FLOWERING APP

TEXT: CLAUDIA CHRISTINE WOLF

For many people today, botanical knowledge doesn't go much beyond daisies, buttercups, and dandelions. But an app is changing that. Flora Incognita can identify almost any plant encountered in Central Europe within seconds. Jana Wäldchen of the Max Planck Institute for Biogeochemistry in Jena has played a key role in developing this AI-based app, which also provides valuable data on the state of nature.

Anyone hiking through the Kyffhäuser Hills in Thuringia may be lucky enough to spot a rare beauty along the fields on the southern slopes: the red blossoms of *Adonis aestivalis*, the summer pheasant's eye. It is Jana Wäldchen's favorite plant. For the biologist, who grew up in the region, this arable wildflower, which thrives on nutrient-poor, calcareous soils, represents both a piece of home and an example of a species made scarce by intensive agriculture. The trails here offer many other botanical treasures as well. Perhaps this is why Wäldchen is so keen to raise awareness of the flora growing at the wayside. After all, we can only protect what we know.

And plants are in urgent need of protection, as global biodiversity is in free fall: habitats are disappearing, soils are over-fertilized, and pesticides are wiping out many wild species. On top of this, knowledge of flora itself is vanishing. Fewer and fewer people can recognize plants such as meadow buttercup, common chickweed, or wood avens. The fact that a meadow is a complex ecosystem in which dozens of species form a community is also little appreciated. This phenomenon even has a name: "plant blindness." It describes the tendency of humans to barely notice the plants around them and to underestimate their importance for ecosystems. The loss of plant knowledge is not confined to the general population. A study by the Bavarian branch of Friends of the Earth Germany (BUND Naturschutz in Bayern) found that over the past 20 years, the number of people who privately, voluntarily, or professionally study a group of animals or plants and collect data on individual species has declined by more than 20 percent.

It may seem paradoxical that artificial intelligence (AI) should provide a bridge back to nature and help protect it. Yet Flora Incognita can identify a wide variety of plant species within seconds thanks to AI. The ⟶

PHOTO: ADOBESTOCK

KNOWLEDGE FROM

ENVIRONMENT & CLIMATE

Most people can recognize the common poppy with its unmistakably bright red flowers even without digital help. For rarer or less conspicuous plant species, the app Flora Incognita, developed by Jana Wäldchen and her team, assists with identification.

PHOTO: HANNES WIEDEMANN

With her app, Jana Wäldchen can find out in a matter of seconds what species a plant belongs to. Each species has a profile with information on its distribution, characteristics, and conservation status. Users can save their plant finds in a personal observation list and display them on a map.

freely available app has proven so reliable that since its launch in 2018, it has been downloaded more than ten million times. Users in Germany have submitted over 60 million identification requests for more than 3,000 plant species. The app makes it easy for people to identify plants, sharpening not only their awareness of the biodiversity around them, but also providing a valuable source of observation data for research. Scientists can use these observations to determine where different plants occur, when they flower, and when they set seed. Information such as this helps to track the effects of climate change, monitor the disappearance of species as well as the arrival of new ones, and design conservation measures accordingly.

A bit of curiosity, a plant, and one to three snapshots with a smartphone camera are all you need to identify a plant using Flora Incognita. The app instantly suggests possible species, ranking them according to how closely the photographed features match those in the database. Each species comes with a profile detailing its appearance, distribution, and conservation status. This can turn hikes and walks into small botanical excursions; users can also take a more targeted approach, collecting data for scientific projects.

SUMMARY

The free, AI-powered app Flora Incognita identifies plants from photos uploaded by users. It can currently recognize 32,000 plant species with high accuracy.

Flora Incognita is based on a neural network that learns plant features on its own, enabling automatic identification.

The app aims to bring the diversity of nature closer to people. Researchers can also use the data – for example, to detect seasonal and geographic changes due to climate change, such as earlier flowering of many plants, and to develop conservation measures. Conservation authorities can also benefit from the documenting of invasive species, for instance.

In the "Chestnut Detectives" project, conducted in collaboration with researchers at the University of Göttingen, 30,000 photos of chestnut leaves were uploaded over just two months in the summer of 2024. The images are intended to help develop an AI capable of automatically detecting leaf-eating insects, such as the leaf miner moth, enabling early identification and the rapid implementation of countermeasures. Building on this, the "Forest Doctor" project documents additional damage to bark and leaves. This too requires extensive training data to be collected in order for the software to learn to recognize damage on trees.

Users are documenting the scents of plant species in a collaborative project with the Max Planck Institute for Chemistry called Scent Incognita. The goal is to investigate which plants contribute smells to our environment and whether these are pleasant or pungent, strong or subtle. In the project PollenNet, which has been running since November 2024, citizen scientists record the flowering of common hazel (*Corylus avellana*) and silver birch (*Betula pendula*). These images are also used to develop an AI that can predict pollen release based on flower images, helping allergy sufferers prepare in advance.

At the Max Planck Institute, Jana Wäldchen leads an interdisciplinary project team alongside computer scientist Patrick Mäder from the Technical University of Ilmenau to further develop the app. "Automated plant identification was long considered nearly impossible," says Wäldchen. First, the researchers had to determine which features of a species are important for identification: the serrated edge or venation of a leaf, or the shape and color of its flowers, for example. These features then had to be described mathematically. An algorithm could use these descriptions to learn automatic species identification through classic machine learning

methods. The process is very labor-intensive, as relevant features must be defined by experts, mathematically described, and extracted from images. Moreover, these methods are less flexible and robust in the face of the large variability within a species. They quickly reach their limits for many species or complex patterns. This is exactly the challenge in plant identification: in Germany alone, there are over 10,000 plant species, and worldwide more than 330,000. Many species differ only minimally in appearance, while others can vary within a species depending on location or season.

Deep Learning for Image Recognition

The project team is therefore taking a different approach, since Flora Incognita is ultimately intended to reliably identify most plants worldwide. The app uses deep learning for image recognition. Its foundation lies in neural networks, whose architecture is inspired by the human brain. These networks consist of artificial neurons that process and transmit information. Deep neural networks, which contain multiple layers arranged in sequence, are particularly powerful. In each layer, the input data is further processed, enabling the network to recognize increasingly complex features. Flora Incognita uses a type of deep neural network called a convolutional neural network, which is optimized for image processing. These networks are already part of many people's daily lives: for example, in smartphone facial recognition. They are also used in medical diagnostics, such as for analyzing X-ray or MRI images.

During the training phase, the algorithm learns to distinguish plant species based on typical external features, such as a European beech from a field maple, or – much more challenging – different grass species that often look very similar. Unlike the original method, where features had to be defined by humans, the model learns during training to recognize the relevant patterns on its own. "We trained our network with a large number of images so it could identify a range of structures – from simple edges and colors to complex traits such as characteristic leaf shapes or flower patterns," Wäldchen explains.

Verified training images, correctly and unambiguously assigned to various plant species by humans, are therefore essential. They come from professional plant experts. "Whenever we gather enough new verified photos, we let the algorithm continue learning from them. This makes it even more accurate and able to recognize more and more species," Wäldchen explains. The AI behind Flora Incognita is only as good as its training. "It's therefore worth investing a lot of effort into high-quality training images," Wäldchen emphasizes. Using this approach, Flora Incognita has learned to identify more than 32,000 plant species with over 90 percent accuracy.

With the millions of observations contributed by its users, the app has ⟶

A flower from the perspective of a human (left) and a computer. A human can identify the plant based on features such as the number, shape, or color of stamens and petals. A computer, in contrast, assigns the image content to a specific object class based on properties like texture and edges. Unlike a human, it considers the entire image when determining the species.

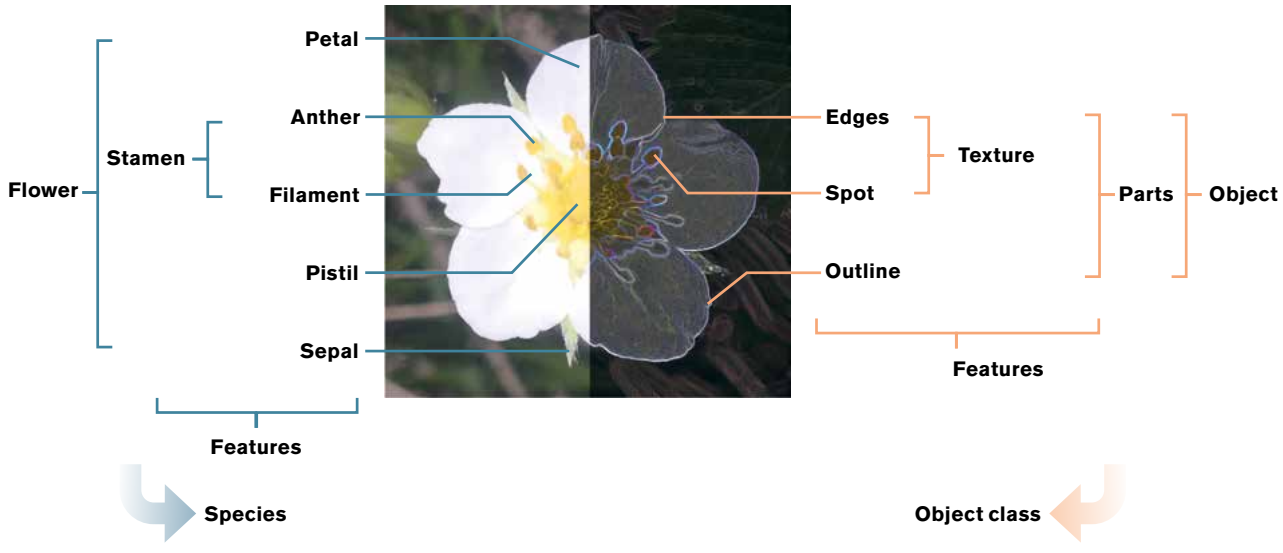
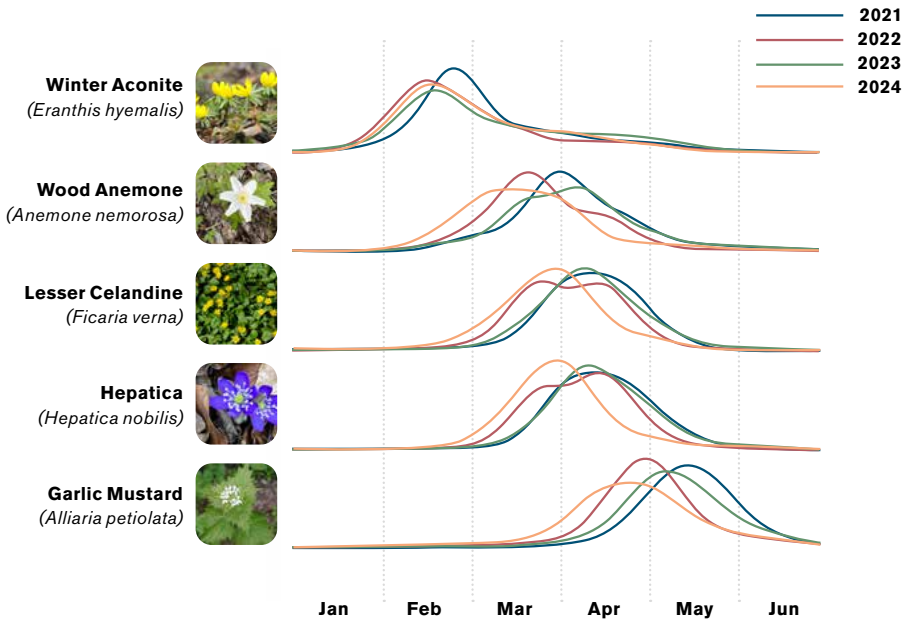


CHART: FLORA INCOGNITA, BASED ON WÄLDCHEN, J., RZANNY, M., SEELAND, M. & MÄDER, P. (2018). AUTOMATED PLANT SPECIES IDENTIFICATION – TRENDS AND FUTURE DIRECTIONS. PLOS COMPUTATIONAL BIOLOGY 14. PLOS COMPUTATIONAL BIOLOGY 14

access to vast amounts of data. However, this data exhibits patterns that are less pronounced in systematically collected datasets. For example, Flora Incognita users tend to be active in good weather and in urban areas rather than in rain or remote regions. Observation numbers show clear peaks on weekends and holidays and are more often recorded along forest or field paths than on open terrain. Moreover, conspicuous and showy species are documented far more frequently, while inconspicuous species are strongly underrepresented in the dataset.

Impacts of Climate Change

To reliably analyze such opportunistically collected data, a variety of analytical methods are required. Several studies by the research team have shown, for example, that Flora Incognita data is well suited to detecting seasonal and geographic shifts. In the long term, this approach aims to make the effects of climate change visible. Even now, however, patterns are emerging: for many plants, flowering periods can vary significantly from year to year. Frequently observed species, such as wood anemone, hepatica, or garlic mustard, flowered earlier in the unusually mild temperatures of 2024 than they did in 2021. If global warming disrupts natural timing, the consequences could be far-reaching. For example, if a plant flowers before the appearance or activity period of its specific pollinators, "pollination gaps" can occur, leading to reduced pollination efficiency, lower seed production, and ultimately a decline in the plant's reproductive fitness. "We want to detect these ecological changes as early as possible," says Wäldchen. The data also benefits official conservation efforts. Occurrences of invasive species, for instance, have been forwarded to the relevant authorities to enable timely management measures, since early detection is crucial, particularly in controlling invasive species.



From the observations collected in the app, researchers can indirectly infer the flowering periods of the plants. The data shows that these can vary greatly from year to year. Almost all of the species shown here flowered several weeks earlier in 2022–2024 compared with 2021.

What began in 2014 as a small research project on plant identification has become an indispensable tool in conservation. Other initiatives can also benefit from the experience gained in developing Flora Incognita. For example, Wäldchen and Mäder, together with the Helmholtz Centre for Environmental Research, have developed an AI to identify butterfly species found in Germany (Day-Flying Butterfly Monitoring). In addition, an automated system for identifying algae is under development. These often single-celled organisms are particularly difficult to classify, because they go through different life stages, the same species can appear very differently. An AI-supported monitoring system for certain species could also aid in the surveillance of water bodies. Before long, the AI behind Flora Incognita is expected not only to analyze individual plant species but entire areas. Researchers could then, for example, determine the plant composition of meadows, fields, and other habitats from photographs much more quickly than is currently possible. ←

LINKS

FLORA INCOGNITA
floraincognita.de

SCENT INCOGNITA
www.mpic.de/scentincognita

POLLENNET
floraincognita.de/citizen-science-pollennet/

DER WALDDOKTOR
floraincognita.de/walddoktor-misteln

TAGFALTER-MONITORING
web.app.ufz.de/tagfalter-monitoring

RESEARCH
DOESN'T HAVE TO BE HEAVY.

The Max Planck Society's magazine is available as an **ePaper**:

www.mpg.de/mpr-mobile
www.mpg.de/mpresearch

DOWNLOAD THE EMAGAZINE FOR FREE!