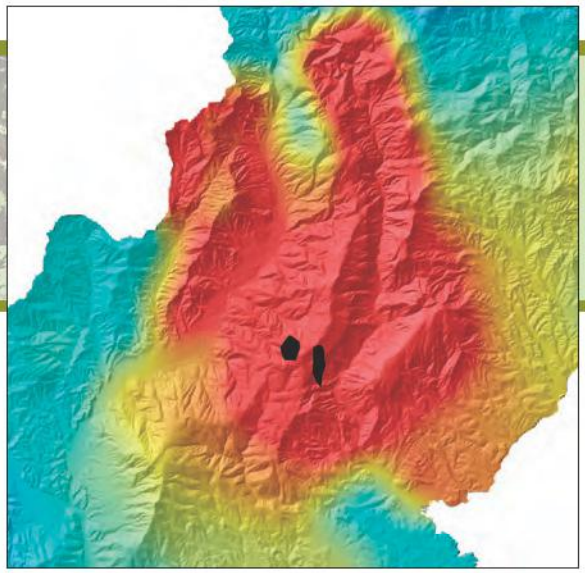

Mapping southern pine beetle hazard in the Pisgah National Forest, North Carolina

Weimin Xi, Lei Wang, Maria D. Tchakerian, Robert N. Coulson

Established in 1916, the Pisgah National Forest is one of the first national forests in the eastern United States. Covering more than 500,000 acres, the Pisgah features rugged mountains, waterfalls, rivers, and wilderness areas. The Pisgah is known as the "Cradle of Forestry" since it is the site of the first school of forestry in the United States, the Biltmore Forest School. This school operated during the late 1800s and early 1900s and was originally managed by Gifford Pinchot, the first chief of the U.S. Forest Service.

Between 2000 and 2002, the southern pine beetle created catastrophic damage to a wide variety of pine species found throughout forests in the southern Appalachian Mountains. The southern pine beetle (*Dendroctonus frontalis*) is the most destructive insect pest of pine forests in the southeastern United States. Tree species affected include Table Mountain pine (*Pinus pungens*), pitch pine (*Pinus rigida*), shortleaf pine (*Pinus echinata*), and Virginia pine (*Pinus virginiana*).

This map was created to identify areas susceptible to future southern pine beetle (SPB) outbreaks in the Grandfather Ranger District of the Pisgah National Forest in western North Carolina. Created to provide forest owners and managers with spatial information on SPB hazard, the map shows specific high-hazard areas where prevention and restoration practices should be conducted. Additionally, this map provides spatial information on SPB hazard for Texas A&M University's ongoing spatial modeling project. The project investigates the utility of landscape models as a decision-making tool for predamage impact analysis and post-damage restoration planning.

A visual solution

Using information that is accessible to the public, this map indicates areas that are most susceptible to potential attack showing a landscape-level SPB hazard rating. Forest owners and managers can use this information to increase the effectiveness of forest management planning and assessment in order to suppress and prevent future SPB outbreaks.

To create the map, research scientists at Texas A&M University developed a procedure that integrates spatial statistics techniques along with scientific knowledge of key factors conducive to SPB activity. This approach is widely applicable in the southern Appalachian Mountains and more generally to adjacent areas of the southeastern United States.

The hazard rating used in this map is based on the spatial configuration of the yellow pine hosts located throughout the landscape with high-hazard areas identified on the map in red. Area-based spatial clustering analysis was used to generate the Getis-Ord general G index as the indicator of susceptible hotspots to SPB. Getis-Ord is a clustering tool used to measure the concentration of high or low values for a specific study area. The tool calculates both the predicted and expected results of the analysis, which is helpful for identifying unexpected spikes in the data.

In addition, elevation and the locations of SPB outbreaks in year 2000 are presented to help forest owners and managers prioritize areas where they should conduct prevention activities.

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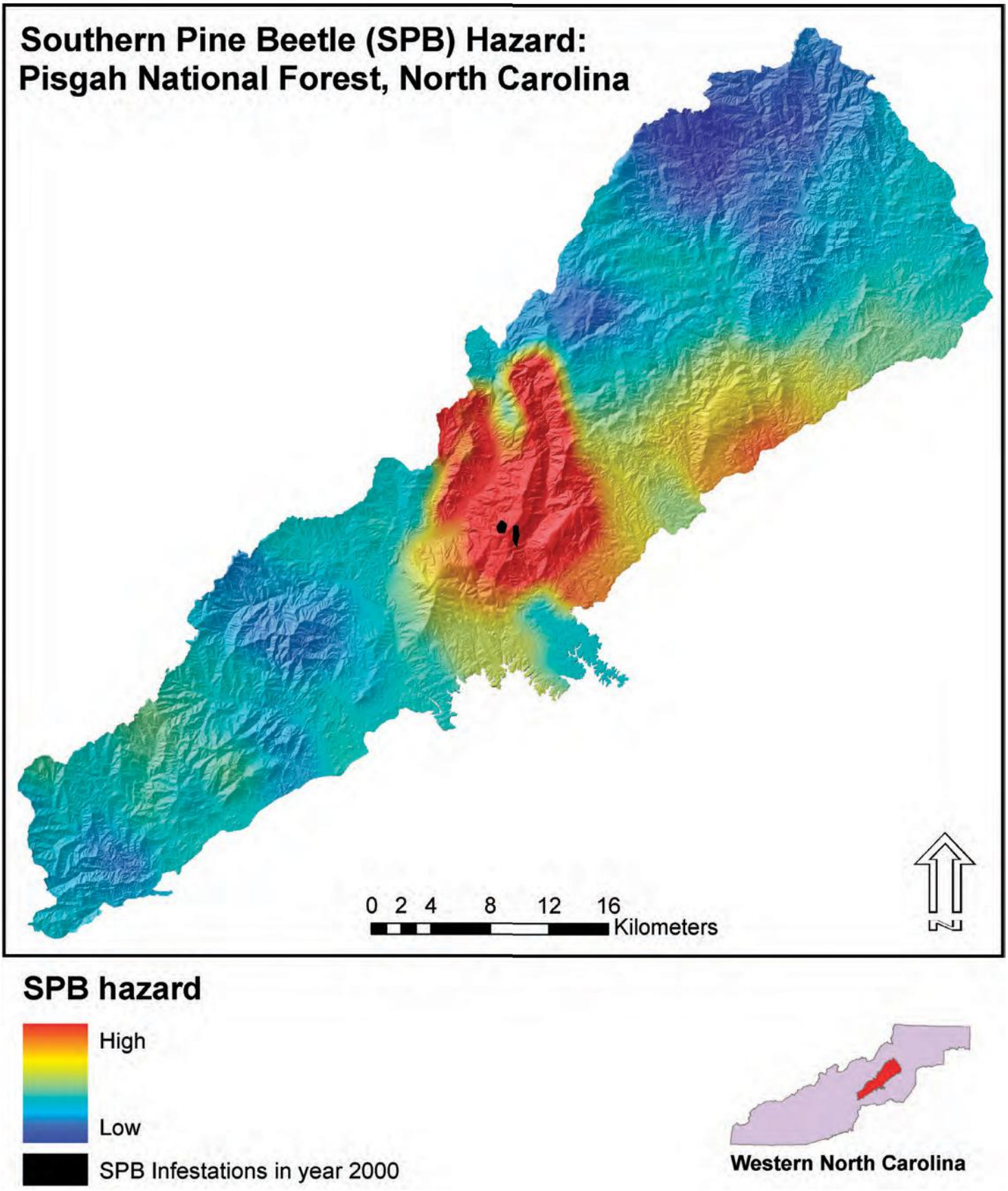

Data courtesy of U.S. Geological Survey; the Southern Appalachian Man and the Biosphere (SAMAB) Program; the National Forests in North Carolina; Weimin Xi; Lei Wang; Maria D. Tchakerian; Robert N. Coulson.

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Resource tables

Data dictionary

General data description	Data sources
Digital elevation models (DEM)	U.S. Geological Survey.
Forest stands	The Southern Appalachian Assessment Database.
Southern pine beetle infestations	National Forests in North Carolina.

Software dictionary

Software	Description
ESRI ArcGIS Desktop	Georeference tool, Editor tool, ArcCatalog data import tool, and projection tool.
ArcGIS 3D Analyst extension	Terrain Modeling.
ArcGIS Spatial Analyst extension	Neighborhood Analysis tool.

Additional resources

Resource	Description and source
Satellite image	U.S. Geological Survey.

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Recipe for map-building success

Step 1: Obtain data

Download forest stand and digital elevation model (DEM) data from publicly accessible sources. SPB infestation locations and boundaries for National Forests in North Carolina are available online in PDF format. These files are then digitized and spatially georeferenced.

Step 2: Forest stand classification

Reclassify the forest stand types into percentage of pine trees according to the description of each stand type. For example, forest stands that belong to pine dominated types will have pine tree coverage at a possible percentage from 70 to 100 percent.

Step 3: Spatial clustering analysis

Run the area-based spatial clustering analysis tool. We chose the Getis-Ord G index calculator in the ArcGIS Spatial Statistics toolbox. The Spatial Statistics toolbox, available with ArcGIS Desktop, contains statistical tools for analyzing the distribution of geographic features. The Getis-Ord p-value (probability value) from this analysis quantifies the spatial clustering tendency of pine trees. It is used as the indicator of SPB hazard rate.

In the ArcGIS Spatial Analyst extension, the neighborhood analysis tools are used to smooth the output data. We used a kernel size of 5x5 pixels.

Step 4: Create shaded relief map

Derive the shaded relief map from the DEM by using the hillshade function in ArcGIS 3D Analyst.

Step 5: Load SPB data

Georeference the SPB infestation data obtained from the national forests in North Carolina to the GIS environment. Additional SPB outbreaks in the year 2000 locations were obtained from hard-copy maps and then digitized.

Step 6: Organize layers

The Getis-Ord G index layer received priority over the hillshade layer in ArcMap. The SPB outbreak data was placed as the topmost layer so it could be quickly and easily identified.

Step 7: Create map

A color scheme changing from blue to red was chosen for the G index. A 50 percent transparency was applied to show the underlying terrain features depicted by the shaded relief map. Other cartographic elements such as a legend, index map, and scale bar complete the map.

Conclusion

This map was developed using spatial analysis techniques and scientific knowledge of southern pine beetle (SPB) population dynamics, including relationships between hosts and SPB spread patterns. The spatial distribution patterns of SPB hosts in the landscape were synthesized to indicate the degree of SPB hazard using outbreak data from the year 2000 to validate analysis results. This approach helped to reveal the landscape-scale SPB hazard in the Grandfather Ranger District of the Pisgah National Forest.

The map is clear and precise, which enables nontechnical personnel or the general public to easily interpret findings. Research scientists at Texas A&M University chose a color legend that gives the strongest contrast between areas with different SPB hazard ratings. The red color represents hot spots, the main theme of the map. An insert map showing the location of our study area is also necessary to orient the reader; here the boundary of western North Carolina is used for the small insertion.

A hillshade relief map was chosen as the basemap layer because it provides the best combination of spatial reference information and visualization effects. The locations of previous SPB outbreaks are identified to demonstrate the validation of the model: these hot spots are located where the hazard rate is expected to be highest. A graduated color scheme from blue to red representing the hazard rating provides the best visualization of the spatial patterns of SPB hazard.

This map uses data sources that are all in the public domain. It does not require complex computations and all tools used are available in ArcGIS Desktop.

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