A 150-year-old herbarium exemplifies change of a regional flora

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The loss of biodiversity in terms of plant species in a certain region can be shown by a comparison of historical herbarium records with the present-day occurrence of species. This holds especially true for time periods before 1900, when only few floristic data are otherwise available. Such a comparison can also show whether the distribution area or the abundance of plant species have changed, which habitat types were especially affected by extinction or whether species with specific environmental requirements showed higher extinction rates than ubiquists. Corresponding results can guide conservation authorities in defining appropriate management actions.

During the years 1820–1847 the pharmacist Johann Conrad Laffon (1801–1882; Fig. 1) collected a herbarium and published a species list for the Swiss Canton of Schaffhausen with the aim to completely compile the flora of the canton (Laffon 1847). By using this rather complete historical herbarium (kept at herbarium SCH) and the published species list we investigated **1** which and how many plant species do no longer occur in the Canton of Schaffhausen today, **2** what the driving forces of potential species decline have been, and **3** which implications can be drawn for nature conservation management.

First, we compiled a list of all plant species in the herbarium and the published species list of Laffon and compared it with species occurrence in 2000–2020 by using a list of all vascular plants of the Canton of Schaffhausen provided by the national data and information centre on the Swiss flora, the Info Flora (Büttner et al. 2022). In order not to miss plant species currently occurring in the Canton of Schaffhausen, this list was checked for completeness by experts for the flora of the canton. We then determined the percentage of extinction of plant species in the Canton of Schaffhausen during the last 153 years (i.e. 1847–2000). In order to identify possible driving forces of species decline, we examined differences in extinction among habitat types and in the environmental requirements of extinct and extant plant species by using ecological indicators values (continentality K, light L, moisture F, soil reaction R, nutrients N and temperature T) and additionally analysed Grime's plant strategies (competition, stress and ruderality), all according to Landolt et al. (2010).

We found that 154 of the 987 species in Laffon's herbarium and species list do no longer occur in the Canton of Schaffhausen, which refers to 15.6 % extinct species in 153

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Fig. 1. Johann Conrad Laffon (1801–1882), collector of the first complete herbarium of the Canton of Schaffhausen, Switzerland

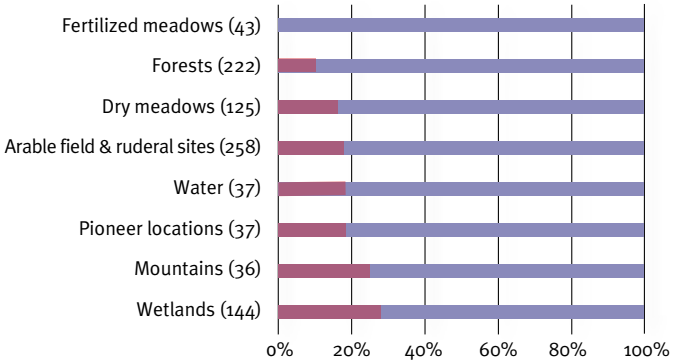

Fig. 2. Percentage of extinct (red) and extant (blue) vascular plant species per habitat type in Johann Conrad Laffon's herbarium and published species list for the Canton of Schaffhausen (Laffon 1847; total number of species at Laffon's time in brackets; figure modified from Büttner et al. 2022).

Fig. 3. Specimen of *Conringia orientalis* collected by J. C. Laffon between 1820–1847. This typical weed from agricultural and ruderal habitats is nowadays extinct in the Canton of Schaffhausen.

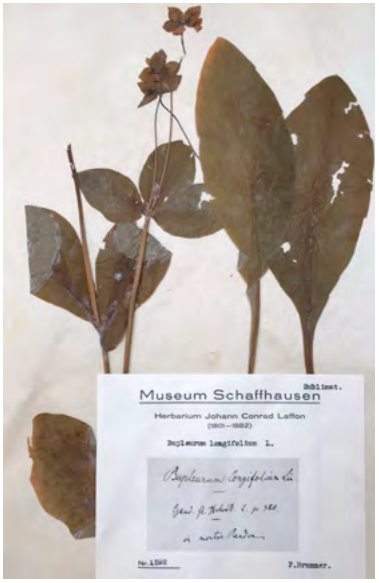

Fig. 4. Specimen of *Bupleurum longifolium*, collected by J. C. Laffon. It is still occurring in the Canton of Schaffhausen.

years or to an extinction rate of one species per year. Habitat types were differently affected by extinction (Chi^2-test: $p \leq 0.001$). Wetlands, mountain, pioneer and ruderal species as well as agricultural weeds were particularly affected by extinction, while extinction was lower in forests (Figs. 2–4). Even though the Canton of Schaffhausen still harbours a fair number of dry meadows, the decline in species from dry meadows was also considerable with 16.8 %. Concerning ecological requirements, light-demanding species showed highest extinction (t-test: $p \leq 0.001$), while for plant strategies, the less competitive and more stress-tolerant species disappeared more often (t-test: $p \leq 0.001$). Hence, species of habitats affected by extreme environmental conditions disappeared at higher rates.

In summary the extinction of plant species in the Canton of Schaffhausen was exceptionally strong in habitats affected by drainage, intensified agriculture, and river management, and habitats under extreme conditions. Our results inform conservation management about particularly endangered habitat types and stress the importance of restoring extreme habitat conditions.

As part of the Swiss digitization initiative SwissCollNet, the Museum zu Allerheiligen will digitize and geo-reference the Laffon herbarium and make it available online.

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