

The OakMapper WebGIS: Improved Access to Sudden Oak Death Spatial Data¹

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Abstract

Access to timely and accurate sudden oak death (SOD) location data is critical for SOD monitoring, management and research. Several websites (hereafter called the OakMapper sites) associated with sudden oak death monitoring efforts have been maintained with up-to-date SOD location information for over five years, providing information and maps of the most current spatial and attribute data on *Phytophthora ramorum* distribution in California to the public, the California oak mortality task force, and researchers. In addition to the spatial locations of *P. ramorum*, the OakMapper websites maintain a range of supporting spatial data. There are two main avenues for which to view the data: static SOD maps (state, county, and local area vicinity), and the interactive and dynamic OakMapper websites.

The OakMapper database, the statewide repository for all positive *P. ramorum* confirmations in California, has several components. The OakMapper webGIS application allows people to view confirmed *P. ramorum* trees, general SOD areas, symptomatic SOD trees submitted via an online form (“SOD sightings”), geo-located photos of SOD, United States Department of Agriculture-Forest Service (USDA-FS) annual aerial survey polygons depicting forest mortality (listed under “Aerial Survey Data”), host species areas, federal, state, and regional parks, highways, interstates, and local roads, state-wide SOD risk model created by Sonoma State University (SSU), and U.S. Geological Survey (USGS) topographical data. With OakMapper, the user can zoom in/out, query data, and search for SOD near an address. The user can link to climate data, which are long-term averages of monthly temperature and total precipitation, for each SOD confirmations, and export and print custom maps. Geographic layers can be turned on and off to customize the view. In addition, all the information behind the geographic data can be queried in order to learn more about each SOD confirmation.

OakMapper visitors can choose to view the OakMapper in three formats. First, they can use the original OakMapper, built with ESRI’s ArcIMS, which contains numerous tools for map viewing and querying. Second, they can use the OakMapper Google Maps, where they can view SOD confirmations with easy-to-use Google Maps interface and data as the backdrop. Click on “Map” to view the road map backdrop, “Satellite” to view aerial and satellite photos as backdrops, and “Hybrid” to view both. Third, they can use the OakMapper-Google Earth, where they can view SOD confirmations and a few other data layers over the interface. Users need to install Google Earth onto their computers before they are able to view this data. Once they have it installed, they can click on the link on oakmapper.org and open the file up in Google Earth. Zoom around and tilt the earth to see a bird’s eye view of SOD. In some places, you can even see the affected dead/dying trees behind the SOD confirmation! Visitors to the OakMapper can submit an SOD sighting, which is a symptomatic tree that is potentially infected with *P. ramorum*. The submitted points are then mapped as part of the OakMapper. In addition, we have been collecting user opinions about the OakMapper through an online

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survey, where users can leave valuable feedback about what they like or dislike about the OakMapper, and give suggestions on its improvement.

Key words: *Phytophthora ramorum*, sudden oak death, WebGIS, OakMapper.

Introduction

Access to timely and accurate information on the locations of trees confirmed to be infested with *Phytophthora ramorum* is critical for SOD monitoring, management and research. Such location information is commonly stored in Geographic Information Systems (GIS), and when linked with the Internet, these tools can provide support for a range of monitoring and management efforts. For example, the data depicting the most current distribution of the disease in California has been used to determine zones of infestation, to map potential climactic niches for the pathogen, and for education and outreach efforts.

We maintain several websites associated with sudden oak death monitoring efforts with up-to-date SOD location information for over five years, providing information and maps of the most current spatial and attribute data on *P. ramorum* distribution in California to the public, the task force, and researchers. There are two main avenues for data viewing and interaction: static SOD maps (at the state, county, and local area scale), and the interactive OakMapper website.

Materials and Methods

Development of a *P. ramorum* spatial database. Accurate disease location information remains a key component of all management efforts. When sampling trees suspected of being infested with *P. ramorum*, samplers are encouraged to use global positioning systems (GPS) to acquire the spatial location of sampled trees in the field. However, not all location data comes from GPS; we also receive disease confirmations with addresses, or photocopies of maps. Once collected in the field, samples are sent to the labs of the California Department of Food and Agriculture, University of California (UC) Davis, or UC Berkeley, and all disease presence/absence results are forwarded to our GIS lab at UC Berkeley.

The location information for positive *P. ramorum* confirmations are entered in a relational database in UTM Zone 10, NAD 83 format; if addresses or coordinates from other projections are provided, they are geo-coded or re-projected. We recommend Universal Transverse Mercator (UTM) as the initial projection because it prevents rounding errors common with the latitude/longitude (geographic) projection, and produces accurate, easily understood, and consistent area and distance measurements in the field. Data are then re-projected from UTM to the 'California Albers' projection created by the Teale Data Center GIS Lab. Additional ancillary geospatial datasets, including political and jurisdictional boundaries and forest and land cover data and both the tracks and overstory mortality polygons from annual aerial surveys of tree are also maintained in the spatial database.

Static SOD map creation and distribution. Maps are powerful and beautiful tools that can be used to easily communicate complex information. We have developed both static and dynamic tools for cartographic product creation and distribution. The sudden oak death monitoring website offers downloadable, "ready-made" static maps that depict SOD distribution for state, county, and vicinity areas, available in JPEG, PDF, and TIFF formats. These are updated as the SOD database is updated. In addition, we accept requests from users for custom maps, for example, the area around a specific address or local park. There have been over 350 map or data requests in the past five years from citizens (50 percent), academics (20 percent), and regulators (30 percent). Maps are used for a wide range of purposes, including state legislature briefings and public meetings, and have appeared in

many research publications, newspaper articles, and informational websites.

OakMapper webGIS. In addition to static paper and digital maps, we have used webGIS to create three internet-based portals to the SOD data. These are dynamic, customizable, and user-driven cartographic environments. The original webGIS application (Fig. 1), was built using Environmental Systems Research Institute, Inc. (ESRI) ArcIMS software, and remains the most feature-rich of the three sites. The original OakMapper allows user-specific interactions—including scale-dependent zooming, customized map creation, hyperlinked photography, and querying functions—with the spatial database. The original OakMapper webGIS site also allows users to report trees that might have the disease so that follow-up sampling can take place. These citizen-monitoring data are not designed to be rendered on the map as “confirmed” cases of SOD, but are guides to tell us where our education efforts are getting out, and if there are clusters of tree symptoms that might be overlooked. Ancillary data included in the system are the flight lines and mortality polygons associated with five years of U.S.DA-FS survey-funded aerial surveys; host species and park boundary information from California GAP Analysis Project (University of California Santa Barbara 2007); and urban areas from the California Spatial Information Library (CaSIL 2007).

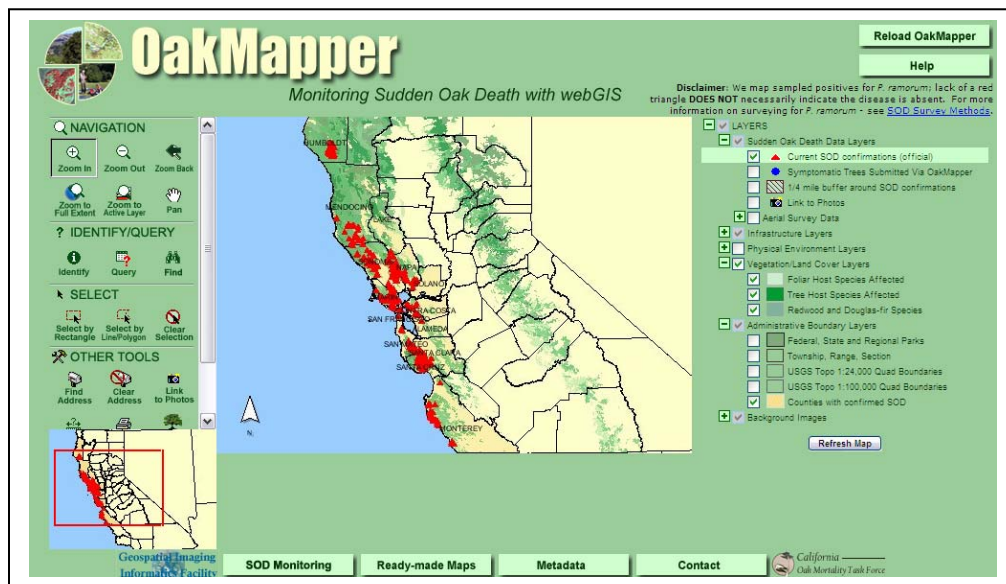


Figure 1—The original feature rich OakMapper webGIS application.

A second mode of interaction provided by the OakMapper site is powered by Google Maps™ (Fig. 2). In recent years, several companies, including Yahoo!, MapQuest, and particularly Google via Google Earth and Google Maps have revolutionized public access to spatial data. While these on-line mapping tools are designed for a business model that focuses on advertising and marketing, the services provided are also a boon to environmental sciences. Using the Google Maps Application Programming Interface (API), we customized an OakMapper application that runs on the Google Maps server, and takes advantage of the abundance of high spatial resolution imagery in the Google Maps archive as backdrops for the *P. ramorum* confirmations. Such visualization can be very powerful at conveying the environmental niche of each confirmation, and can also be a useful outreach tool. Like the original OakMapper tool, the user need have only a web browser to interact with the data; expensive GIS software is not needed. Zoom and identify functionality are made easy through the Google Maps interface, and have proved useful for visualizing SOD confirmations over imagery with resolution high enough to view dead crowns of SOD-affected trees.

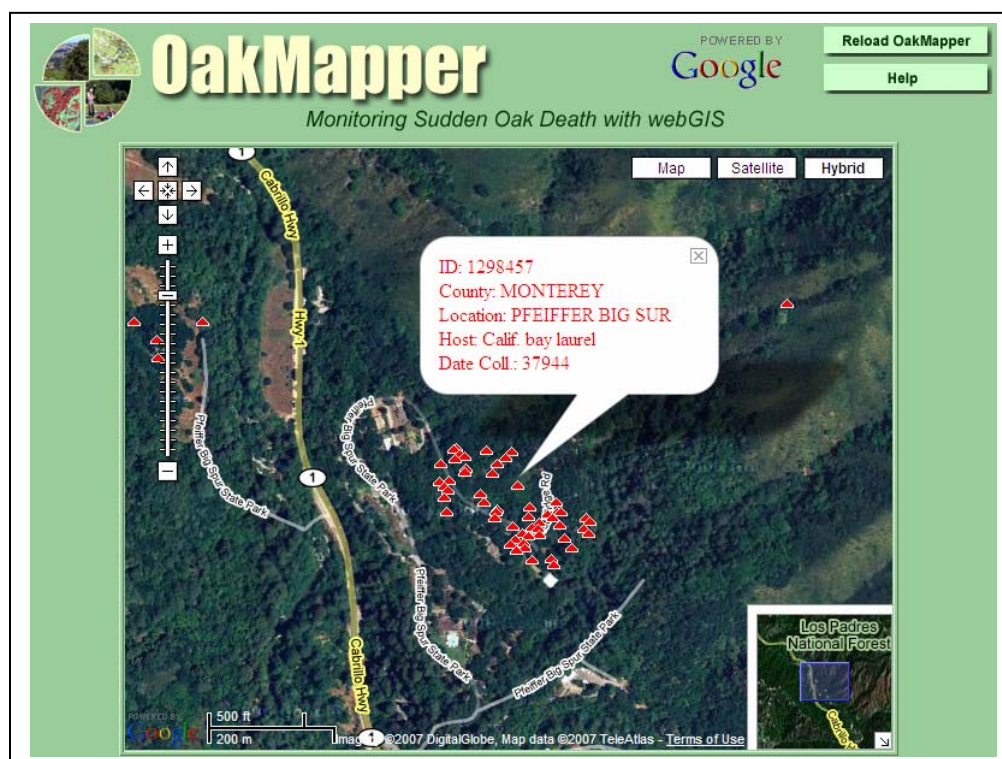


Figure 2—OakMapper webGIS powered by Google Maps.

The third model of interaction uses Google Earth™ technology (Fig. 3). Here the user must have a copy of Google Earth (the basic version is free), or Google Earth Plus or Pro (which are not free) on their computer. Our spatial data depicting the *P. ramorum* confirmations can be added to a client-side Google Earth session, allowing seamless fly-through visualizations of the environment of each *P. ramorum* confirmation. Other data layers that exist within the Google Earth application can be viewed with the SOD confirmations; in addition, the most advanced version (Google Earth Pro) allows GIS layers on the user's computer to also be added to the layer list for enhanced GIS map-making and visualization.

Software and Hardware Information. The University of California at Berkeley has a site license for ESRI, Inc. products, and all SOD GIS data and maps are created and maintained using ESRI's GIS suite, including ArcGIS 9.2 and specialized extensions (ESRI, 2004a; ESRI, 2004b). The original OakMapper webGIS application uses ESRI's ArcIMS (version 9), an internet mapping service software package that uses languages like HTML and Java to provide users access to geospatial data residing on a server using any Internet browser. The OakMapper powered by Google Maps uses the Google Maps API to connect the OakMapper data with the Google Maps imagery and functionality. This API code is open-source and available for free from the Google Maps API website (Google 2007). The OakMapper powered by Google Earth uses Keyhole Markup Language (KML) to connect the OakMapper data with the Google Earth application.

The online submission form that allows users to enter symptomatic SOD sightings uses PHP programming languages to connect with our MySQL database. Reports submitted with a specific address are geocoded into a shapefile using ArcGIS and TIGER 2000 street data.

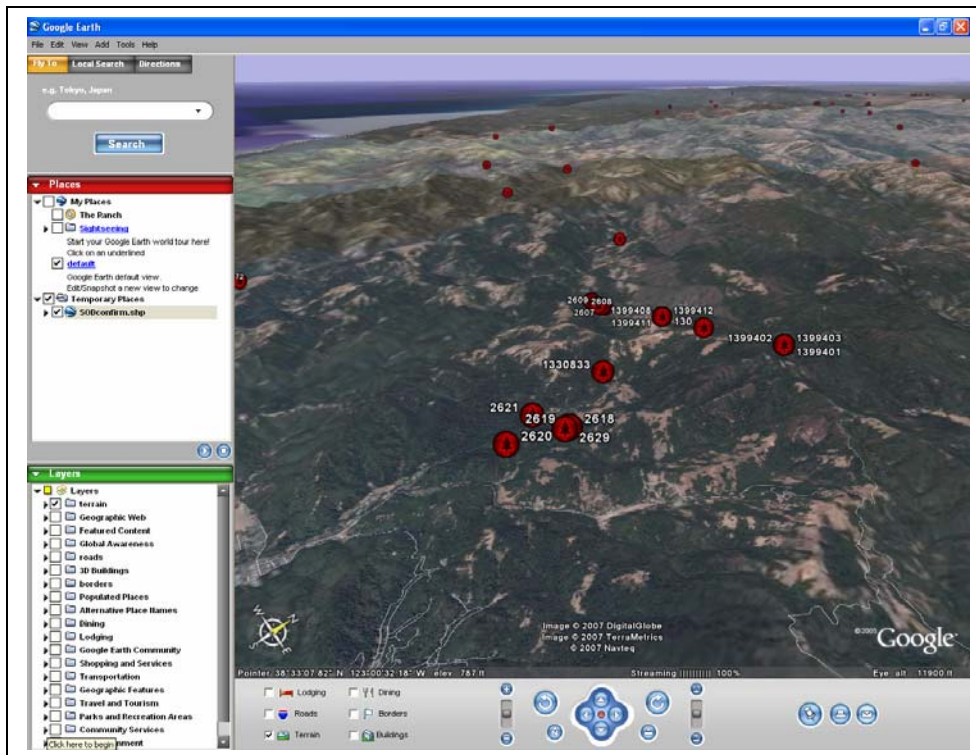


Figure 3—OakMapper webGIS powered by Google Earth.

Currently, all GIS data is stored in static vector (e.g., shapefiles, coverages) and raster (for example, GRID) formats; however, migration of all data to Arc Spatial Database Engine (ArcSDE) is planned in the near future to allow real-time updates, while also retaining the data integrity and security offered by a spatial relational database management system.

Results and Discussion

With all versions of the OakMapper, you can view the current distribution of SOD throughout California; zoom, view, and search monitoring data for both confirmed and reported SOD in California. The feature-rich original OakMapper provides additional data that the other sites do not, and allows additional queries, such as searching by street address, county, zip code, and congressional district. This site also provides additional educational material about SOD, including symptoms, host species, and monitoring updates. Also, a user can find contact information for their county's Agricultural Commissioner's office and UC Cooperative Extension office in California counties. In all versions, users can create a custom map, or snapshot of a visualization.

The data in the OakMapper database has several caveats associated with it. Privacy is a concern to many people who may have SOD on their property. With such high resolution to the backdrop imagery on the OakMapper, users can zoom in and see individual properties and houses. Oftentimes, you can see actual dead crowns on SOD-affected trees. With high-resolution data becoming ubiquitous in most web mapping application, privacy will continue to be an issue, especially surrounding environmental problems like SOD. However, as *P. ramorum* establishes itself in areas along the urban-wildland boundaries, it is less of a privacy concern affecting only a few homeowners and is more of an ecological concern affecting entire neighborhoods.

The dating of imagery is of concern to many people who use the OakMapper for decision-making. While the SOD confirmations and host layers are updated as new trees are confirmed and new species are added to the host plant list, other datasets may not be updated as frequently. Examples of these datasets include road layers, which may still consist of line files gathered from the 2000 U.S. Census TIGER data. Another example is the dates of the imagery hosted by Google Maps/Earth. While Google strives to update their image databases with the most timely and high-resolution imagery, it is important to remember that the imagery is not real-time and may have a 1 to 3 years lag time before new imagery is acquired and bought by Google to display on their applications. In addition, the dates that are displayed at the bottom of the Google Maps and Google Earth interface do not necessarily correspond with the date of imagery acquisition, and may instead indicate copyright or other image dating.

The OakMapper webGIS applications continue to be a valuable outreach tool for the sudden oak death project. We have distributed data, maps, and animated movies showing change in SOD over time to multiple people and groups. Highlights include the creation of SOD maps and animated movie for KQED's Quest online and television program (<http://www.kqed.org/quest/>), as well as the production of maps for a feature in the October-December 2006 issue of Bay Nature (http://www.baynature.com/v06n04/v06n04_toc.html). We have made maps for the Government Accountability Office (GAO), the USDA-F.S., Pacific Gas & Electric (PG&E), and numerous other consulting firms, government agencies, and local groups. In addition, numerous undergraduate and graduate students have requested SOD data in the past few years.

The development of web-based efforts continues to prove effective in communicating SOD information to researchers, regulators, and the general public by providing a readily available avenue for viewing, searching, querying, and exporting data and maps. The ultimate goal of the OakMapper webGIS is to empower stakeholders to participate in disease monitoring. To this end, the application is designed with non-GIS experts in mind. An online form is used to gather reports of potential SOD sightings by allowing users to: 1) select a host and visible SOD symptoms (chosen from pictures and explanations that aid in identification), 2) enter information about their familiarity with forest and forest diseases, and 3) submit the location of the tree (in other words, GPS coordinates, addresses, or location on map). The numerous submissions to date have demonstrated the success of citizen-generated data in widening the sampling effort for this disease (Kelly and Tuxen 2003). The OakMapper webGIS took more than a year to develop, and is continual work in progress as improvements are made and data is updated. We found that while a team was needed for the overall webGIS development, we needed a single champion dedicated to customizing a webGIS application for our specific project.

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