The changing face of farmers’ home gardens: a diachronic analysis from Sillian (Eastern Tyrol, Austria)

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Abstract

Background: Home gardens are an integral part of many traditional land use systems around the world. They are subject to various conversion processes and undergo a variety of changes. We were interested if change is an ongoing process in farmers’ home gardens of Eastern Tyrol (Austria).

Methods: In Sillian, 16 farmers’ home gardens (FHGs) were studied. They had been studied in 1998 and were revisited in 2013 including again a botanical inventory of cultivated and non-cultivated plants, and structured interviews on appearance, management and plant use. In 2017, all the 16 gardens were visited again to verify whether any visible change on spatial configuration had occurred.

Results: The home garden size had decreased between 1998 and 2013. A wider range of sizes was observed. The occurrence of plant taxa per garden was the same but an increase in the standard deviation of occurrence is seen. Plant diversity (occ./m²) increased between 1998 and 2013. Seventy-nine plant taxa were no longer cultivated in 2013, but 95 new plant taxa were being cultivated. The correlation between garden size and occurrence was not significant, i.e. small gardens might host many different plant taxa or large gardens might have fewer plant taxa. The occurrence for certain use categories was not significantly different between the years, except for the increase in the occurrence of plant taxa used as food and the food subcategory spice. The mean abundance of individuals for all plant taxa showed a significant decrease between the years. In 2017, an increase in standard deviation of abundance is seen. The variation in the different use categories expressed in abundance between the years was not significantly different, except for the decrease in the abundance of plant taxa used as food. Between 1998 and 2017, six home gardens showed a change of their spatial configuration (replacement by raised beds; merging with other structures; conversion to lawn). One FHG shows signs of abandonment.

Conclusions: In Sillian, gardens are by no way static agroecological units, but are dynamic and individual in their appearance, composition and function. Farmers’ home gardens in Sillian show a trend towards becoming more individual, i.e. conversion from being a product of a homogenous local cultural script of the community into an area where gardeners define more individually the role that farmers’ homegardens are expected to play for them or their family.

Keywords: Gardening, Garden, Subsistence, Ethnobotany, Agrobiodiversity, Land use change, Transition, Sustainability, Alps, Mountain farming, Agroecology, Homegarden
Background

Home gardens are an integral part of many traditional land use systems around the world [1–5]. In Europe, traditional land use systems focusing on subsistence and the local exchange of produce have seen dramatic changes in recent decades as a result of various socio-economic transformations that are also perceived to be a threat to the continuation of diversified agroecosystems [6–9].

The second half of the twentieth century is often identified as the period in which agriculture shifted from a “traditional”, subsistence-oriented agrarian mode of production to a “modern”, commercially oriented one [10–12].

In Eastern Tyrol, that period saw the abandonment of arable subsistence farming (e.g. the production of rye and wheat) in the mountainous parts of the region and many labour-intensive manually operated subsistence practices (e.g. the gathering of wild plants for food/medicinal purposes [13, 14]), as was the case in other parts of Europe as well [11, 15]. Decisions were taken in Eastern Tyrol to specialise in grassland with higher livestock productivity and a strong focus on national and international markets [11, 16].

There have also been changes in farmers’ home gardens (FHGs) in Eastern Tyrol. Until the 1960s, FHGs were small, fenced, horticulturally managed plots with limited plant diversity focusing on medicinal use and spices. In 1998, these FHGs had increased in their diversity, size and importance for subsistence, with some plant taxa even entering the garden from fields in distinct environments [17, 18], as also observed for example by Coomes and Ban [19], showing that FHGs are a dynamic system [17, 20]. Indeed, home gardens are not only recognised worldwide as multi-purpose, ecological and socially sustainable systems [1–3, 21], but also as exhibiting changes over time in line with the needs and views of those managing these agroecosystems [2, 17, 22].

As dynamic systems, home gardens are subject to various conversion processes worldwide and undergo a variety of changes—garden modernisation does not occur uniformly [23]—with regard to plant diversity, functional diversity, structural diversity, knowledge and resource inputs for example [17, 24–27]. Changing cultural values, socio-economic, demographic, political and climatic conditions, plus technical and infrastructural development—among other variables—are mentioned as underlying driving forces of this [2, 17, 25, 28–30].

The collection of data at different time periods could open up new perspectives for understanding the dynamics of the home garden system [3, 25, 31]. FHGs in Eastern Tyrol were studied in 1998 with regard to their dynamics from the 1960s to their status in 1998. The present study analysed the dynamics of the management, structure, plant use (occurrence and abundance) and function of FHGs in Sillian (Eastern Tyrol) between 1998 and 2013. Furthermore, data from 2017 were also studied to identify whether FHGs continued to be production systems.

Methods

Study area

The district of Lienz (Eastern Tyrol) is located in the Austrian part of the Eastern Alps. The large altitudinal gradient from 600 m to almost 4000 m above sea level gives rise to a narrow sequence of different natural and agricultural zones. Annual precipitation in the region is 826–1354 mm, and the mean annual temperature is 2.8–6.9 °C (values depend on exposure and altitude). This broad range of natural conditions within a small area has led to a highly diverse pattern of human-environment relationships [32]. Adaptive management of natural resources by Alpine small farmers has created a typically diverse and multifunctional landscape. The historical form of agriculture in this region can be described as “mountain cereal grazing” [33] in which the farming of arable land (up to 1700 m a.s.l.) for cereal cultivation, field vegetables, fibre crops, etc. and the farming of a wide range of domesticated animals, with a low number of individuals per species, were the main components of the subsistence system until the 1960s [13, 17, 34]. Large parts of today’s meadowlands used to be tilled up to an altitude of 1700 m. Farming systems in Eastern Tyrol have undergone change in the past few decades. The cultivation of cereals, fibre crops and field vegetables (e.g. *Pisum sativum* L., *Vicia faba* L., *Brassica rapa* L. ssp. *rapa*) has declined in the last three decades due to unfavourable economic conditions and the need for high labour inputs. The agricultural focus of mountain farms today is on grasslands, with the cultural landscape dominated by meadowland in lower zones, where hay is produced for winter fodder, and by pastureland in the higher alpine zones, where cattle remain throughout the summer. The economy of the majority of mountain farms in Eastern Tyrol is based on cattle breeding, milk production and timber harvesting for cash income. Some farmers offer beds to tourists and/or process milk, meat and other products from the farm. For their own consumption, some farmers diversify their basic activities by also keeping sheep, goats, pigs, chicken or bees, and/or growing fruit, herbs and vegetables (e.g. potatoes). Farming is combined with different kinds of off-farm labour, with federal subsidies playing an important role in farm income [13].

The village of Sillian, one of the 33 villages in Eastern Tyrol, is situated at 1100 m a.s.l. (village centre) in the Pustertal valley in the western part of the district of Lienz. The village includes various hamlets, such as Sillian Berg and Arnbach, and has a population of 2044 in total. In this village, 124 farms manage a total
of 2964 ha, an area that is constantly declining in parallel with a decreasing number of farmers working the land [35–39].

**Data collection and analysis**

Farmers’ home gardens, according to the local perception of the term *Bauerngarten* used in this area, are small, manually operated horticultural cultivation spaces adjacent to the farmers’ households, in which annual, biennial and perennial cultivated plants are grown (also following the definition of the previous study in 1998 [13]). In 1998, FHGs were perceived by the gardeners and the authors of that study as discrete units with a determinate boundary (called “FHG with traditional spatial configuration”), easily identified as a unit used entirely for horticulturally cultivated plant taxa and clearly distinct from, for example, arable plots, orchards, pure ornamental plots in front of the house or recreational areas close to the homestead [18]. Arable land (e.g. planted with potatoes) where ploughing is characteristic, orchards where fruit trees (e.g. apple) are a dominant feature or gardens where only ornamental plants are grown were not included in the data on FHGs presented here.

In this paper, cultivated plant taxa refer to domesticated plants and wild plants under incipient management (tolerated, encouraged or protected) [40] and the family member primarily responsible for managing the garden is called the “gardener”.

In 1998, 196 FHGs in 12 villages in Eastern Tyrol, including Sillian, were studied [17, 18, 20, 41]. In 2013, out of this sample of 12 villages, one village (Sillian) was selected for a comparative study and 16 FHGs here, corresponding to 16 farm households (*n* = 16), were investigated. Every garden recorded in 1998 was revisited in 2013. In 1998, the average age of the gardeners was 49, in 2013 53 years of age, with no statistically significant difference. We do refer to specific gardens by adding to the abbreviation FHG our internal respondents’/Garden ID such as e.g. “FHG_1011”. In two cases where the garden had been relocated, the new location was studied. In Sillian in 2013 a total of 2060 inhabitants were living. The village counts with 67 farms. To our observation all these farms do have FHGs. Therefore, the sample of 16 FHGs represents roughly a quarter of all FHGs of Sillian.

The reasons this village was sampled were the typicality and representativeness of the village, its hamlets and FHGs in Eastern Tyrol. Sillian is a village with FHGs in the urbanised valley plain, but also along a gradient of altitude up to 1573 m.a.s.l., and along a gradient of distance with FHGs also situated in remote valleys—comparable to Eastern Tyrolean villages such as Matrei or Virgen for example.

In 1998 and 2013, a botanical inventory of cultivated and non-cultivated, i.e. spontaneously reproducing plants [41], was undertaken. In 1998 this was done during three visits in the growing season in early May, July and October, while in 2013 the inventory was conducted in midsummer (July). Therefore plants only grown in the spring and autumn of 1998 were excluded from the comparative evaluation. For the botanical inventories in 1998 and 2013, wherever possible a sterile or fertile plant voucher specimen was collected and added to the authors’ collection and deposited in the herbarium at the University of Natural Resources and Life Sciences in Vienna. Plants were identified mainly in the field or in the laboratory based on the collected vouchers, as also described by [42].

Structured interviews were conducted with each responsible gardener. Among other topics, these interviews collected information on the appearance and management of FHGs and on plant use. Furthermore in 2013 the person responsible for the garden (the gardener) was interviewed about the changes observed in the recent period since 1998.

In 2017 all the FHGs were visited once to be photographed and checked to verify whether it was still possible to identify the FHGs at the homestead and if any visible changes on spatial configuration—compared to 2013—had occurred. No interviews, inventory or measurements were conducted in 2017.

The nomenclature used in this paper is in accordance with [43]. Cultivated plants are aligned with the official nomenclature of the International Code for the Nomenclature of Cultivated Plants (ICNCP), as acknowledged also by the International Code of Nomenclature for algae, fungi and plants (ICBN). Inventoried plants were identified at genus, species (sp.), subspecies (ssp.) or varieties (var.) taxonomical levels. Popular garden plants were summarised under the term Cultivars (e.g. all six different Rosa hybrid categories from 1998 were summarised as just *Rosa* L. Cultivars) or Groups (e.g. *Allium cepa* L. *Aggregatum* Grp.). Some names used in 1998 are no longer valid and these plants were renamed. In the present paper, all the ranks mentioned are referred to below as “plant taxa”.

Whenever possible and permitted, photographs were taken and deposited at the University of Natural Resources and Life Sciences in Vienna. Collected data were stored and categorised in an MS ACCESS (Microsoft Inc. 2013) database and subsequently analysed with SPSS (IBM SPSS Statistics 24). The impact of the independent nominal variable year (1998 or 2013) on the dependent metric variables, such as number of species or number of individuals, was tested with a paired t-test. Correlations between garden size and other metric variables were tested using the
Pearson correlation. A level (alpha) of < 0.05 was used when referring to significance and ≥ 0.05 to < 0.1 when referring to a tendency. Due to the small sample size, no tests were performed for the frequency of nominal variables (e.g. on management practices).

In the present analysis the parameters studied were defined as follows:

- Occurrence: the absolute frequency of plant taxa per FHG;
- Abundance: the absolute frequency of individual plants per plant taxon per FHG;
- Relative occurrence: the occurrence of plant taxa per FHG compared to total occurrence of plant taxa in the sample “n” (sum of plant taxa per garden divided by sum of all plant taxa in all gardens × 100, expressed in %);
- Relative abundance: the abundance per FHG compared to total abundance in the sample “n” (sum of individual plants per garden divided by all individual plants in all gardens × 100, expressed in %);
- FHG plant diversity: occurrence per m²;
- FHG abundance: abundance per m²;
- Functional characteristics: occurrence/abundance of different plant-use categories (ornamental, food, fodder, human medicinal, veterinary medicinal, fence, customs, fertiliser).

**Results**

**Management**

In 2013, all 16 gardeners were still managing their FHG in Sillian, compared to 1998. In 2013, the FHGs were still located right next to the farmhouses (mean distance: 1998, 10 m; 2013, 13 m). Fourteen FHGs were located on the same spot as that identified in the 1998 survey. Two FHGs had been relocated to another, steeper area because the flat areas of the former FHGs were needed for a path and a parking area respectively.

All 16 gardeners in 1998 were female, and of these, 11 were still managing the garden in 2013. Of the five successors, one was male. In 2013, 15 FHGs had a single gardener who was primarily responsible for the FHG (16 in 1998). One FHG was managed by several family members (not all of them lived in the household) and a neighbour due to the advanced age of the previous responsible gardener (FHG_1011). The most important motivation of gardeners in both years was an appreciation for home-grown produce. Of the 16 gardeners surveyed in 2013, 14 said that they would continue to manage the FHGs in future. Of these, three stated that they were enthusiastic gardeners and even wanted to expand their gardening. Ten gardeners wanted to continue gardening at the same level. One gardener was undecided (FHG_1012), and two gardeners had thought about giving up gardening to avoid the related workload (among them the male gardener; FHG_1008 and FHG_1003).

A change in equipment and supplies was rarely observed. Labour had not been replaced by machinery. In 2013, manual digging of the soil and manual weeding were still common. Synthetic pesticides were used by one gardener in 1998 and by three gardeners in 2013. All the gardeners interviewed used manure from their farm’s own cattle. Synthetic fertilisers were not used. The comparison between the years showed a higher frequency in 2013 of the use of homemade herbal teas for spraying plants, composting and mulching, of the use of green manure, the presence of recreational areas and raised beds within the FHG area, and a lower frequency of intercropping within beds for example. These differences were not statistically tested however due to the small number of cases.

**Size and spatial configuration**

In 1998, 14 FHGs were separated from the surrounding area by fences; in 2013, this number was 12.

The FHG size (arithmetic mean; 1998, 65 m²; 2013, 48 m²; P test paired = 0.056) had decreased (tendency) between 1998 and 2013 (significant difference, if outlier FHG_1011 was excluded: 65 m² in 1998; 42 m² in 2013; P test paired = 0.006) (Table 1).

A wider range of FHG sizes (1998: min, 30 m²/max: 105 m²) in 2013 (min, 9 m²/max, 134 m²) was observed, increasing from 75 to 125 m². In 2013, 13 FHGs showed a similar or smaller size, and three (FHG_1015, FHG_1011, FHG_1005) had increased their size, one of them (FHG_1011) from 72 to 134 m² (Fig. 1, Table 1).

FHG_1011 was exceptional because it was the only FHG that had almost doubled in size by 2013. This gardener, and the family members who worked with her, had expanded the cultivated area by placing various small, horticulturally cultivated plots outside the former boundaries of the garden in an adjacent orchard. By reducing high-maintenance vegetable growing undertaken in 1998 to various small cultivated plots and expanding the growing of less demanding shrubs (e.g. redcurrant Ribes rubrum L.), a clearly delimited “low maintenance home garden space” was established, even though it was twice the size. Family members said that garden management was difficult for the responsible gardener due to her advanced age and it was only feasible with the assistance of family members, although there was no explicit mention of her giving up gardening altogether.

In another case (FHG_1015), the garden size was slightly increased in 2013 by expanding the cultivated area across the former boundary and merging it with other structures (grassland) (Fig. 7).
In one case (FHG_1005), in 2013 the size had been increased by constructing an additional new garden with a traditional spatial FHG configuration. Respondents mentioned the estimation for self-supply with home-grown products and being passionate about gardening as reasons for the increase in size. These two gardeners along with FHG_1004 (similar size in both years) referred to themselves as “keen gardeners.”

For 2013, the reduction in the size under cultivation was achieved by converting horticulturally cultivated area into lawn for use as a play area for example. In three cases this led to a reduction of the clearly delimited cultivated area by ≥ 50% (FHG_1003, FHG_1007 and FHG_1010) (Fig. 7). In two cases, former FHGs were relocated, reducing the size of the new garden (FHG_1001, FHG_1012), but maintaining the traditional FHG spatial configuration. According to the respondents, the reasons for reducing the area of

### Table 1 Overview of quantitative data obtained from $n = 16$ FHGs in 1998 and 2013

| Year   | 1998 | 2013 | $p$  |
|--------|------|------|------|
| Garden size |      |      |      |
| Mean   | 65.56| 48.13| 0.056|
| Median | 66   | 34   |      |
| Std. deviation | 28.467| 37.352|      |
| Minimum | 30  | 9    |      |
| Maximum | 105 | 134  |      |
| Range  | 75   | 125  |      |
| Occurrence |      |      |      |
| Mean   | 39.19| 40.00| 0.799|
| Median | 38.50| 32.50|      |
| Std. deviation | 12.55| 16.90|      |
| Minimum | 21.00| 16.00|      |
| Maximum | 68.00| 69.00|      |
| Range  | 47.00| 53.00|      |
| Abundance |      |      |      |
| Mean   | 691.75| 487.13| 0.027|
| Median | 681.00| 335.00|      |
| Std. deviation | 310.23| 329.14|      |
| Minimum | 220.00| 87.00 |      |
| Maximum | 1138.00| 1196.00|      |
| Range  | 918.00| 1109.00|      |

(Please note: Table continues on the next page.)
cultivation were the high labour demand (time that needed to be invested) for gardening, the perception of gardening as hard work or the reduced need for garden produce.

Flora and function
Occurrence (number of plant taxa) and plant use
The total number of cultivated plant taxa found in the 16 inventoried home gardens in Sillian was 223 in 1998 and 239 in 2013 (Table 2).

There was no significant difference in the occurrence of plant taxa per FHG between the years (arithmetic mean; 1998, 39; 2013, 40; $p_{t-test\ paired} = 0.799$) (Table 1). In 2013, an increase in variability (e.g. expressed in the standard deviation) could be seen (Table 1), i.e. gardens with a higher maximum and lower minimum number of plant taxa per garden compared to 1998 (Fig. 2).

One-hundred and six (1998) and 113 (2013) plant taxa were found in one garden alone. Seventy-nine plant taxa were no longer cultivated in the gardens in 2013 (compared to 1998). For example, the cultivation of *Cosmos bipinnatus* Cav., *Centaurea cyanus* L. and *Vicia faba* L. had been abandoned. In 2013, 95 new plant taxa were being cultivated, such as rocket salad (*Eruca sativa* Mill.) and basil (*Ocimum basilicum* L.).

In 1998, 20 plant taxa, and in 2013, 16 plant taxa contributed to the similarity (presence in ≥50% of FHGs) (Table 3), e.g. *Allium schoenoprasum* L. var. *schoenoprasum* was present in 100% of FHGs in both years. Eleven plant taxa were present in ≥50% of FHGs in both years. The mean of the relative occurrence of plant taxa per garden was 17% for both years (no significant difference between the years; $p_{t-test\ paired} = 0.536$), with gardens containing between 7% and 30% (Table 1) of all plant taxa identified (FHG_1015; FHG_1002; FHG_1004 were the top three in both years).

FHG diversity (occ./m²) increased significantly ($p_{t-test\ paired} = 0.021$) between 1998 (arithmetic mean 0.7) and 2013 (arithmetic mean 1.2) (Fig. 3, Table 1). The highest FHG diversity in 2013 was found in FHG_1001, FHG_1003 and FHG_1004. Two of these gardens (FHG_1001, FHG_1003) had been considerably reduced in size and, according to the gardeners, a reduction was the only way the FHG could be maintained given the time available for gardening—either by maintaining or even increasing the occurrence of plant taxa. Both gardeners expressed unhappiness with gardening. The gardener of FHG_1003 mentioned that it would be possible to continue farming or being a farmer without having a FHG. The gardener of FHG_1004 was one of the three “keen gardeners”.

The correlation between FHG size and occurrence was not significant for 1998 ($p_{PEARMON} = 0.214$; correlation coefficient 0.329) or 2013 ($p_{PEARMON} = 0.101$; correlation coefficient = 0.425), i.e. small gardens might host many different plant taxa or large gardens might have fewer plant taxa (Fig. 4).

FHGs may be characterised as being primarily managed for ornamental and food uses, as the absolute number of plant taxa with ornamental use prevailed in both years (116 plant taxa in 1998 and 155 in 2013), followed by plant taxa used as food (79 plant taxa in 1998 and 122 in 2013). Of the eleven plant taxa occurring in ≥50% of the FHGs in both the surveyed years and contributing to the similarity between the years, food function was represented by nine plant taxa. However, as ornamental and food uses were never the only function mentioned by the gardeners (both in 1998 and 2013), FHGs could therefore be perceived overall as multifunctional systems.

In FHGs in Sillian, 26 plant taxa in 1998 and 117 in 2013 were categorised in more than one functional group, e.g. nine plant taxa in 1998 and 45 in 2013 were mentioned both for medicine and food use (or food sub-categories), such as:

- Medicinal and food/spice (e.g. *Salvia officinalis* L., *Borago officinalis* L.);
- Medicinal and food/vegetable (e.g. *Aegopodium podagraria* L., *Urtica dioica* L.);
- Medicinal and eaten raw as food/salad (e.g. *Rumex obtusifolius* L., *Galinsoga ciliata* (Raf.) S.F. Blake);
- Medicinal and food/beverage (e.g. *Nepeta cataria* L., *Mentha x piperita* L.).

The variation in the different use categories expressed in the occurrence between the years was not significantly different, except for the increase in the occurrence of
| Scientific name | English name | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|----------------|-------------|-------------|--------------|-------------|--------------|
| Acer platanoides L. | Norway Maple | 0 | 0 | 1 | 1 |
| Achillea filipendulina Lam. | Fernleaf Yarrow | 0 | 0 | 1 | 1 |
| Achillea millefolium L. | Common Yarrow | 0 | 0 | 3 | 1 |
| Achillea ptarmica L. | Sneezewort | 10 | 4 | 14 | 3 |
| Aconitum napellus L. | Garden Monkshoot | 0 | 0 | 1 | 1 |
| Aegopodium podagraria L. | Ground Elder | 0 | 0 | 100 | 1 |
| Agastache foeniculum (Pursh) Kuntze | Anise Hyssop | 1 | 1 | 0 | 0 |
| Agrostemma githago L. | Corn Cockle | 5 | 1 | 0 | 0 |
| Alcea rosea L. | Hollyhock | 0 | 0 | 20 | 2 |
| Alchemilla L. sp. | Lady's Mantle | 0 | 0 | 1 | 1 |
| Allium cepa L. Aggregatum Grp. | Shallot | 24 | 1 | 0 | 0 |
| Allium cepa L. Cepa Grp. | Onion | 710 | 11 | 428 | 8 |
| Allium fistulosum L. | Welsh Onion | 6 | 1 | 13 | 2 |
| Allium porrum L. var. porrum | Leek | 151 | 9 | 204 | 11 |
| Allium ramosum L. | Fragrant Garlic | 1 | 1 | 0 | 0 |
| Allium sativum L. var. sativum | Common Garlic | 110 | 3 | 0 | 0 |
| Allium schoenoprasum L. var. schoenoprasum | Chives | 521 | 16 | 342 | 16 |
| Allium tuberosum Rottler ex Spreng. | Oriental Garlic | 0 | 0 | 11 | 2 |
| Allium ursinum L. | Wood Garlic | 0 | 0 | 6 | 2 |
| Althaea officinalis L. | White Mallow | 6 | 6 | 5 | 4 |
| Arnica montana L. | Love Lies Bleeding | 3 | 1 | 0 | 0 |
| Anacyclus L. sp. | Anacyclus | 1 | 1 | 0 | 0 |
| Anemone coronaria L. | Windflower | 0 | 0 | 3 | 1 |
| Anethum graveolens L. var. hortorum Alef. | Dill | 3 | 2 | 0 | 0 |
| Antinrinum majus L. | Snapdragon | 41 | 4 | 17 | 3 |
| Apium graveolens L. var. rapaceum (Mill.) Gaudin | Turnip -rooted Celery | 100 | 8 | 41 | 6 |
| Apium graveolens L. var. secalinum Alef. | Chinese Celery | 16 | 2 | 0 | 0 |
| Aquilegia L. Cultivars | Columbine | 10 | 5 | 1 | 1 |
| Aquilegia vulgaris L. | Columbine | 0 | 0 | 19 | 4 |
| Armoracia rusticana P.Gaertn., B.Mey. et Scherb. | Horseradish | 7 | 5 | 47 | 3 |
| Arnica montana L. | Mountain Arnica | 0 | 0 | 6 | 1 |
| Artemisia abrotanum L. | Southernwood | 2 | 2 | 1 | 1 |
| Artemisia absinthium L. | Common Wormwood | 3 | 3 | 10 | 4 |
| Artemisia dracunculus L. | Tarragon | 3 | 2 | 1 | 1 |
| Artemisia vulgaris L. | Mugwort | 1 | 1 | 1 | 1 |
| Anuncio dioicus (Walter) Fernald var. dioicus | Goat's Beard | 1 | 1 | 0 | 0 |
| Asparagus officinalis L. | Sparrow Grass | 8 | 5 | 3 | 2 |
| Aster amellus L. | Italian Aster | 2 | 1 | 0 | 0 |
| Aster cordifolius L. | Blue Wood Aster | 1 | 1 | 2 | 1 |
| Aster dumosus L. | Bushy Aster | 5 | 4 | 0 | 0 |
| Aster nova-eangliae L. | New England Aster | 8 | 2 | 8 | 2 |
| Aster nova-belgiae L. | Michaelmas Daisy | 3 | 2 | 20 | 4 |
| Aster tongolensis Franch. | Aster | 1 | 1 | 0 | 0 |
| Astilbe Buch.-Ham. Ex D. Don sp. | False Buck's Beard | 2 | 1 | 0 | 0 |
Table 2 List of plant taxa identified in n= 16 FHGs in 1998 and 2013 (Continued)

| Scientific name | Englisch name | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|-----------------|---------------|-------------|--------------|-------------|--------------|
| Aubrieta Adans. Cultivars | Aubrietia | 2 | 2 | 1 | 1 |
| Bellis perennis L. | Daisy | 70 | 1 | 16 | 2 |
| Beta vulgaris L. ssp. vulgaris var. rapacea K.Koch | Beet | 60 | 1 | 0 | 0 |
| Beta vulgaris L. ssp. vulgaris var. vulgaris | Beetroot | 476 | 12 | 166 | 7 |
| Beta vulgaris ssp. cicla (L.) W.D.J. Koch var. cicla | Foliage Beet | 27 | 4 | 23 | 3 |
| Borago officinalis L. | Borage | 7 | 1 | 36 | 3 |
| Brassica napus L. ssp. rapifera (Metzg.) Sinskaya | Swedish Turnip | 40 | 1 | 0 | 0 |
| Brassica oleracea L. var. botrytis L. | Cauliflower | 221 | 8 | 9 | 3 |
| Brassica oleracea L. var. capitata (L.) Alef. | Cabbage | 378 | 11 | 137 | 7 |
| Brassica oleracea L. var. gemmifera (DC.) Zenker | Brussels Sprouts | 3 | 2 | 45 | 1 |
| Brassica oleracea L. var. gongylodes L. | Turnip Kale | 194 | 8 | 114 | 10 |
| Brassica oleracea L. var. italicula Plenck | Broccoli | 20 | 2 | 20 | 4 |
| Brassica oleracea L. var. sabauda L. | Savoy Cabbage | 41 | 4 | 11 | 3 |
| Brassica rapa L. ssp. pekinensis (Lour.) Hanelt | Chinese Cabbage | 0 | 0 | 4 | 1 |
| Brassica rapa L. ssp. rapa L. | Turnip | 122 | 2 | 31 | 2 |
| Buxus sempervirens L. | Common Box | 4 | 3 | 21 | 3 |
| Calendula L. sp. | Marigold | 2 | 1 | 0 | 0 |
| Calendula officinalis L. | Scotch Marigold | 280 | 6 | 159 | 7 |
| Callistephus chinensis (L.) Nees | China Aster | 76 | 5 | 4 | 1 |
| Calystegia sepium (L.) R. Br. | Bindweed | 0 | 0 | 1 | 1 |
| Campanula carpatica Jacq. | Carpathian Harebell | 1 | 1 | 0 | 0 |
| Campanula glomerata L. | Clustered Bellflower | 8 | 3 | 0 | 0 |
| Campanula L. sp. | Bellflower | 0 | 0 | 1 | 1 |
| Campanula persicifolia L. | Peach Leaved Bellflower | 1 | 1 | 1 | 1 |
| Cannabis sativa L. | Hemp | 100 | 1 | 0 | 0 |
| Capsicum annuum L. | Red Pepper | 24 | 1 | 2 | 1 |
| Capsicum frutescens L. | Hot Pepper | 0 | 0 | 1 | 1 |
| Carum carvi L. | Caraway | 100 | 1 | 0 | 0 |
| Centaurea cyanus L. | Cornflower | 12 | 3 | 0 | 0 |
| Centaurea montana L. | Perennial Cornflower | 2 | 2 | 0 | 0 |
| Cerasium tomentosum L. | Snow-in-Summer | 3 | 2 | 4 | 1 |
| Chelidonium majus L. | Greater Celadine | 1 | 1 | 0 | 0 |
| Chrysanthemum x grandiflorum (Ramat.) Kitam. | Chrysanthemum | 1 | 1 | 0 | 0 |
| Cicorium endivia L. var. crispum Lam. | Endive | 15 | 1 | 3 | 1 |
| Cicorium endivia L. var. latifolium Lam. | Escarole | 105 | 4 | 6 | 2 |
| Cicorium intybus L. var. foliosum Hegi | Chicory Radicchio | 70 | 1 | 45 | 3 |
| Clarkia amoena (Lehm.) A. Nelson e J.F.Macbr. | Satin Flower | 10 | 1 | 0 | 0 |
| Convolvulus tricolor L. | Lily-of-the-Valley | 0 | 0 | 53 | 4 |
| Convolvulus tricolor L. | Dwarf Morning Glory | 3 | 2 | 0 | 0 |
| Coriandrum sativum L. | Chinese Parsley | 0 | 0 | 5 | 1 |
| Cosmos bipinnatus Cav. | Garden Cosmos | 90 | 4 | 0 | 0 |
| Cucumis sativus L. | Cucumber | 16 | 2 | 13 | 4 |
| Cucurbita maxima Duches ex Lam. | Pumpkins | 0 | 0 | 16 | 5 |
| Cucurbita pepo L. | Courgette | 15 | 4 | 21 | 8 |
| Scientific name | English name | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|-----------------|--------------|-------------|--------------|-------------|--------------|
| Cytisus scoparius (L.) Link | Broom | 0 | 0 | 1 | 1 |
| Dahlia Cav. Cultivars | Dahlia | 30 | 5 | 24 | 6 |
| Daucus carota L. ssp. sativus (Hoffm.) Schübl. et G. Martens | Carrot | 1746 | 9 | 1318 | 10 |
| Delphinium L. Cultivars | Larkspur | 4 | 3 | 0 | 0 |
| Deutzia Thunb. sp. | Deutisia | 1 | 1 | 0 | 0 |
| Dianthus barbatus L. | Sweet William | 186 | 9 | 52 | 5 |
| Dianthus caryophyllus L. | Carnation | 36 | 4 | 3 | 2 |
| Dianthus chinensis L. | Annual Pink | 9 | 2 | 0 | 0 |
| Dianthus deltoides L. | Maiden Pink | 0 | 0 | 1 | 1 |
| Dianthus gratianopolitanus Vill. | Cheddar Pink | 3 | 2 | 0 | 0 |
| Dianthus L. sp. | Carnation | 0 | 0 | 1 | 1 |
| Dianthus plumarius L. | Pink | 2 | 1 | 0 | 0 |
| Dianthus seguieri Vill. | 0 | 0 | 2 | 2 |
| Dicentra Borkh. ex Bernh. Cultivars | Bleeding Heart | 8 | 8 | 5 | 3 |
| Digitalis purpurea L. | Foxglove | 0 | 0 | 1 | 1 |
| Doronicum L. sp. | Leopard’s Bane | 6 | 4 | 11 | 2 |
| Dorotheanthus bellidiformis (Burm. F.) N.E.Br. | Livingstone Daisy | 4 | 1 | 0 | 0 |
| Echinops bannaticus Rochel ex Schrad. | Blue Globe Thistle | 2 | 2 | 2 | 2 |
| Epilobium angustifolium L. | Fire Weed | 3 | 1 | 0 | 0 |
| Erigeron annuus (L.) Pers. | Annual Fleabane | 0 | 0 | 1 | 1 |
| Erigeron L. Cultivars | Fleabane | 1 | 1 | 0 | 0 |
| Eruca sativa Mill. | Rocket Salad | 0 | 0 | 115 | 6 |
| Eryngium planum L. | Sea Holly | 3 | 2 | 0 | 0 |
| Eschscholzia californica Cham. | California Poppy | 2 | 1 | 1 | 1 |
| Euonymus europaeus L. | Common Spindle | 0 | 0 | 1 | 1 |
| Euphorbia amygdaloides L. | Wood Spurge | 2 | 1 | 0 | 0 |
| Euphorbia helioscopia L. | Sun Spurge | 0 | 0 | 1 | 1 |
| Filipendula ulmaria (L.) Maxim. | Meadow Sweet | 0 | 0 | 1 | 1 |
| Foeniculum vulgare Mill. ssp. vulgare var. azoricum (Mill.) Thell. | Florence Fennel | 8 | 1 | 7 | 1 |
| Forsythia Vahl Cultivars | Forsythia | 0 | 0 | 1 | 1 |
| Fragaria vesca L. var. vesca | Wild Strawberry | 0 | 0 | 33 | 3 |
| Fragaria vesca L. var. hortensis (Duchesne) Staudt | Strawberry | 12 | 1 | 0 | 0 |
| Fragaria x ananassa (Duchesne) Guérdès | Garden Strawberry | 324 | 8 | 182 | 10 |
| Fraxinus excelsior L. | Common Ash | 0 | 0 | 1 | 1 |
| Fritillaria imperialis L. | Fritillary | 2 | 1 | 0 | 0 |
| Galinsoga ciliata (Raf.) S.F. Blake | Shaggy Soldier | 0 | 0 | 25 | 1 |
| Galium aparine L. | Goosegrass | 0 | 0 | 30 | 1 |
| Galium odoratum (L.) Scop | Sweet Woodruff | 4 | 1 | 1 | 1 |
| Geranium L. sp. | Crane’s Bill | 1 | 1 | 0 | 0 |
| Geranium robertianum L. | Herb Robert | 0 | 0 | 20 | 1 |
| Geum L. Cultivars | Avenis | 9 | 2 | 5 | 2 |
| Gladiolus L. Cultivars | Gladiolus | 200 | 6 | 75 | 4 |
| Glebionis segetum (L.) Fourr. | Corn Marigold | 7 | 1 | 3 | 1 |
| Scientific name                      | English name               | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|--------------------------------------|----------------------------|-------------|--------------|-------------|--------------|
| Glechoma hederacea L.                | Ground Ivy                | 0           | 0            | 40          | 1            |
| Gynostemma pentaphyllum (Thunb.) Makino | Jiaogulan              | 0           | 0            | 1           | 1            |
| Gypsophila muralis L.                | Cushion Baby’s Breath     | 0           | 0            | 1           | 1            |
| Gypsophila paniculata L.             | Baby’s Breath             | 2           | 2            | 2           | 1            |
| Hebe Comm. Ex Juss. Cultivars        | Hedge Veronica            | 0           | 0            | 1           | 1            |
| Helianthus annuus L.                 | Common Sunflower          | 39          | 2            | 25          | 3            |
| Helianthus pauciflorus Nutt.         | Pauciflorus               | 15          | 1            | 27          | 1            |
| Helianthus tuberosus L.              | Jerusalem Artichoke       | 0           | 0            | 20          | 3            |
| Heliopsis helianthoides (L.) scabra  | Ox Eye                    | 1           | 1            | 6           | 2            |
| Hemerocallis fulva (L.) L.           | Orange Daylily            | 0           | 0            | 10          | 4            |
| Hemerocallis L. Cultivars            | Daylily                   | 5           | 3            | 14          | 5            |
| Henacaleum spondylium L.             | Hogweed                   | 0           | 0            | 1           | 1            |
| Humulus lupulus L.                   | Common Hop                | 0           | 0            | 1           | 1            |
| Hydrangea L. Cultivars               | Hydrangea                 | 1           | 1            | 5           | 3            |
| Hypericum perforatum L.              | St. John’s Wort           | 2           | 2            | 8           | 2            |
| Hyssopus officinalis L.              | Hyssop                    | 1           | 1            | 2           | 2            |
| Iberis amara L.                      | Wild Candytuft            | 3           | 1            | 0           | 0            |
| Iris pumila L. Cultivars             | Dwarf Flag                | 10          | 1            | 31          | 1            |
| Iris sibirica L. Cultivars           | Siberian Iris             | 2           | 2            | 0           | 0            |
| Iris x germanica L. Cultivars        | Common Iris               | 27          | 6            | 42          | 4            |
| Juniperus communis L.                | Common Juniper            | 1           | 1            | 0           | 0            |
| Laburnum anagyroides Medik.          | Common Laburnum           | 1           | 1            | 0           | 0            |
| Lactuca sativa L. var. capitata L.   | Cabbage Lettuce           | 437         | 16           | 425         | 14           |
| Lactuca sativa L. var. crispa L.     | Leaf Lettuce              | 90          | 6            | 26          | 9            |
| Lamium album L.                      | White Dead Nettle         | 0           | 0            | 30          | 1            |
| Lamium purpureum L.                  | Purple Archangel          | 0           | 0            | 13          | 1            |
| Lavandula angustifolia Mill.         | English Lavender          | 4           | 3            | 5           | 3            |
| Leontopodium nivale (Ten.) A. Huet ex Hand.-Mazz. | Edelweiss | 2           | 2            | 11          | 2            |
| Leonurus cardiaca L.                 | Motherwort                | 0           | 0            | 5           | 1            |
| Lepidium sativum L.                  | Garden Cress              | 18          | 4            | 100         | 1            |
| Leucanthemum heterophyllum (Willd.) DC. | Oxeye Daisy              | 0           | 0            | 1           | 1            |
| Leucanthemum ircutianum DC.          | Oxeye Daisy               | 0           | 0            | 2           | 1            |
| Leucanthemum Mill. sp.               | Oxeye Daisy               | 8           | 4            | 34          | 3            |
| Levisticum officinale W.D.J. Koch    | Lovage                    | 9           | 9            | 11          | 11           |
| Liatris spicata (L.) Wild.            | Button Snakeroot          | 1           | 1            | 0           | 0            |
| Lilium bulbiferum L.                 | Fire Lily                 | 6           | 3            | 8           | 2            |
| Lilium candidum L.                   | Madonna Lily              | 0           | 0            | 9           | 1            |
| Lilium L. Cultivars                  | Lily                      | 20          | 6            | 45          | 6            |
| Lilium lancifolium Thunb.            | Tiger Lily                | 0           | 0            | 10          | 1            |
| Lilium martagon L.                   | Martagon Lily             | 1           | 1            | 0           | 0            |
| Limonium Mill. sp.                   | Sea Lavender              | 20          | 3            | 2           | 1            |
| Linaria marococana Hook.             | Baby Snapdragon           | 4           | 1            | 0           | 0            |
| Linum grandiflorum Desf.             | Red Flax                  | 4           | 1            | 60          | 1            |
| Linum usitatissimum L.               | Common Flax               | 200         | 1            | 0           | 0            |
| Scientific name | Englisch name | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|-----------------|---------------|-------------|--------------|-------------|--------------|
| Lobularia maritima (L.) Desv. | Sweet Alsion | 5 | 1 | 0 | 0 |
| Lonicera caprifoliurn L. sp. | Honeysuckle | 0 | 0 | 1 | 1 |
| Lunaria annua L. | Annual Honesty | 1 | 1 | 0 | 0 |
| Lupinus L. Cultivars | Garden Lupin | 13 | 4 | 8 | 4 |
| Lycium barbarum L. | Box Thorn | 0 | 0 | 2 | 1 |
| Lycopersicon esculentum Mill. | Tomato | 9 | 2 | 21 | 4 |
| Lysimachia punctata L. | Dotted Loosestrife | 19 | 5 | 11 | 6 |
| Mahonia aquifolium (Pursh) Nutt. | Oregon Grape | 1 | 1 | 0 | 0 |
| Malus domestica Borkh. | Apple | 2 | 1 | 5 | 2 |
| Malva neglecta Wallr. | Common Mallow | 4 | 1 | 2 | 1 |
| Malva sylvestris L. ssp. mauritiana (L.) Boiss. Ex Cout. | Mallow | 2 | 1 | 0 | 0 |
| Malva sylvestris L. ssp. sylvestris | Blue Mallow | 0 | 0 | 1 | 1 |
| Malva verticillata L. | Curled Mallow | 0 | 0 | 13 | 1 |
| Marrubium vulgare L. | Common Horehound | 2 | 1 | 0 | 0 |
| Matricaria discoida DC. | False Chamomile | 0 | 0 | 23 | 1 |
| Matricaria recutita L. | Chamomile | 82 | 8 | 83 | 6 |
| Mauantherum paludosum (Poir.) Vogt et Oberpr. | | 2 | 1 | 0 | 0 |
| Medicago lupulina L. | Black Medick | 0 | 0 | 3 | 1 |
| Melissa officinalis L. | Lemon Balm | 5 | 3 | 11 | 5 |
| Mentha L. sp. | Mint | 10 | 3 | 5 | 1 |
| Mentha longifolia (L.) L. | Horse Mint | 1 | 1 | 0 | 0 |
| Mentha spicata L. | Spearmint | 0 | 0 | 1 | 1 |
| Mentha suaveolens Ehrh. | Apple Mint | 3 | 2 | 46 | 4 |
| Mentha x piperita L. | Peppermint | 6 | 2 | 14 | 4 |
| Mirabilis jalapa L. | Four O’Clock Plant | 5 | 1 | 0 | 0 |
| Monarda L. Cultivars | Beebalm | 3 | 1 | 3 | 3 |
| Myosotis L. sp. | Forget-me-not | 6 | 3 | 1 | 1 |
| Nepeta cataria L. | Cat Mint | 5 | 4 | 7 | 5 |
| Ocimum basilicum L. | Basil | 0 | 0 | 33 | 5 |
| Origanum majorana L. | Sweet Marjoram | 11 | 4 | 7 | 5 |
| Origanum vulgare L. | Oregano | 3 | 1 | 9 | 5 |
| Osteospermum L. Cultivars | African Daisy | 0 | 0 | 9 | 1 |
| Paeonia lactiflora Pall. Cultivars | Common Garden Peony | 34 | 11 | 27 | 8 |
| Paeonia officinalis L. | Common Peony | 16 | 8 | 3 | 3 |
| Papaver nudicaule L. | Iceland Poppy | 2 | 1 | 9 | 1 |
| Papaver orientale L. | Oriental Poppy | 1 | 1 | 3 | 2 |
| Papaver somniferum L. ssp. setigerum (DC.) Corb. | Poppy | 0 | 0 | 2 | 1 |
| Papaver somniferum L. ssp. somniferum | Opium Poppy | 1 | 1 | 0 | 0 |
| Persicaria lathyrifolia (L.) Delarbre | Pale Persicaria | 0 | 0 | 1 | 1 |
| Petroselinum crispum (Mill) Fuss | Parsley | 44 | 12 | 496 | 11 |
| Phaseolus vulgaris L. var. nanus (L.) G. Martens | Dwarf Bean | 457 | 7 | 460 | 6 |
| Phaseolus vulgaris L. var. vulgaris | French Bean | 20 | 1 | 38 | 3 |
| Philadelphus L. Cultivars | Mock Orange | 1 | 1 | 1 | 1 |
| Phlox paniculata L. | Garden Phlox | 20 | 7 | 45 | 10 |
Table 2 List of plant taxa identified in n= 16 FHGs in 1998 and 2013 (Continued)

| Scientific name                  | Englisch name          | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|----------------------------------|------------------------|-------------|--------------|-------------|--------------|
| Phlox subulata L.                | Moss Phlox             | 7           | 2            | 0           | 0            |
| Physalis alkekengi L.            | Chinese Lantern Plant  | 5           | 1            | 0           | 0            |
| Physostegia virginiana (L.) Benth. | Obedient Plant        | 6           | 2            | 1           | 1            |
| Pinus cembra L.                  | Arolla Pine            | 2           | 1            | 2           | 1            |
| Pisum sativum L. ssp. sativum   | Garden Pea             | 746         | 7            | 65          | 2            |
| Plantago lanceolata L.           | English Plantain       | 1           | 1            | 9           | 1            |
| Plantago major L.                | Common Plantain        | 0           | 0            | 25          | 1            |
| Polemonium L. Cultivars          | Jacob's Ladder         | 0           | 0            | 1           | 1            |
| Potentilla fruticosa L.          |                        | 1           | 1            | 0           | 0            |
| Prunus armeniaca L.              | Apricot                | 0           | 0            | 1           | 1            |
| Prunus avium (L.) L.             | Gean                   | 0           | 0            | 2           | 2            |
| Prunus domestica L.              | Plum                   | 1           | 1            | 8           | 1            |
| Prunus triloba Lindl.            | Flowering Almond       | 0           | 0            | 1           | 1            |
| Pyxillium Mill. sp.              | Plantain               | 3           | 1            | 0           | 0            |
| Pulmonaria officinalis L.        | Lungwort               | 0           | 0            | 1           | 1            |
| Pyrus communis L.                | Common Pear            | 1           | 1            | 1           | 1            |
| Raphanus sativus L. var. niger (Mill.) J.Kern. | Oriental Radish      | 30          | 1            | 0           | 0            |
| Raphanus sativus L. var. sativus | Small Radish           | 310         | 9            | 231         | 7            |
| Rheum rhabarbarum L.             | Garden Rhubarb         | 10          | 7            | 5           | 5            |
| Ribes nigrum L.                  | Blackcurrant           | 6           | 2            | 28          | 6            |
| Ribes rubrum L.                  | Red Currant; White Currant | 29       | 4            | 45          | 8            |
| Ribes uva-crispa L.              | Gooseberry             | 0           | 0            | 3           | 2            |
| Ribes x nidigrolaria Rud. Bauer et A. Bauer |            | 1           | 1            | 9           | 1            |
| Rosa L. Cultivars                | Rose                   | 20          | 10           | 21          | 9            |
| Rosa L. sp.                      | Rose                   | 0           | 0            | 2           | 2            |
| Rosa x alba L.                   | White Rose             | 1           | 1            | 0           | 0            |
| Rosa x centifolia L.             | Rose                   | 4           | 3            | 3           | 2            |
| Rosmarinus officinalis L.        | Rosemary               | 1           | 1            | 6           | 5            |
| Rubus idaeus L.                  | Raspberry              | 9           | 5            | 42          | 5            |
| Rubus L. sect. Rubus             |                        | 0           | 0            | 1           | 1            |
| Rudbeckia hirta L.               | Black-Eyed Susan       | 0           | 0            | 50          | 1            |
| Rudbeckia laciniata L.           | Cutleaf Coneflower     | 1           | 1            | 0           | 0            |
| Rumex obtusifolius L.            | Bitter Dock            | 0           | 0            | 8           | 1            |
| Ruta graveolens L.               | Rue                    | 0           | 0            | 2           | 2            |
| Sagina subulata (Sm.) C. Presl   | Pearlwort              | 5           | 1            | 0           | 0            |
| Salvia officinalis L.            | Common Sage            | 6           | 6            | 8           | 8            |
| Sambucus nigra L.                | Common Elder           | 0           | 0            | 1           | 1            |
| Sanguisorba minor Scop.          | Small Burnet           | 2           | 1            | 0           | 0            |
| Santalina chamaeyparissus L.     | Lavender Cotton        | 0           | 0            | 1           | 1            |
| Satureja hortensis L.            | Summer Savory          | 10          | 1            | 2           | 2            |
| Satureja montana L.              | Winter Savory          | 1           | 1            | 1           | 1            |
| Saxifraga L. Cultivars           | Saxifrage              | 4           | 2            | 0           | 0            |
| Scorzonera hispanica L.          | Black Salsify          | 8           | 1            | 0           | 0            |
| Scientific name | English name | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|-----------------|--------------|-------------|--------------|-------------|--------------|
| Sedum acre L.   | Wall Pepper  | 0           | 0            | 1           | 1            |
| Sedum cauticola Praeger | Stonecrop     | 2           | 1            | 0           | 0            |
| Sedum hispanicum L. | Stonecrop     | 9           | 3            | 0           | 0            |
| Sedum L. sp.    | Stonecrop    | 0           | 0            | 1           | 1            |
| Sedum spurium M. Bieb | Two Row Stonecrop | 3           | 2            | 4           | 2            |
| Sedum telephium L. | Stonecrop    | 3           | 2            | 2           | 2            |
| Silene chalcedonica (L.) E.H.L. Krause | Maltese Cross | 0           | 0            | 1           | 1            |
| Silene coronaria (L.) Clairv. | Crown Pink | 0           | 0            | 1           | 1            |
| Silene latifolia Poir. | White Campion | 5           | 1            | 0           | 0            |
| Silybum marianum (L.) Gaertn. | Our Lady's Thistle | 0           | 0            | 1           | 1            |
| Solanum tuberosum L. | Potato       | 590         | 4            | 220         | 5            |
| Solidago canadensis L. | Canada Goldenrod | 3           | 2            | 5           | 1            |
| Sorbus aucuparia L. | Mountain Ash | 1           | 1            | 1           | 1            |
| Spinacia oleracea L. | Spinach      | 16          | 3            | 38          | 2            |
| Spiraea japonica L. | Japanese Meadowsweet | 1           | 1            | 3           | 2            |
| Spiraea L. sp.  | Bridewort    | 1           | 1            | 1           | 1            |
| Stellaria media (L.) Vill. | Common Chickweed | 0           | 0            | 60          | 1            |
| Symphoricarpos albus (L.) S.F. Blake | Snowberry    | 4           | 2            | 5           | 2            |
| Symphytum asperum Lepech. | Rough Comfrey | 0           | 0            | 1           | 1            |
| Symphytum officinale L. | Common Comfrey | 2           | 1            | 13          | 6            |
| Syringa vulgaris L. | Common Lilac | 6           | 2            | 4           | 3            |
| Tagetes L. sp.  | Marigold     | 94          | 5            | 13          | 4            |
| Tanacetum coccineum (Willd.) Grierson | Painted Daisy | 2           | 2            | 0           | 0            |
| Tanacetum parthenium (L.) Sch. Bip. | Feverfew    | 1           | 1            | 4           | 3            |
| Tanacetum vulgare L. | Tansy        | 1           | 1            | 2           | 2            |
| Taraxacum sect. Ruderalia Kirschner | Dandelion    | 0           | 0            | 20          | 1            |
| Thuja occidentalis L. | Red Cedar | 0           | 0            | 4           | 2            |
| Thymus pulegioides L. | Thyme        | 0           | 0            | 3           | 2            |
| Thymus vulgaris L. | Common Thyme | 4           | 2            | 3           | 3            |
| Thymus x citriodorus (Pers.) Schreb. | Lemon Thyme | 1           | 1            | 1           | 1            |
| Tilia cordata Mill. | Little Leaf Linden | 1           | 1            | 0           | 0            |
| Tilia platyphylla Scop. | Large Leaved Lime | 1           | 1            | 0           | 0            |
| Tradescantia x andersoniana W. Ludw. et Rohwedder | White Spiderwort | 1           | 1            | 0           | 0            |
| Trifolium pratense L. | Red Clover | 0           | 0            | 30          | 1            |
| Trigonella caerulea (L.) Ser. | Fenugreek | 21          | 2            | 3           | 3            |
| Tropaeolum majus L. | Nasturtium   | 41          | 5            | 28          | 3            |
| Tussilago farfara L. | Coltsfoot    | 0           | 0            | 5           | 1            |
| Urtica dioica L. | Stinging Nettle | 10          | 1            | 43          | 4            |
| Vaccinium corymbosum L. | High Bush Blueberry | 4           | 1            | 4           | 2            |
| Valeriana officinalis L. | Common Valerian | 3           | 2            | 1           | 1            |
| Valerianella locusta (L.) Laterr. | Cornsalad | 9           | 1            | 21          | 1            |
| Verbascum densiflorum Bertol. | Large-flowered Mullein | 0           | 0            | 6           | 3            |
| Verbascum olympicum Boiss. | Olympic Mullein | 2           | 1            | 0           | 0            |
| Verbena officinalis L. | Turkey Grass | 2           | 1            | 0           | 0            |
Abundance (frequency of individuals)
The abundance of all FHGS was 11,068 individuals in 1998 and 7794 individuals in 2013. The mean abundance of individuals for all plant taxa showed a significant decrease for the mean of individual plants per garden between the years (1998, 691; 2013, 487; \( P_{\text{test paired}} = 0.027 \)) (Table 1). In 2013, an increase in variability (e.g. expressed in the standard deviation; Table 1) compared to 1998 could be seen, i.e. FHGs with a higher maximum and FHGs with a lower minimum number of individuals per FHG could be observed compared to 1998 (Fig. 5).

The two FHGs with the greatest abundance in 2013 could be characterised as gardens, with gardeners using spontaneously growing plant taxa (FHG_1015; e.g. ground elder; *Aegopodium podagraria* L., 100 individuals or *Glechoma hederacea* L., 40 individuals), or growing spice plant taxa with a high abundance (FHG_1013; e.g. *Petroselinum crispum* (Mill.) Fuss., 240 individuals).

There were no significant differences in relative abundance between the years (\( P_{\text{test paired}} = 1.000 \)), with FHGs holding between 1% (FHG_1001) and 15% (FHG_1015) of the total abundance in 2013. FHG abundance showed no difference between the years (\( P_{\text{test paired}} = 0.700 \)). FHGs had between three and 19 plant individuals per m² (Table 1).

A significant correlation between FHG size and abundance could be observed for 1998 (\( r_{\text{pearson}} = 0.016; \) correlation coefficient 0.591) and 2013 (\( r_{\text{pearson}} = 0.006; \) correlation coefficient = 0.653) (Fig. 6).

The variation in the different use categories expressed in abundance between the years was not significantly different, except for the decrease in the abundance of plant taxa used as food (\( P_{\text{test paired}} = 0.047 \)). In spite of the significant decrease in the abundance of food on average, for certain plant taxa their abundance increased (Table 1), e.g. the abundance of *Petroselinum crispum* (Mill.) Fuss.

### Table 2

| Scientific name                  | English name               | Abundance98 | Occurrence98 | Abundance13 | Occurrence13 |
|----------------------------------|----------------------------|-------------|--------------|-------------|--------------|
| *Viburnum lantana* L.             | Wayfaring Tree             | 0           | 0            | 1           | 1            |
| *Viburnum opulus* L.              | European Cranberrybush     | 0           | 0            | 2           | 2            |
| *Vicia faba* L.                   | Broad Bean                 | 150         | 1            | 0           | 0            |
| *Vicia sepium* L.                 | Bush Vetch                 | 0           | 0            | 5           | 1            |
| *Vinca minor* L.                  | Smaller Periwinkle         | 0           | 0            | 10          | 5            |
| *Viola arvensis* Murray           | European Field Pansy       | 0           | 0            | 1           | 1            |
| *Viola x wittrockiana* Gams ex Kappert | Garden Pansy             | 24          | 4            | 15          | 2            |
| *Vitis vinifera* ssp. *vinifera*  | Common Grape Vine          | 0           | 0            | 5           | 2            |
| *Weigelia Thunb.* Cultivars       | Weigela                    | 0           | 0            | 1           | 1            |
| *Xerochrysum bracteatum* (Vent.) Tzvelev | Straw Daisy           | 20          | 2            | 5           | 2            |
| *Zinnia elegans* Jacq.            | Youh-and-Old-Age           | 87          | 4            | 8           | 2            |

Most recent changes in spatial configuration in 2017
Between 2013 and 2017 three FHGs showed very recent changes in their spatial configuration, while 13 remained as observed in 2013 (Fig. 7).

The traditional spatial configuration of FHG_1009 and FHG_1020 changed between 2013 and 2017 by (i) converting ≥ 50% of the garden into grassland or (ii) replacing the FHG with one raised bed. Horticultural activities could clearly be observed.

Already in 2013 in FHG_1003 ≥ 50% of the area under cultivation had been converted into lawn. In 2017, only some perennial shrubs and flowering plants served as a reminder of the FHG. Between 2013 and 2017 the area had been fully converted into...
Table 3  Plant taxa found in > 50% of the studied home gardens in at least one of the study years of 1998 or 2013 (n = 16 each year). Grey: > 50% in both years

| Plant taxa: Scientific name | English name | Frequency of FHGs (n=16) |
|-----------------------------|-------------|-------------------------|
| Brassica oleracea L. var. botrytis L. | Cauliflower | 8 3 |
| Dicentra Borkh. ex Bernh. Cultivars | Bleeding heart | 8 3 |
| Paeonia officinalis L. | Common peony | 8 3 |
| Apium graveolens L. var. rapaceum (Mill.) Gaudin | Turnip-rooted celery | 8 6 |
| Matricaria recutita L. | Chamomile | 8 6 |
| Brassica oleracea L. var. gongylodes L. | Turnip kale | 8 10 |
| Fragaria x ananassa (Duchesne) Guébédès | Garden strawberry | 8 10 |
| Dianthus barbatus L. | Sweet william | 9 5 |
| Raphanus sativus L. var. sativus | Small radish | 9 7 |
| Daucus carota L. ssp. sativus (Hoffm.)Schübl. et G. Martens | Carrot | 9 10 |
| Allium porrum L. var. porrum | Leek | 9 11 |
| Levisticum officinale W.D.J. Koch | Lovage | 9 11 |
| Rosa L. Cultivars | Rose | 10 9 |
| Brassica oleracea L. var. capitata (L.) Alef. | Cabbage | 11 7 |
| Allium cepa L. Cepa Grp. | Onion | 11 8 |
| Paeonia lactiflora Pall. Cultivars | Common garden peony | 11 8 |
| Beta vulgaris L. ssp. vulgaris var. vulgaris | Beetroot | 12 7 |
| Petroselinum crispum (Mill.) Fuss | Parsley | 12 11 |
| Lactuca sativa L. var. capitata L. | Cabbage lettuce | 16 14 |
| Allium schoenoprasum L. var. schoenoprasum | Chives | 16 16 |
| Cucurbita pepo L. | Courgette | 4 8 |
| Ribes rubrum L. | Red/whitecurrant | 4 8 |
| Salvia officinalis L. | Common sage | 6 8 |
| Lactuca sativa L. var. crispa L. | Leaf lettuce | 6 9 |
| Phlox paniculata L. | Garden phlox | 7 10 |

Fig. 3  FHG-specific diversity (occurrence/m²) for n = 16 in 1998 and the same n = 16 in 2013, shown as a box plot with median

Fig. 4  Scatter plot for garden size and occurrence for n = 16 in 1998 and the same n = 16 in 2013
pastureland. Two sides of the all-surrounding fence had been removed and no horticultural activity could be observed.

Discussion

Between 1998 and 2013, incipient change was apparent in the spatial configuration of the 16 studied FHGs in Sillian, with this continuing trend also visible in 2017.

While the boundaries of the FHG plots were accurately defined until 1998 and contributed to a homogeneous picture of these environments [18], some FHGs had now expanded into other functional structures of the homestead (e.g. orchards or grassland), including recreational areas and lawn with more open boundaries (semi-fenced or not fenced) or new structural elements (e.g. raised beds). A common attribute of tropical home gardens is the diversity in the spatial configurations of cultivated spaces [24, 44–47] and the gradual transition of home gardens to surrounding areas [48], contributing to the heterogeneity of these agroecosystems and making the definition of boundaries unfeasible [44]. Indeterminate boundaries, which make the measurement of size subjective and inaccurate, e.g. in Benin [44], were not observed in 1998, but were observed in 2013 and 2017. For temperate FHGs, we have not found scientific evidence discussing fences or boundaries. We hypothesise that presence/absence of fences might be an indicator of change for the FHGs studied.

The decrease in the cultivated area of FHGs in Sillian may be linked to challenges in the management of the FHGs, as indicated by the gardeners. Strategies for avoiding high labour demand included reducing the size of the FHG and growing plant taxa such as redcurrant that require less time-consuming maintenance and cover more space per individual, maintaining or even expanding the garden size. Therefore raised beds also appeared to be a strategy applied by the gardeners, as they demand less labour and are easier to manage, especially by the older generation.

It can be argued that management factors, e.g. time to invest in gardening, should be more strongly considered as predictors of structural conversion or abandonment. Furthermore, other household features have to be taken into account in future evaluations, e.g. whether better-off households (defined by wealth in land and kinship affiliation [19]) have more time to invest in gardening and therefore tend to have greater agrobiodiversity, as observed in Peru for example [19].

Although some gardening activities in East Tyrolean FHGs in 1998 were shared between different household members (e.g. digging by men), women were mainly responsible for gardening (100% in 1998 in Sillian FHGs), which was also reported for the 1960s [13]. This differs from research into FHGs on the Iberian Peninsula, for example, which suggests that men have main responsibility for gardening activities in 52% of the households or that it is shared by family members in 21% of the households [42]. In 2013 in Sillian FHGs, the first steps towards gardening being shared more between family members or becoming a man’s domain might indicate a transition in the cultural roles expected of household members in the management of FHGs.

The incipient change in spatial configuration and the heterogeneous nature of FHGs may be seen as an ongoing expression of individualisation. It can be argued that farmers’ home gardening might be undergoing a process of reconsideration of culturally-rooted forms of home gardening. In future home gardens, seen as a marker of
cultural identity in other regions in Europe [49], may become more differentiated, in line with farmers’ perceptions of what a FHG means for them individually.

No difference was observed between the mean occurrences of plant taxa between the years 1998 and 2013. Nevertheless, in 2013, the gardeners had increased the absolute number of all plant taxa in all 16 FHGs and FHG-specific diversity (occ./m²) had increased. In neither of the periods surveyed was diversity related to the size of the garden, as observed in tropical home gardens for example [19, 31], but unlike home gardens in Nepal [50], where size and species richness were positively correlated, or Vietnam [51] where smaller FHGs showed greater diversity. While households with an interest in plant taxa tend to have more diverse gardens, e.g. in Peru [19], in Sillian, more diverse gardens were not clearly related to the enthusiasm for gardening. One of the highly diverse gardens in the village was abandoned in 2017.

Trends in home garden dynamics in other regions are showing a gradual decrease in diversity and structural simplification as a result of intensification of crop production [24, 52]. FHGs are therefore described as being under threat of conversion to mono-cropping land use systems [28, 53].

FHGs in Sillian face a “different kind of threat”, i.e. a continuous process of decline in the cultivated area, radical structural change (e.g. conversion of the FHG to one raised bed, as observed in one FHG in 2017) or the complete abandonment of the horticulturally managed system and conversion to another land-use system such as pasture (observed in one FHG in 2017). In FHGs in Germany, Schulmeyer-Torres [22] identifies the 1990s as a period in which structural changes to a high proportion of lawn and coniferous plant taxa might have taken place. Such a change can be confirmed for 2013 onwards in Sillian.

The flora in the studied gardens was highly variable in both 1998 and 2013, suggesting the heterogeneous nature of FHGs, also observed by [53] and indicated by [19] as substantial differences in garden composition and plant diversity between households. Although no significant difference in the number of occurrence of plant taxa (per garden) between the years was observed, an increase in the variability of the occurrence of plant taxa, an increase in the absolute number of plant taxa that entered the FHGs than left them, and fewer plant taxa that contributed to the similarity in 2013 showed that the differences between FHGs increased over the years. This increase in variability might be understood as a flora-specific indicator of individualisation of the composition of the FHGs based on the gardeners’ differing preferences.

The multifunctional characteristics of FHGs found in Eastern Tyrol in 1998 could also be confirmed for 2013, similar to tropical home gardens [3].
on the Iberian Peninsula, a specialised role of home gardens for food production with a low frequency of nonedible taxa was found [54].

The main function of the historic FHGs until the 1960s was to provide the household with edible plant taxa for use as seasoning, besides their medicinal function, with both functions continuing to be important in 1998. In 2013, human medicinal uses continued to play a steady role, whereas food uses showed an increase of occurrence of plant taxa for 2013 and a decrease in the abundance of individuals cultivated.

These findings may be interpreted as showing that it is not large quantities (abundance) that are important, but the taste and health of garden products of specific taxa (occurrence) for the diet of the gardeners. This is also obvious in the increase of the occurrence of plant taxa used as spices (spice being a subcategory of food).

In several studies, spices are not just valued as seasoning, but seen as plants with medicinal and/or therapeutic potential [55] and are therefore the subject of experimental research on their health benefits, based on the knowledge of the chemistry and pharmacology of their active principles [56]. Viewing food use as nutritional or medicinal is often only a matter of definition and thus difficult to assess [57]. Since half of the food plants in Northern Spain [15] or 60% in Lucca, Italy [58] for example have medicinal uses, there are differing degrees of correlations along the food-medicine continuum [57]. The emic perception of this continuum might be of interest for further evaluation in East Tyrolean FHGs.

The use of plant taxa for healthy food and medicinal purposes was consistent with the respondents who called themselves “keen” gardeners making management decisions linked to use categories. The knowledge associated with “healthy” plants grown in FHGs in Sillian might be of conservation significance, as stated by Huai et al. [59]. A prime requirement for success in conservation is the presence of local people who are knowledgably about their local natural world, e.g. medicinal plants. A link between use categories and agrobiodiversity maintenance—the more functions there are, the better it is for agrobiodiversity, as observed elsewhere [19, 60, 61]—might also be true for FHGs in Sillian, which still show high plant diversity and multifunctional characteristics.

Finally, the exchange of seeds and planting material is recognised as an important determinant of diversity, with implications especially for in situ conservation of varietal diversity [19]. In 1998, interviews still recorded the regional sources for seeds and planting material [20]. This regional economy might be affected by the increased expression of individualisation in the garden system of the 16 Sillian FHGs, particularly in a system where markets for seeds and planting material are omnipresent. Access to and the origin and dynamic of garden planting material were not investigated in 2013. This issue merits closer attention in studies of agrobiodiversity [19, 50] and should be taken into account in future research. Future studies should include the importance of assessing diversity through more extensive sampling and giving more extensive consideration to the underlying socioecological and sociocultural drivers that lead to the fragmentation, conversion or abandonment of FHGs.

Conclusions

The diachronic perspective of this study provides a first understanding of the ongoing conversion underway in FHGs at different points in time (1998, 2013, 2017 of the same 16 FHGs), including changes in the 1960s for FHGs in the study area. In Sillian, FHGs are by no way distinct or static agroecological units, but are dynamic in their appearance, composition and function. FHGs in Sillian show a trend towards becoming more individual, i.e. conversion from being a product of a homogenous local cultural script of the community into an area where gardeners define more individually the role that FHGs are expected to play for them or their family. As an FHG may no longer consist of a single fenced plot, but instead cover various locations or growing sites, a careful redefinition should be made of the system boundary comprised by a “FHG” in Eastern Tyrol. This observation might also be of relevance in the design of further studies in other regions.

Abbreviations

FHG: Farmer’s homegarden; FHGs: Farmers’ homegardens

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Availability of data and materials

Data without participant data can be obtained upon reasonable request from the corresponding author.
Authors’ contributions
BVL undertook the research in 1998 with the support of technical staff for data collection, in 2013. BVL undertook the research with the masters student Katrin Plüger, who collected the data, and in 2017, BVL performed the research on her own, accompanied by Heidemarie Pirker and CRV. BVL and CRV designed the research for 1998, 2013 and 2017, performed the analysis and drafted the manuscript jointly. The two authors read and approved the final manuscript.

Ethics approval and consent to participate
Prior informed consent was obtained from all the informants. Under Austrian law and under our university procedures, no specific additional procedure is requested for this kind of study.

Consent for publication
This manuscript does not contain any data on an individual person and further consent for publication is not required.

Competing interests
The authors declare that they have no competing interests.

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