* tree cover on the Archean complex. The soils were described as eluvial cover of the ancient peneplain, where this has not been covered by Kalahari sand or rejuvenated by recently renewed erosion cycles. Characteristic of the soils are nodular ironstone deposits at level sites, either in the profile or exposed at dambo margins or by rejuvenation.

Trapnell listed four sub-divisions of the Plateau group, and the abstract gives no details beyond the names. They pick out contrasts in soil texture: sandy Plateau soil and Plateau red loams, although the latter were identified as a new main group in the northeastern survey (Trapnell, 1943) and the final map (Trapnell et al., 1947). The shallow nodular soils and ironstone swamp soils pick out local conditions related to drainage and erosion history, with clear implications for land use.

Table 2. Development of main soil units used by Trapnell in published accounts. Within any one column, the units have sometimes been reordered to show relationships between the legends, but the numbers show the original ordering in each source. A cell with a bullet, •, indicates that there was no unit in that legend corresponding to other units in the same row of the table.

Zanzibar abstract (Milne, 1935)	North-Western report (Trapnell and Clothier, 1937)	North-Eastern report (Trapnell, 1943)	Vegetation–Soil Map (Trapnell et al., 1947)
1. Karroo Valley group	4. Lower Valley soils	5. Lower Valley soils	6. Lower Valley soils
2. Kalahari group	2. Kalahari sands	NA[1]	4. Kalahari sands
3. Plateau group	1. Plateau soils	2. Plateau soils	3. Plateau soils
•	•	1. Red earths[2]	Red earths and related red loam soils
4. Upper Valley group	3. Upper Valley soils	4. Upper Valley soils	5. Upper Valley soils
•	5. Grey and black soils	6. Dambo and swamp soils	7. Grey and black swamp soils
•	•	3. Lake basin soils	2. Lake basin soils
•	•	•	8. Escarpment hill soils[3]

[1] Kalahari sands are restricted to the west of Zambia, and so the unit was not used in this part of the ecological survey. [2] Introduced as a variant of the Plateau soils.
[3] There is a reference to these by Trapnell and Clothier (1937), but they are not treated as a distinct unit, although they do appear implicitly in one of the map legend units ("*Isoberlinia globiflora–Brachystegia* woodlands of escarpment hill country passing into Lower Valley types", the third of the "Southern Plateau types").

The Upper Valley group of soils has distinctive vegetation: *Combretum* and *Acacia* tree cover on the Archean complex and on younger sedimentary rocks other than those of the Karroo group found in the lower valley. The soils were formed as a result of erosion on the ancient peneplain, resulting from rejuvenated drainage, and so appear to be less mature than the Plateau soils. Ironstone concretions are absent or present as residual decomposing surface blocks.

More information is provided on the sub-divisions of this main group than for the Plateau soils. The transitional soils are residual or residual–colluvial soils (i.e. soils formed either in situ at denuded sites or in a mixture of such residual material and colluvium). They comprise immature sandy loams, grey colluvial soils, and red sandy loams. These are contrasted with the thorn soils with three sub-divisions: red thorn loams, black thorn clays, and the winterthorn alluvium (winterthorn refers to *Acacia albida*). At this stage, Trapnell did not name characteristic vegetation of the transitional soils, and it is left implicit that the thorn soils were predominantly formed in colluvial or alluvial material. The abstract promised further notes on the fertility of these soils and their suitability for staple African crops, and, had Trapnell presented these, they would presumably have been consistent with Clothier's report (Clothier, 1933).

6 Reports of the Ecological Survey

6.1 The Soils, Vegetation and Agricultural Systems of North-Western Rhodesia, Trapnell and Clothier (1937)

This was the first publication from the Ecological Survey, apart from departmental reports. Some of the key information contained in this report about soils and the vegetation mapping units is summarized in Table S7.

6.1.1 Soils and vegetation

The account of the soils in the report is structured mainly by topography, reflecting Trapnell's summary for the second East African meeting (Milne, 1935). This is presented as an alternative to a description of the soils based on chemical analyses, which were not available due to the retrenchment of the soil chemist position. In the account of the soil classes, the (then) recently published East African Soil Map (Milne, 1936) is treated as normative; the point is emphasized that the soils are described "in terms consistent with those employed by the recently prepared East African Soil Map".

Here, we focus on the Upper Valley soils and their neighbouring Plateau soils. Trapnell and Clothier (1937) note that the latter are widespread on the south-central African plateau and, while showing some variations with respect to colour and particle size distribution, have in common that they have formed on topography in a state of maturity and stability, in which they have been subject to seasonal leaching over a long period of time. Typically nodular or concretionary ironstone is found close to the regolith, and this is most pronounced in poorly drained conditions, which may arise from flat topography, impervious underlying rock, or proximity to a dambo.

A broad distinction was made between the northern Plateau (north of the 40 in. isohyet), with deeper soils with a larger clay content and brighter colours than those of the southern Plateau, which are typically 50 %–60 % sand. Chemical analyses were available only for the southern soils, and these indicated low fertility.

Three soil subgroups were recognized. The first are older ironstone soils, pallid and shallow, from the older land surfaces with little variation despite the underlying geological variation and with ironstone, which drew a parallel with the murram soils of Milne (1936). While used to grow finger millet, these soils were described as "agriculturally useless".

Light-coloured Plateau soils were associated with partially regraded plateau surfaces and show greater variation, particularly in colour and texture. Yellow and orange clay soils were found on the northern Plateau, and orange and pink to buff soils were found around the Copperbelt. In the drier conditions of the southern Plateau, the colours were more muted, and the Plateau soils were sandier in texture. These soils are explicitly compared to the Plateau soils of Milne (1936). Finally, red and brown Plateau soils were identified, specifically soils in residual or colluvial material, including deep-red clay soils over calcareous parent material on the northern Plateau. These soils are correlated with the red earths of Milne (1936) and are described as including the most fertile Plateau soils. Note that the term "correlation" in this context means that two soil classes, identified and mapped in two different settings, are recognized as equivalent. The term is applied this way in geological and soil surveys and was used in the discussion at the Amani meeting reported by Milne (1932).

Trapnell and Clothier (1937) mapped four principal units on Plateau soils. On the northern Plateau, they identified *Brachystegia* woodland on clay soils and *Brachystegia–Isoberlinia* woodland on more variable soil. On the southern Plateau, *Isoberlinia paniculata–Brachystegia* woodland was mapped over sandy soils, and *Isoberlinia globiflora–Brachystegia* was mapped over sandy loam, extending from the Plateau onto adjacent Kalahari sands, the "Kalahari contact" soils. The map legend also groups *Isoberlinia globiflora–Brachystegia* woodland over the escarpment hills, extending to the lower valley with the Southern Plateau units.

The Upper Valley soils are contrasted with their neighbouring Plateau soils. Trapnell compares them to the Non-calcareous Plains Soils of Milne (1936). It is noted that the distinction between the Upper Valley and Plateau soils was first recognized because of the former's distinctive vegetation cover. However, the fundamental difference lies in the Upper Valley's more modified topography, with the country being broken or rolling rather than graded to a mature surface and with free drainage. There are also some differences in parent material from the Plateau soils, with limestone and mica schists being common. The younger soils, both residual ones formed in situ on rejuvenated surfaces and those formed in resulting colluvium, are loamy in texture, varying from sandy to clay loams. While they might show some mobilization of iron as mottles or coatings on rock fragments, ironstone formations are lacking. Like the soils of the Lower Valley, the subsoils may have a basic reaction. The key practical difference from the Plateau soils is their larger base saturation and larger content of phosphate and nitrogen, making them notably more fertile.

The key sub-division of the Upper Valley Soils, made by the time of the central and western report, was between the thorn soils under *Acacia*-dominated cover and the transitional soils, intermediate between the thorn soils and the Plateau types, although the vegetation map published by Trapnell and Clothier (1937) did not attempt to display these as mapping units.

The transitional soils had tree cover dominated by *Combretum* and members of *Papilionoideae*, notably *Afrormosia angolensis*. The thorn soils were mainly on colluvial sandy loam material and also included some alluvial soil under *Acacia*. Trapnell and Clothier (1937) describe the thorn soils as finer in texture than the transitional soils, as well as being more coherent (by which we assume that they meant more cohesive). The thorn soils were described by Trapnell and Clothier (1937) as the "best maize land and dry grazing in the country", generally with a larger nitrogen content than other soils, the phosphate content being variable. The transitional soils, mainly residual, were described as well-drained, friable sandy loams of variable coherence and with double the phosphate content of the adjoining Plateau soils. They were regarded to be light maize soils with potential to grow tobacco and cotton.

This synthesis inevitably requires generalization of the observations made on the ground and recorded in the traverse records. For example, in the Macha to Namwala record, commencing on page 533, there is an interval, mapped to transitional soils in the Upper Valley, where the records show a complex pattern of woodland, tall grassland on level ground, and gentle slopes with red soils over schists and quartz. Characteristic species of the transitional soils were seen (*Albizzia, Pterocarpus, Afrormosia*), along with other tree species (*Afzelia, Ostryoderris*) and even some "rogue" *Brachystegia*. Of particular note is the appearance of *Acacia campylacantha* and *A. albida* on dambo soils surrounded by *Brachystegia* of the Plateau (e.g. at Mukulaikwa's, p. 438). Alluvial dambo soils carry local vegetation characteristic of the colluvial thorn soils in the Upper Valley and also have considerable agricultural value. This was made explicit by Clothier (1933) in his Kafue basin report (Sect. 5.1), where he notes the parallels between the type-C cultivation systems of the sweet bush under *Acacia campylacantha* and the dambo heads and sweet dambo of the Plateau bush, where gardens were established in places where *A. campylacantha* was found along with tall *Hyparrhenia* grass.

6.1.2 Agricultural systems

Trapnell and Clothier (1937) describe five principal agricultural systems of the Upper Valley and two principal Southern Plateau systems, along with local variants. The descriptions of these systems are summarized in Table S8. The three transitional country systems are distinguished with respect to topography: dense scrub adjoining the Plateau, dambos and their margins, and bush gardens. In all of these, ploughing might be practised, and the cultivation period can be extended beyond that under traditional cultivation. A single thorn soil system was recognized, often subject to large-scale cultivation with the plough, although not by the Ila people. A transitional sand system was also described, dependent on the burning of brushwood and cultivated with maize in the first year and then with bulrush millet with groundnuts planted in garden extensions in the second year. This was sometimes followed by a maize crop with or without sorghum.

The primary distinction made within the Southern Plateau system was between *Isoberlinia paniculata–Brachystegia* woodland, cultivated as the main gardens and village gardens in the central regions and over poorer Kalahari contact soils, and the *Isoberlinia globiflora* woodland cultivated by Tonga people in the south, again in main gardens and village gardens. All variants were dependent on the felling, piling, and burning of tree branches followed by hoeing of all the cleared land.

As with the soil and vegetation observations, the agricultural systems delineated by Trapnell and Clothier (1937) are generalizations of the complexity that they observed in the field. For example, at Chongo's (31 August 1932, p. 381), Trapnell observed what he called "semi-permanent" cultivation on thorn soils of the Upper Valley, with 3 years of cultivation, followed by 2 years' fallow practised on two fields, with the second one cultivated for the first time in the third year of cultivation, compensating for reduced yield. Trapnell called this a system of "minor shifts" (i.e. of the principal field in cultivation), with major shifts happening perhaps only when a son took over cultivation from his father. The 3-year-long cultivation might be extended to 4 years where less land was available.

Similarly, on the plateau, at Chisako's (1934, p. 542), under *Isoberlinia paniculata*, Trapnell observed a complex variant of the Southern Plateau system where grass was brought in to supplement the wood that was burned around an anthill; where earlier-maturing crops were grown on the edge of the plot; and where the larger sites were sown with different sequences of maize, finger millet, or pumpkin depending on local soil conditions, which might be followed by a sweet potato crop before being abandoned.

6.1.3 Agricultural development

The Ecological Survey reports (Trapnell and Clothier, 1937; Trapnell, 1943) provide recommendations for agricultural development, structured around the traditional systems that had been identified. Trapnell and Clothier (1937) comment that the improvement of "a consistent but flexible body of agricultural tradition ... is not a task to be undertaken lightly". They also note that the Ecological Survey can be regarded only as a first attempt to develop the understanding of these systems, which is needed prior to any attempt at improvement. In the case of the Upper Valley system, however, they observed that, in the vicinity of the rail line, the main priority was remediation in light of rapid change which had already occurred. However, they see the traditional Upper Valley system as offering the best basis for development. Tentatively, they suggest that some changes to rotations, including groundnuts, cotton as a new crop, and the use of composts, could be preferable to increased cultivation of dambos or of thorn soils with greater potential for European agriculture.

6.2 The Soils, Vegetation and Agricultural Systems of North-Eastern Rhodesia, Trapnell (1943)

The traverse records on which we focused in this study contributed to the report of Trapnell and Clothier (1937), and so, here, we focus in brief on the emerging structure for representing soil variation as it stood after completion of fieldwork across the country.

The account of the regional soil types starts with more reflection on general principles than in the earlier report. Three primary factors to which soils owe their characteristics are identified. The first is climate (past and present), and the second is the parent material. Trapnell describes the third factor as "the age of the land surface or the alterations which have taken place in its relief". This third factor controls both the maturity of the soil and the extent to which past or present climate influences the properties observed now. This factor of relief, says Trapnell (1943), "cuts across the broad zonal arrangement of climatic soil types". This emphasis on a climatic pattern, albeit one disrupted by geomorphic processes, is in contrast with the northwestern report where soil variations attributable to climate (e.g. the strongly alkaline soils of the Lower Valley) do not map simply onto the emphasized topographic grouping. This is most probably because extension of the survey to the east of the country introduced a substantial region of lower latitudes than those traversed in the west. Trapnell (1943) notes, for example, the pronounced contrast between the humid environment in which the grey humic soils of the lake basin region were formed and the "pedocal" conditions in the Lower Valley environments where intense evaporation and soil moisture deficits result in the development of alkaline soils, sometimes with nodular lime. Traverses in the east of the country also covered red earth soils, which Trapnell correlated with those of the East African Soil Map.

Of particular interest here, however, is the comment of Trapnell (1943) on how the age of the land surface and changes in the relief modify the effects of climate and parental material due to this being key to the genesis of the Upper Valley and its distinctive and agriculturally important soils. The rejuvenation of the ancient land surface creates residual and colluvial soil parent material, within which soils develop under near-contemporary climatic conditions. Trapnell (1943) describes the Upper Valley soils as "essentially soils of the present, formed, and in North-Eastern Rhodesia probably still in the process of formation, in areas rather lower than the general plateau level where the land surface appears to have undergone comparatively recent modification". This younger parent material is one reason why the Upper Valley soils are typically very fertile.

As in the previous report, Trapnell explains that a "regional physiographic basis" for classification was used because of the paucity of soil analytical data. However, he states that, when physiographic differences are accounted for, he expects to see a "climatic sequence". Such a sequence might be seen in the transition, north to south, from Plateau soils ("light pink-brown or buff topsoils over "rawer" coloured subsoil. Largely structureless save for ironstone pellets") to Upper Valley soils ("warmer chocolate-toned soils with increasing clod-structure to brown pedocal soils with vertical cracking in the Lower Valley").

6.3 The Vegetation–Soil Map of Northern Rhodesia

The notion of climatic sequences cut across by physiographic differences, introduced in the northeastern report (Trapnell, 1943), was developed further and presented in the memoir of the 1947 vegetation–soil map (Trapnell et al., 1947). In the introductory paragraph (15), the "climatic sequence" model of national-scale soil variation is developed and extended. In the northeastern report, the Lower Valley soils, Upper Valley soils, and Plateau soils were treated as a sequence from those formed in the wettest conditions (plateau) to those formed in the most arid conditions (pedocals of the Lower Valleys). This sequence was recognized "after physiographic differences were accounted for". In the 1947 memoir, the red earths and lake basin soils (or grey earths) were placed at the top of a "main series" (after the Plateau soils), representing, respectively, tropical and more temperate high-rainfall conditions, with the former being lateritic (in the sense of including pisolithic or concretionary ferruginous material) and the latter being humic and podsolic. Two associated series are identified, again on a dry-to-wet climatic gradient. The first are "hydrogenic soils" from black calcareous clays at the dry end through to grey dambo soils to moorland and swamp peats at the wet end. The second are the "lithological types", essentially soils on sand, from transition soils to Kalahari sands to the bracken sands in the wettest conditions.

Within this fully developed framework, Trapnell et al. (1947) note that the Plateau soils give way to Upper Valley soils in lower areas of younger relief. The soils of the Upper Valley are described as "warmer-toned" pink-brown or cocoa-coloured to chocolate or darker-brown soils with a more pronounced increase in base saturation and in exchangeable bases with depth than on the neighbouring Plateau soils. The earlier correlation with the Non-calcareous Plains Soils of Milne (1936) is reiterated.

Trapnell et al. (1947) note that there are associated "limited belts" of soils with affinities for red loams, treated as intrazonal soils. In 1962, the 1947 map was reprinted, and it is from this that the map published by Smith and Trapnell (2001) was produced. One difference between the two maps is the introduction of some red "R" symbols denoting the occurrence of red loams on areas mapped to Upper Valley soils in the eastern map sheet and in the easternmost parts of the western map sheet. These would have been introduced by Trapnell, who by then had worked in East Africa.

7 Conclusions

Trapnell and Clothier (1937) offer a framework for thinking about soil variation in the Upper Valley and surrounding Plateau of western and central Zambia which is based primarily on physiography. Trapnell presents a sophisticated understanding of how normal erosion, in response to a change in base level, and the consequent rejuvenation of the plateau produce both residual and colluvial parent material for pedogenesis with a larger content of weatherable minerals and so greater fertility than the soils of the Plateau. Furthermore, the climatic steady state to which this soil is converging is different from that reached by the Plateau soils in a contrasting palaeoclimate. These pedogenetic differences account for the observed ecological variation and the associated differences in land capability for farming. In the wider western and central regions, there are climate differences related to topography between the Lower and Upper Valleys and the Plateau, and, to the west, a covering of aeolian Kalahari sand imposes a parent material over the underlying bedrock, with the characteristics of the soil depending on the thickness of the superficial material.

At the time of Trapnell's fieldwork, soil scientists such as Marbut, influenced by the Russian school of pedology through the writings of scientists such as Glinka, which Marbut translated from German to English (Anonymous, 1930), were convinced that soil conditions were primarily determined by climate. Differences between soils in a common climatic setting, inherited from parent material, could simply be attributed to the soils' immaturity. This view is expressed by Shantz and Marbut (1923) and provided the basis for their proposed map of African soils based on a handful of samples interpreted with respect to a climatic map. This school of thought was largely rejected by soil scientists working in British territories in Africa (Milne, 1932), and it is clearly not consistent with Trapnell's recognition of the importance of the effective age of the weathered material in explaining the ecological and agricultural differences between most soils of the Plateau and those of the Upper Valley.

On the extension of the Ecological Survey to the rest of the country (Trapnell, 1943; Trapnell et al., 1947), Trapnell encountered a wider range of climatic variation, and so his overall pedogenetic model was extended. Trapnell thinks of parent material, hydrology, and relief as "cutting across" the climate trend so that soils under comparable climates do not necessarily converge when other factors of soil formation operate at different spatial scales. In recognizing that plural and connected factors control pedogenesis, Trapnell's practice in the field anticipated the contribution of Jenny (1941).

This is a striking parallel with the views of Trapnell's mentor, Arthur G. Tansley, in Tansley's opposition to Clements's climatic "mono-climax" model of vegetation ecology (Van Der Walk, 2014). John Phillips argued for the mono-climax model in southern Africa, specifically in dispute with Alfred P. G. Michelmore, who noted the distinct vegetation found at the margins of the central African plateau, where it is rejuvenated by drainage – he describes what Trapnell would call transitional bush (Michelmore, 1934).

Trapnell's work in the Upper Valley, and the overall Ecological Survey, is arguably of greater significance than the East African Soil Map. While the work of Milne (1936) was an impressive piece of synthesis, it was largely a desk exercise in correlating existing observations with a set of classes acceptable across the region. Milne's important field observations (Milne, 1947) were made after the map was published. By contrast, Trapnell developed a conceptual model in the field that allowed the interpretation of the observed land form and vegetation to guide the delineation of mapping units.

The geomorphological understanding behind the Upper Valley soils was at least as sophisticated as the catena model presented alongside the East African Soil Map. Furthermore, the idea of regular lateral patterns of soil conditions had already been identified by Henkel (1931), and Trapnell's field records frequently capture such lateral patterns of soil and associated ecological variations in cross-section diagrams. That these were confined to field notes and did not feature in published reports meant that Trapnell's innovative practice of science in the field was not recognized.

Trapnell states (Trapnell and Clothier, 1937) that the Ecological Survey soil units are consistent with those of Milne (1936). The reading of his field records makes clear that they were not simply derivative from the East African work. Emphasizing their consistency would have been important for validation of the Ecological Survey work, given Bourne's critical comments (Sect. 4.4), but may have resulted in an under-emphasis of the originality of the work in Zambia.

While Trapnell made only limited use of air photography, his collaboration with Robbins showed how careful field interpretation could be combined with imagery to support ecological soil mapping. Key to Trapnell's approach was the development of a conceptual model linking land forms, soil development, vegetation, and agricultural potential. Studies have shown the model to be robust (e.g. Mukumbuta et al., 2022a), at least in so far as the mapping is consistent with later work. Substantial loss of natural vegetation means that Trapnell's original framework is no longer directly applicable in the field, but his approach offers a model for assessing challenges for land management within a framework based on an understanding of processes.

The wider value of Trapnell's field method was that it enabled him to identify ecological soil selection rules used by African cultivators and to relate them to both farming practices and underlying soil variations, with these having a basis in physiography and climate. This provided the empirical basis for an understanding of the ecology of traditional farming practices and for a representation of how these practices might be distributed in space. But Trapnell's understanding of the practices of African cultivators and their distribution was not simple determinism. He recognized that cultivators often have to move over varying distances and for reasons which may be political, economic, or the result of environmental change. In that setting, rules are adapted, and Trapnell and Clothier (1937) gave examples of how a cultivator in a new environment might adapt and combine features of systems used by their neighbours. Although Trapnell regarded the adoption of European technology, such as the plough, by African cultivators to be detrimental, it was not irredeemable (Trapnell, 1934a), and further adaptation was possible. In this, his understanding of African cultivation is more nuanced than the "ecological model" proposed by Speek (2014), in which the African cultivator is essentially an unconscious "natural" actor in the ecosystem.

That said, Trapnell's field records do show how critical aspects of life on the plateau and Upper Valley can be missed without an openness to local "ways of knowing". Trapnell regards cultivators' interpretations of ecosystems as "unconscious" where they do not parallel the taxonomic practice of a western ecologist in "naming" species, but it is entirely possible that a "structural" rather than a taxonomic approach to ecological indicators could constitute important "indigenous knowledge". Similarly, Trapnell was inclined to disparage groups such as the Lamba (Speek, 2014), who were reluctant to participate in the changed agricultural economy under colonialism or to move to agriculturally superior land, with respect to their "backwardness" or lack of industry. As we have seen, this view overlooks other factors that may influence decisions on land use, including social, cultic, and ideological ones. This consideration underlines the importance of an approach to indigenous knowledge of soil and land use that starts with careful and respectful attention to the conceptual framework in which the knowledge is produced. This requires cross-disciplinary research, particularly with linguists, as illustrated by an early sketch of traditional soil classification in post-independence Zimbabwe (Nyamapfene, 1983), rather than looking for mappings of "indigenous" soil classifications onto "scientific" ones (e.g. Oudwater, 2003).

A target of recent decolonizing cultural and historical criticism is the colonial fallacy of "emptiness" to justify the appropriation of land portrayed as unused, underused, or misused (Wahu-Mũchiri, 2023). Trapnell's model of the complexity of environmental history on Zambia's Upper Valley and Plateau, including climate change, fire, secondary succession under fallow, and social adaptation to new conditions, certainly could not sustain the fallacy but rather undermines it. As such, it deserves wider historical attention.

The natural advantages of the Upper Valley made the Southern province Zambia's "breadbasket" after independence, with maize production being over one-third of the national total in the early 1980s (Kasali, 2011). However, in subsequent years, these advantages have been lost, and the contribution of the province to national maize production had declined to around 10 % by 2008. Kasali (2011) attributes this to the large-scale adoption of ploughing and stumping and attendant deforestation, precisely the concerns that Trapnell had raised. Kasali (2011) suggests that conservation farming strategies, drawing on traditional cultivation practices, offer a way forward. Stump (2010) argues that, too often, attempts to intervene to address such problems in Africa start from judgements about land use based on historical arguments which are unsubstantiated. Traditional practices are, according to Stump (2010), typically framed in oversimplified terms as "ancient and backward" or "long-lived and sustainable". In the setting of the Upper Valley we are better placed, thanks to Trapnell, to make more nuanced historical judgements and to recognize traditional practices as "sustainable because [they are] capable of adaptation and of underpinning further adaptation." This has implications for how future challenges can be addressed. Cross-disciplinary evaluation of the Ecological Survey and other information on farming practices collected in a colonial or post-colonial setting (so that the technical material is evaluated and understood in its historical and social context) can contribute to the reclamation of traditional knowledge for the development of resilient and sustainable agriculture in a changing environment.

Code and data availability. The data presented in this paper are available upon reasonable request to the corresponding author.

Supplement. The supplement related to this article is available online at: https://doi.org/10.5194/soil-10-887-2024-supplement.

Author contributions. Funding acquisition was done by RML, LMC, and SS. Systematic reading of Trapnell's field records was undertaken by IM, RML, NLM, and MJH. Archival materials were located, read, and reported by NLM, MJH, and RML. Visualization of data was done by RML. RML, NLM, and MJH produced the initial draft of the text, and all the authors contributed to subsequent revisions and the production of the final version.

Competing interests. The contact author has declared that none of the authors has any competing interests.

Disclaimer. Publisher's note: Copernicus Publications remains neutral with regard to jurisdictional claims made in the text, published maps, institutional affiliations, or any other geographical representation in this paper. While Copernicus Publications makes every effort to include appropriate place names, the final responsibility lies with the authors.

Acknowledgements. This research was funded by the United Kingdom Research and Innovation (UKRI) Arts and Humanities Research Council (grant no. AH/T00410X/1) through their Programme "Cultures, Behaviours and Histories of Agriculture, Food, and Nutrition", part of the UK Research and Innovation's Global Challenges Research Fund.

Financial support. This research has been supported by the Arts and Humanities Research Council (grant no. AH/T00410X/1).

Review statement. This paper was edited by Simeon Materechera and reviewed by Doyle McKey, Paul Smith, and one anonymous referee.

References

Adamson, R.: Report on Inauguration of the Ecological Survey, Unpublished Report to the Government of Northern Rhodesia. Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia, Reference NAZ/-MAG 2/9/0, 1932.

Allan, W.: Studies in African Land Usage in Northern Rhodesia, Oxford University Press for Rhodes-Livingstone Institute (Paper No. 15), London, 1949.

Allan, W.: The African husbandman, Oliver & Boyd, Edinburgh, 1965.

Allan, W., Gluckman, M., Peters, D., Trapnell, C., McNaughton, J., and Conroy, D.: Land Holding and Land Usage among the Plateau Tonga of Mazabuka District: A Reconnaissance Survey, Oxford University Press for Rhodes-Livingstone Institute (Paper No. 14), London, 1948.

Anker, P.: Imperial Ecology: Environmental order in the British Empire, 1895–1945, Harvard University Press, Cambridge, Mass, 2002.

Anonymous: Soil Genesis and Morphology. Review of The Great Soil Groups of the World and their Development by K.D. Glinka translated from the German by C.F. Marbut. Thomas Murby and Co., London, 1928, Nature, 126, 88–89, 1930.

Baldwin, R.: Economic Development and Export Growth: A Study of Northern Rhodesia, 1920–1960, University of California Press, 1966.

Bowman, A.: Ecology to technocracy: scientists, surveys and power in the agricultural development of late-colonial Zambia, J. S. Afr. Stud., 37, 135–153, 2011.

Clarke, G.: The Study of Soil in the Field, Oxford University Press, Oxford, 1936.

Clothier, J.: Ecological Survey Report (1932–1933), Part One: Native Agriculture, Kafue Basin, Agricultural and Bush Types, Unpublished Report to the Government of Northern Rhodesia. Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia. Reference NAZ/-MAG 2/9/004, 1933.

Cole, M.: Vegetation and geomorphology in Northern Rhodesia: an aspect of the distribution of the savanna of Central Africa, Geogr. J., 129, 290–305, 1963.

Colonial Office: Correspondence with regard to native policy in Northern Rhodesia, in: British National Archive CO 755/40/10, 1930.

Colson, E.: The Plateau Tonga of Northern Rhodesia, Manchester University Press, Manchester, 1962.

Dalal-Clayton, B.: An historical review of soil survey and soil classification in tropical Africa, Soil Survey and Land Evaluation, 8, 138–160, 1988.

D'Hoore, J.: Soil Map of Africa, Scale 1:5 000 000: explanatory monograph, Commission for Technical Co-operation in Africa (Publication No. 93), CTCA, Lagos, https://edepot.wur.nl/480538 (last access: 4 December 2024), 1964.

Dixey, F.: The geomorphology of Northern Rhodesia, Transactions of the Geological Society of South Africa, 47, 9–45, 1944.

Ellery, W., Scholes, R., and Scholes, M.: The distribution of sweetveld and sourveld in South Africa's grassland biome in relation to environmental factors, African Journal of Range and Forest Science, 12, 38–45, 1995.

Fowler, D.: Traditional Ila plant remedies from Zambia, Kirkia, 18, 35–48, 2002.

Haines, E.: "Pledging the future": Investment, risks and rewards in the topographic mapping of Northern Rhodesia, 1928–1955, Environ. Plann. A, 48, 648–664, 2015.

Hammarström, H., Forkel, R., Haspelmath, M., and Bank, S.: Glottolog 4.8., Leipzig: Max Planck Institute for Evolutionary Anthropology, http://glottolog.org (last access: 13 July 2023), 2023.

Henkel, J.: Types of vegetation in Southern Rhodesia, Proceedings of the Rhodesia Scientific Association, XXX, 1–24, 1931.

Hodge, J.: Triumph of the Expert, Agrarian doctrines of development and the legacies of British colonialism, Ohio University Press, Athens, OH, 2007.

Jaspan, M.: The Ila-Tonga Peoples of North-Western Rhodesia: social and religious studies, Ethnographic Survey of Africa, West Central Africa, Part IV, Routledge, Abingdon, Oxford, https://doi.org/10.4324/9781315304755, 2017.

Jenny, H.: Factors of soil formation: a system of quantitative pedology, McGraw-Hill, New York, 1941.

Kasali, G.: Integrating indigenous and scientific knowledge systems for climate change adaptation in Zambia, in: Experiences of Climate Change Adaptation in Africa, edited by: Filho, W., 281–295, Springer-Verlag, Berlin, https://doi.org/10.1007/978-3-642-22315-0, 2011.

King, L.: South African Scenery, a textbook of geomorphology, Oliver & Boyd Ltd., Edinburgh, 1942.

Lewin, C.: Letter from C.J. Lewin to the Chied Secretary, Livingston. 29th December 1933, Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia. Reference NAZ/MAG 2/9/005, 1933.

Lloyd, J., Bird, M., Vellen, L., Miranda, A., Veenedaal, E. M., Djagbletey, G., Miranda, H. S., Cook, G., and Farquhar, G. D.: Contributions of woody and herbaceous vegetation to tropical savanna ecosystem productivity: a quasi-global estimate, Tree Physiol., 28, 451–468, 2008.

Michelmore, A.: Letter to the Editor: Vegetation Succession and Regional Surveys, with Special Reference to Tropical Africa, J. Ecol., 22, 313–317, 1934.

Mielke, H. and Mielke, P.: Termite mounds and chitemene agriculture: a statistical analysis of their association in southwestern Tanzania, J. Biogeogr., 28, 499–504, 1982.

Milne, G. (Ed.): Proceedings of a Conference of East African Soil Chemists, Agricultural Research Station, Amani, Tanganyika Territory, 21–26 May 1932, Government Printer, Nairobi, 1932.

Milne, G.: Letter from G. Milne to C.G. Trapnell, from Amani, 29 May 1934, in: File CGT/3/3/ Notes and Correspondence 1930s–1950s, Archive of the Royal Botanic Gardens, Kew, London, 1934.

Milne, G. (Ed.): Proceedings of the Second Conference of East African Agricultural and Soil Chemists, Zanzibar, 3–9 August 1934, Government Printer, Nairobi, 1935.

Milne, G.: Provisional Soil Map of East Africa (Tanganyika), in: Available at the WOSSAC Archive, Cranfield University, Cranfield, Bedfordshire, UK (Item 44922), Government of Tanganyika, Amani, http://www.wossac.com/search/wossac_detail.cfm?ID=44922 (last access: 4 December 2024), 1936.

Milne, G.: A Soil Reconnaissance Journey Through Parts of Tanganyika Territory December 1935 to February 1936, J. Ecol., 35, 192–265, 1947.

Moore, H. and Vaughan, M.: Cutting Down Trees. Gender, nutrition and agricultural change in the Northern Province of Zambia, 1890–1990, Social History of Africa, Heinemann, Portsmouth, NH, 1994.

Mukumbuta, I., Chabala, L., Sichinga, S., Miti, C., and Lark, R.: A comparison between three legacy soil maps of Zambia at national scale: the spatial patterns of legend units and their relation to soil properties, Geoderma, 402, 115193, https://doi.org/10.1016/j.geoderma.2021.115193, 2022a.

Mukumbuta, I., Chabala, L., Sichinga, S., Miti, C., and Lark, R.: Accessing and assessing legacy soil information, an example from two provinces of Zambia, Geoderma, 420, 115874, https://doi.org/10.1016/j.geoderma.2022.115874, 2022b.

Nyamapfene, K.: Traditional systems of soil classification in Zimbabwe, Zambezia, 11, 55–57, 1983.

Oudwater, N., M. A.: Methods and issues in exploring local knowledge of soils, Geoderma, 111, 387–401, 2003.

Pawlowicz, M., Fleisher, J., and de Luna, K.: People on the Move: Spatial Analysis and Remote Sensing in the Bantu Mobility Project, Basanga, Zambia, African Archaeology Review, 37, 69–73, https://doi.org/10.1007/s10437-020-09363-0, 2020.

Posner, D.: The Colonial Origins of Ethnic Cleavages: The Case of Linguistic Divisions in Zambia, Comparative Politics, 35, 127–146, 2003.

Ranger, T.: Missionaries, migrants and the Manyika: the invention of ethnicity in Zimbabwe, in: The Creation of Tribalism in Southern Africa, edited by: Vail, L., Currey University of California Press, London Berkeley, 118–150, http://ark.cdlib.org/ark:/13030/ft158004rs/ (last access: 4 December 2024), 1989.

Ribeiro, N., Grundy, I., Gonçalves, F., Moura, I., Santos, M., Kamoto, J., Ribeiro-Barros, A., and Gandiwa, E.: People in the Miombo woodland: socio-ecological dynamics, in: Miombo woodlands in a changing environment: securing the resilience and sustainability of people and woodlands, edited by Ribeiro, N., Katerere, Y., Chirwa, P., and Grundy, I., 55–100, Springer, https://doi.org/10.1007/978-3-030-50104-4_3, 2020.

Robbins, C.: Report by Capt. C.R. Robbins (Aircraft Operating Company) in conjunction with the Agricultural Survey Commission, Report with associated correspondence and commentary by Bourne, R., Trapnell, C. G., Smith, J., Lewin, C. J., Department of Agriculture, Government of Northern Rhodesia, Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia, Reference NAZ/MAG 2/9/005 Location 170, 1932.

Robbins, C.: Northern Rhodesia; an experiment in the classification of land with the use of aerial photographs, J. Ecol., 22, 88–105, 1934.

Sampson, H.: Memorandum, 28 June 1928, in: Kew/2NR4 Ecological Survey, Archive of the Royal Botanic Gardens, Kew, London, 1928.

Shantz, H.: Agriculture in East Africa, in: Education in East Africa, Phelps-Stokes Fund, New York, 353–401, 1925.

Shantz, H. and Marbut, C.: The Vegetation and Soil of Africa, American Geographical Society Research Series No. 13, National Research Council and American Geographical Society, New York, 1923.

Shaw, J. T., Allen, G., Barker, P., Pitt, J. R., Pasternak, D., and Bauguitte, S. J.-B.: Large methane emission fluxes observed from tropical wetlands in Zambia, Global Biogeochem. Cy., 36, e2021GB007261, https://doi.org/10.1029/2021GB007261, 2022.

Siegel, B.: The "Wild" and "Lazy" Lamba: Ethnic Stereotypes on the Central African Copperbelt, in: The Creation of Tribalism in Southern Africa, edited by: Vail, L., Currey University of California Press, London Berkeley, 350–371, http://scholarexchange.furman.edu/ant-publications/5 (last access: 4 December 2024), 1989.

Smith, E. and Dale, A.: The Ila-speaking peoples of Northern Rhodesia, MacMillan and Co., London, 1920.

Smith, P. and Trapnell, C.: Ecological Survey of Zambia, the traverse records of C.G. Trapnell 1932–43, Royal Botanic Gardens, Kew, London, 2001.

Soil Survey Staff: Soil Survey Manual, U.S. Department of Agriculture Miscellaneous Publication 247, Washington D.C., 1937.

Speek, S.: Ecological concepts of development? The case of colonial Zambia, in: Developing Africa: Concepts and practices in Twentieth Century colonialism, edited by: Hodge, J. M., Hödel, G., and Kopf, M., Manchester University Press, 133–154, https://doi.org/10.7228/manchester/9780719091803.003.0006, 2014.

Stump, D.: "Ancient and Backward or Long-Lived and Sustainable?" The role of the past in debates concerning rural livelihoods and resource conservation in eastern Africa', World Dev., 38, 1251–1262, 2010.

Tilley, H.: Africa as a living laboratory, The University of Chicago Press, Chicago, 2011.

Trapnell, C.: Ecological Survey, Resumé of operations August–November 1932., Unpublished Memorandum, Department of Agriculture, Government of Northern Rhodesia, Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia, Reference NAZ/MAG 2/9/004 1932 – 3 Survey Correspondence, 1932a.

Trapnell, C.: Zambia Collecting Notebook NW9 1932, in: File CGT/1/23, Archive of the Royal Botanic Gardens, Kew, London, 1932b.

Trapnell, C.: Mr Bourne's comments on WORKING PRINCPLES AND ORGANISATION OF ECOLOGICAL SURVEY, Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia, Reference NAZ/-MAG 2/9/005, 1933.

Trapnell, C.: Problems of Agricultural Development among the Batonga of Reserve 11., Unpublished Memorandum, Ecological Survey, Government of Northern Rhodesia. Copy held at the National Archives of Zambia, Government Road, Ridgeway, P. O. BOX 500 10, Lusaka, Zambia, Reference NAZ/MAG 2/9/003, On Native Agriculture 1934, 1934a.

Trapnell, C.: Notes "Vegetation classification", in: File CGT/3/5, Archive of the Royal Botanic Gardens, Kew, London, 1934b.

Trapnell, C.: A vegetational grouping of soils in Northern Rhodesia south of latitude 15° 30′, in: Proceedings of the second conference of East African agricultural and soil chemists, held at Zanzibar, 3–9 August 1934, edited by: Milne, G., Government Printer, Nairobi, 53–55, 1935.

Trapnell, C.: Ecological Methods in the Study of Native Agriculture in Northern Rhodesia, Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew), 1937, 1–10, 1937.

Trapnell, C.: The Soils, Vegetation, and Agriculture of North-Eastern Rhodesia: Report of the Ecological Survey, Government Printer, Lusaka, 1943.

Trapnell, C. and Clothier, J.: The Soils, Vegetation and Agricultural Systems of North-Western Rhodesia, Report of the Ecological Survey, Government Printer, Lusaka, 1937.

Trapnell, C., Martin, J., and Allan, W.: Vegetation–Soil Map of Northern Rhodesia, Government Printer, Lusaka, 1947.

Van Der Walk, A.: From Formation to Ecosystem: Tansley's Response to Clements' Climax, J. Hist. Biol., 47, 293–321, 2014.

Wahu-Mũchiri, N.: Writing on the soil: land and landscape from Eastern and Southern Africa, University of Michigan Press, Ann Arbor, https://doi.org/10.3998/mpub.12211422, 2023.

Webster, R.: Soil genesis and classification in Central Africa, Soils and Fertilizers, 23, 77–79, 1960.

Weintroub, J.: Dorothea Bleek, a life of scholarship, Wits University Press, Johannesburg, https://doi.org/10.18772/12016038790, 2015.

Wetherell, H.: Settler Expansionism in Central Africa: The Imperial Response of 1931 and Subsequent Implications, African Affairs, 78, 210–227, 1979.

Wood, A. and Thawe, P.: Catchments and wetlands: a functional landscape approach to sustainable use of seasonal wetlands in Malawi, in: Wetland Management and Sustainable Livelihoods in Africa, edited by: Wood, A., , Dixon, A., and McCartney, M., Taylor & Francis, 63–84, https://doi.org/10.4324/9780203128695, 2013.

Young, A.: Thin on the ground, Land Resources Books, Norwich, 2017.