Twentieth century changes in floral diversity and distributions: *classifying historical land use in R.*

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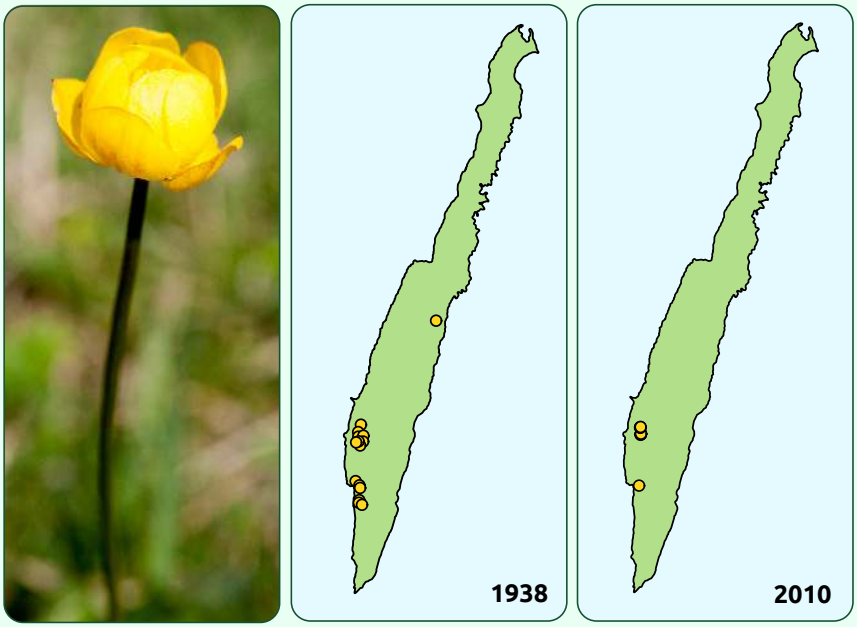
Land use change is an important driver for changes in species diversity and distributions over time. To accurately predict responses to future changes, it is important to understand how organisms have responded to changes in the past (see right).

Historical maps allow us to quantify land-use change between different points in time. This can then be linked to species occurences over the same time period. Unfortunately, digitising historical maps is hard work, and very time-consuming.

However, scanned maps are just three bands of pixels, with values of red, green and blue combining to produce the colours we see. Surely we can use these colours to classify historical maps (semi-) automatically?

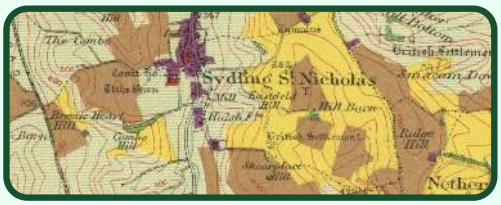


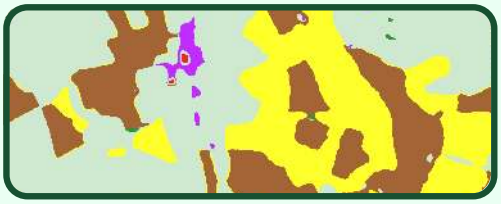
Observations of the globeflower *Trollius europeaus* have decreased on the Swedish island of Öland during the 20th century

Sweden: *Ekonomiska kartan* 1930s-1960s

Sweden: *Häradskartan* 1840s-1900s

UK: *Land Utilisation Survey* 1930s





We developed some functions in the **R** environment to classify scanned historical maps, using RGB values to differentiate between the colours used to indicate different land-cover types. The method:

1. Removes low RGB values (i.e. dark colours), commonly used for text, boundaries and other symbols.
2. Uses a moving window to smooth each of the three bands, assigning each pixel with the average of surrounding values. This evens out inconsistencies common in historical maps arising from scanning, or from just being old.
3. The user then clicks on a range of instances of each habitat within the map to define the colour ranges of each land-cover class.
4. Levels of deviation from these colour ranges can be set, as can the relative weightings of categories for when colours overlap.
5. After testing within the R environment, results can then be written a raster file for closer inspection using your favourite GIS program.

It's fast! Classification is fast, and on similar maps, hundreds of sheets can be looped using the same arguments.

It works! We have tried out the method on three different historical maps (see above). Classifications aren't perfect, but they are generally very good, especially at the landscape level.

We hope that our method can be used to increase the use of historical land-use maps in ecology and conservation. Please talk to me about any maps you think need digitising, or about how to incorporate land-use change into assessments of changing species distributions (which is what I plan to do with the maps in the future).

Important contributors to the project: Adam Kimberley, James Bullock, Sara Cousins, Mira Gartz, Danny Hooftman, Simon Jakobsson, Jan Plue, Helle Skånes, Louise Tränk, Emelie Waldén, Marika Wennbom, Heather Wood.
We also couldn't have done this without the creators of the raster package in R (Hijmans 2015). Or indeed R itself.
Maps: Swedish historical maps © Lantmäteriet. UK Land Utilisation Survey of Great Britain, 1933-49, © Audrey N. Clark, provided through www.VisionofBritain.org.uk.
Funding: The Swedish Research Council Formas.

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