








AppPopuli: Web Application for Real-Time Damage Report in Poplar Plantations Using Citizen Science

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Abstract. AppPopuli is a citizen science project developed by a multidisciplinary team, in the fields of forest health and computer science. The core of the project was to develop a web application that allows both foresters and ordinary citizens to inform, in real-time, about damages in hybrid poplar plantations (*Populus* spp.) caused by pests or diseases. The damage report is done individually by the user through a form that they fill in with information related to the damaged tree, such as, for example, the name of the pathogen causing the damage (if known), the geographical location, photographs, etc.; so that this data is stored in a database. The database aims to monitor the status of poplar plantations and provide feedback to the app users about the damage they have reported. On the other side, the application also includes a help section with information about the pests and diseases that could damage poplar trees, so that non-experts in the field are able to identify damages found in poplar trees correctly; and an explore section with a table that contains some of the data of the reports sent by the users with their location marked on a world map. The application is focused on its use using mobile devices (but not limited to), which has been kept in mind while designing the user interface in order to guarantee a good user experience, no matter the device you are using and the size of its screen. This application will contribute to sustainable and responsible wood production, providing more resilient poplar plantations and promoting the early control of potential pests and diseases.

Keywords: App · Web responsive · Forest health · Monitoring

1 Introduction

1.1 Forest Health Monitoring and Citizen Science

In forestry, the possibilities of eradicating or minimizing the effects of a new plague or disease depend to a large extent on the speed with which the problem is detected, in order to stop or slow down its progress. Early detection therefore becomes a key element, which has led several countries to define early warning systems such as Early Warning System (EWS) in the United States, Tree Health Action Plan (THAP) in the UK or the future Tree Health Early Warning System (THEWS) in Europe [1]. These systems are based on four key aspects to detect and respond to environmental threats [2]: (1) Identify potential threats, (2) Detect actual threats, (3) Assess impacts, and (4) Provide a response.

Regarding the second aspect, to detect existing (real) threats, it is necessary to carry out surveillance and monitoring tasks, carried out by specialists in forest health (forestry administration, universities, research centres, forestry associations), forest managers, nursery workers, as well as society in general. In this area, it can be highlighted the “Observtree” initiative [3] of the Forestry Commission of the United Kingdom, which tries to establish a new system for early detection of the health status of forests based on “citizen science”, where citizens who participate voluntarily report the location of a forest pest or disease as soon as they see it, through the “Tree Alert” mobile application. This maximizes the chance of eliminating or controlling future outbreaks/infestations. These volunteers receive prior and ongoing training to increase their effectiveness in detecting pathogens, and this information is passed on to forest health specialists for verification. AlertaForestal [4] is a similar project that seeks to collect data on phenomena that affect the health of forests by citizens who do not have to be forestry experts. In addition to sending alerts, it allows the alerts sent by users to be viewed on a world map. iNaturalist [5], Pl@ntNet [6] and BiodiversidadVirtual [7] are citizen science websites that collect data on observations made by users, of living beings in the case of the former and of plants in the case of the latter. These applications are citizen science projects in which citizens are encouraged to be part of by sending data that will be very useful for researchers and, in the case of AlertaForestal, spreading the importance of maintaining healthy forests to the population, since they provide maximum economic, social and environmental benefits, as well as warnings about the impact of climate change on forests.

1.2 Real-Time Damage Report in Poplar Plantations

Sustainable production of wood is threatened over the world by the increase in biotic damages, caused by pests and diseases that attack these trees and slow down their growth or, worst case, kill the plant. These issues affect as well commercial poplar plantations which account for 7.6 million ha in China, followed by France (236,000 ha), Turkey (125,000 ha), Spain (105,000 ha), and Italy (101,430 ha) [8]. In Spain there is no general database that collects information about poplar trees damaged by these agents. For this reason, and in collaboration with the poplar value chain, the objective was to design a system that would allow reporting, in real-time, the health status of the poplar trees, based on symptoms observed in the field. Such a system would give both companies in

the wood industry and small owners the possibility of managing their poplar plantations much more efficiently, locating possible damage found in the trees early. In addition, one of the aims was that the population in general would participate in the project, sending data about damages found in the field. In this way, much more information would be collected and the idea of how important it is to maintain healthy forests and the economic and environmental benefits that this entails would spread.

2 Objective

The objective was to develop AppPopuli, a web application that allows both foresters and ordinary citizens to inform, in real-time, about damages in hybrid poplar plantations (*Populus* spp.) caused by pests or diseases, and integrate that information into a database that can be used by forest managers for monitoring forest health status.

3 Material and Methods

3.1 Contents

The contents and functionalities that should be included in the application were set considering the feedback from two companies from the poplar sector and the forest administration. The main requirements are listed below:

1. Sending reports with the following data regarding the forest health issue:

- Geographical location of the damage
- Date the damage was identified
- Identification of the pest or disease causing the damage
- Photographs of the damage (if any)
- User comments
- Extent of damage
- Severity of damage

2. User contact information

3. User help section with:

Information on the most common pests and diseases that can attack poplars, including photographs and files in PDF format for download.

A user guide on how to use the application, submit a damage report and take photographs so that the damage is correctly displayed.

Training videos complementary to the user guide.

4. Storing the information of the reports in a database.

3.2 Prototype

The prototype was designed using the tools provided by the Moqups website [9], which has a wide variety of entirely free design options to obtain a layout that is as close as possible to the interface of a real system. As well, the principles that characterize a quality user experience were reviewed [10].

3.3 Database Design

To design the database, it was necessary to identify the data that must be stored and the relationships that may exist between them. Given the information that needs to be stored, four tables were necessary (Fig. 1): one for the damage reports, one for users (contact information, to later login with that data), one for the list of pests and diseases (information is available in the help section), and another for the listed symptoms (information is available in the help section).

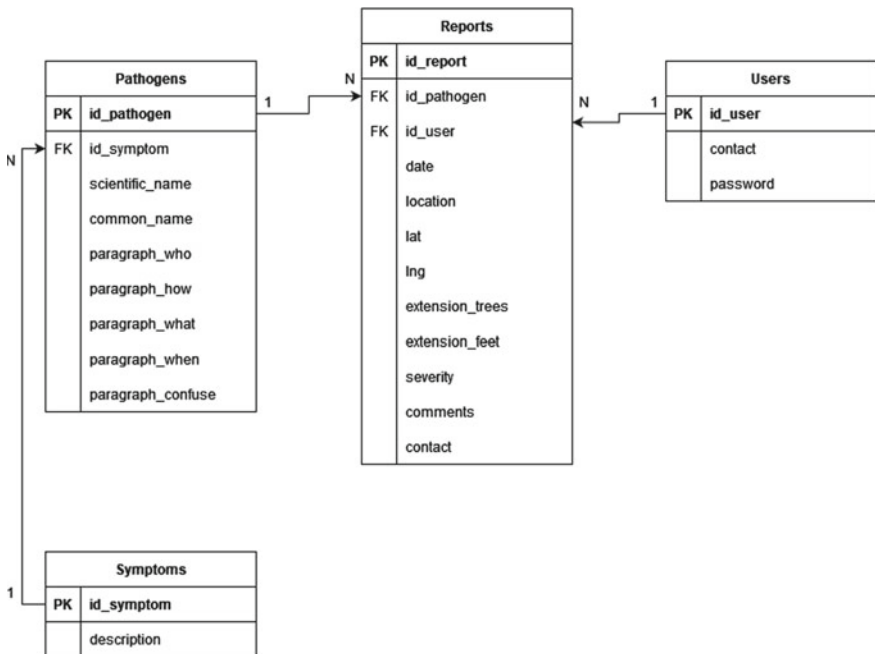


Fig. 1 Relational diagram of the database of AppPopuli

3.4 Tools

The following tools were used to develop the application:

- **Plesk**, a secure and easy-to-use web server control panel. This tool allows, through its graphical interface, to manage the domains hosted on a web server, including transferring files to it, databases (through phpMyAdmin), integration of extensions, traffic statistics and space used, etc.
- **phpMyAdmin** is a free tool that allows the management of MySQL through a graphical interface on the Web. In our case, we used MariaDB, another database management system with which it shares many of its features instead of MySQL. Thanks to phpMyAdmin (which is integrated in Plesk) we were able to create databases, manipulate tables and carry out CRUD (create, read, update, and delete) functions on the data simply and effectively.
- **XFTP** allowed the transfer of files with a server remotely, being able to use the SFTP protocol in the connection for the encryption of the transferred traffic or FTP for traffic without encryption, but at the maximum connection speed. Through this tool, the necessary files to start the application will be sent to the server.
- **Postman** is an application dedicated to the use of APIs (in English ‘application programming interface’), application programming interfaces for the connection between a client and a server, so that when a client makes a request to the server, it has a specific communication endpoint configured for the said call. The application was used to send requests, both locally to the computer from which we work and remotely to the web server, to the API which was configured to receive the requests of the GET and POST methods, and thus verify that these are they carried out correctly.
- **Node.js** is an asynchronous object-oriented JavaScript runtime environment (<https://nodejs.org/en/about/>) designed to build scalable web applications. This tool served as the backend of the application. It has the ability to serve many connections simultaneously and independently thanks to the event loop it uses as execution runtime. It was used to execute code written in JavaScript on the web server.
- **Express** is a fast, minimalist, and flexible framework for Node.js web applications [11]. Express provided the following mechanisms to the application [12]: handle requests received on the server with different HTTP versions on different routes, integration with view rendering engines, and add additional processing on requests.
- **Vue.js** is a JavaScript framework designed to create user interfaces [13]. This environment allowed us to create the views that were designed for the prototype.
- **Visual Studio Code** is a source code editor with support for JavaScript, HTML and CSS, although not for Vue.js, at least not natively, so it was necessary to install the official Vue extension, Volar.

4 Results

4.1 Backend and Frontend

The development of the application was divided into two parts: the first one focused on the backend and the second on the frontend. To develop the first, and for it to be able

to communicate with the second, the guide provided by BezKoder [14] was used as a reference, in which the process of creating and deploying a web application with Node is explained step by step. js, Express, MySQL and Vue.js.

Regarding the backend, in order to interact with the database, a REST API was created, where the routes to access the data and the methods to be used were specified. In this case 10 actions were included in the REST API. We verified that the API worked correctly with the Postman program by making HTTP requests of different types to the different routes of the server that we previously defined in the files of the routes folder.

For the frontend, Vue.js was the primary tool used to develop the application interface [13]. The BezKoder guide used to build the backend was needed to learn how the interface should communicate with the API [14].

4.2 Appearance and Final Content of the Application

With all of this we would have the application ready for use through the following link: <http://test.apppopuli.es>. The application is focused on its use through mobile devices (but not limited to), which has been kept in mind while designing the user interface in order to guarantee a good user experience (Fig. 2), no matter which device you are using and the size of its screen.

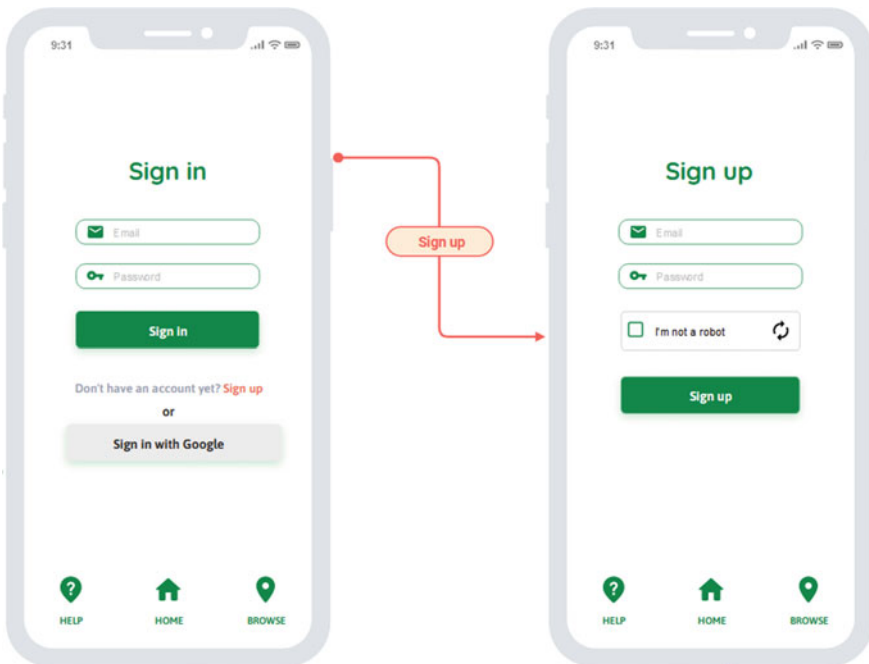


Fig. 2 Screenshots of the login and signup sections of AppPopuli

As an example, Fig. 3 shows the information collected by AppPopuli for the report, while Fig. 4 shows the list of reports already stored in the database. The database aims

to monitor the status of poplar plantations and provide feedback to the app users about the damage they have reported. The owners of poplar trees will also be able to store their damage reports and view those from other areas, contributing to the digitization and progress of the poplar sector.

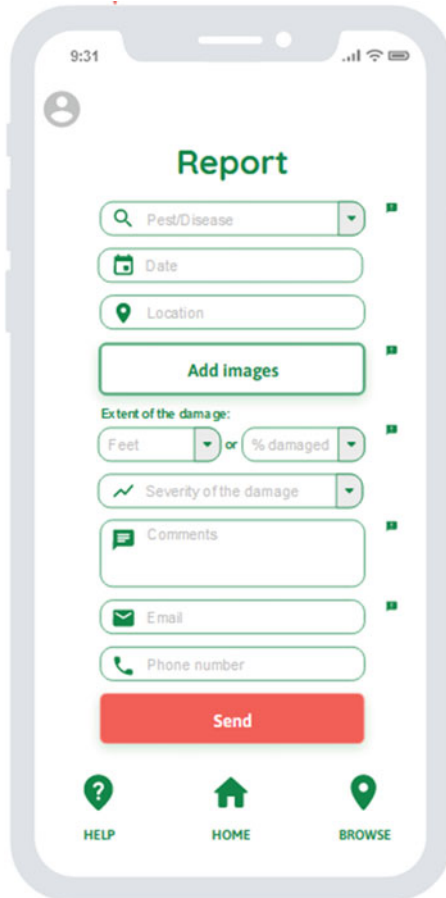


Fig. 3 Information collected by AppPopuli for the report

The application also includes a help section with information about the most common pests and diseases that could damage poplar trees, so that non-experts in the field can correctly identify damages found in poplar trees. This contributes to raising awareness among the population about the importance of maintaining healthy forests as well as the benefits that it entails.

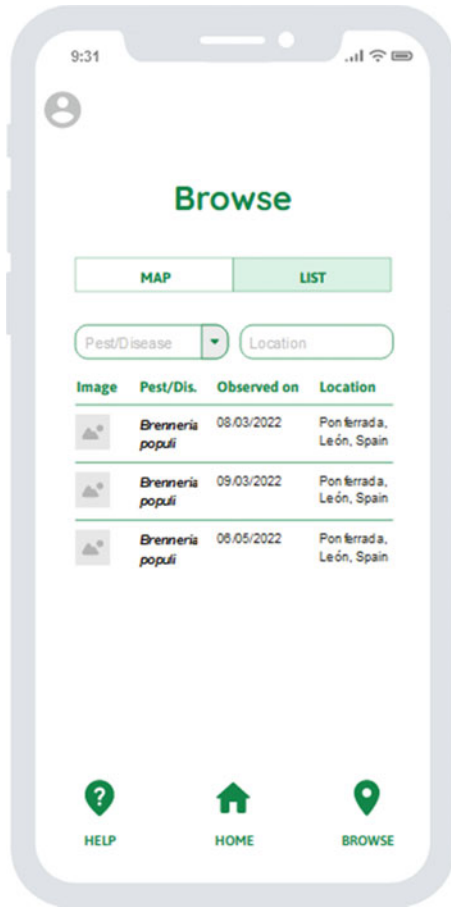


Fig. 4 Example of list of reports stored in the database and collected by AppPopuli

5 Conclusion

The main objective of the application, which was to create a responsive web application to report in real time about damage found in poplar trees, has been satisfactorily fulfilled, as well as the adaptive design that was sought to achieve to offer an optimal user experience regardless of the device from which it was accessed. Early identification of damaged areas using AppPopuli will contribute to sustainable and responsible wood production, providing more resilient poplar plantations and promoting the early control of possible pests and diseases. It is expected that events will be held to present the application to potential users and make use of it, in order to receive feedback that will help us improve the application.

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