Interactive Visualization Promotes Pattern Discovery in 50-year Record of Cone Production in Upper-slope Conifers of the Pacific Northwest

Tuan Pham · Ronald Metoyer · Jerry Franklin · Julia Jones · Frederick Swanson

Problem Statement

Although cyclical cone production is a salient feature of many conifer life histories, relatively little is known about the temporal patterns of cone production in high-elevation conifer forests and factors that link conifer population dynamics to climate dynamics [1]. Since 1959, J. Franklin and others have collected data on cone production of upper slope conifers in the Cascade Range of Oregon and Washington. Cone counts were obtained for nine species: Abies amabilis (Pacific silver fir), Abies concolor (white fir), Abies grandis (grand fir), Abies magnifica (California red fir) Abies procera (noble fir), Picea engelmannii (Engelmann spruce), Pinus lambertiana (sugar pine), Pinus monticola (western white pine), Tsuga mertensiana (mountain hemlock). Twenty to thirty trees were monitored in each of 37 plots spanning 800 km from northern Washington to southern Oregon in ten National Forests: Mt. Baker, Snoqualmie, Olympic, Wenatchee, and Gifford Pinchot in Washington, and the Mt. Hood, Willamette, Umpqua, Rogue River, and Siuslaw in Oregon. The data set has been difficult to analyze because it is large (45,704 observations), it contains many trees (934 distinct trees of 9 species), and trees died/were added during the study period.

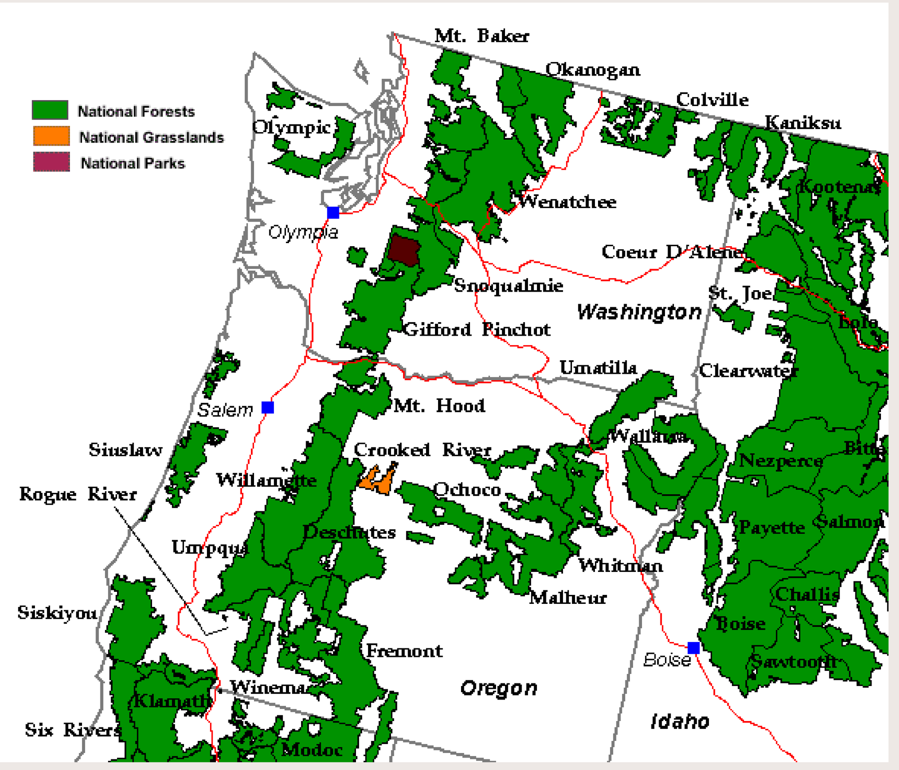

Fig. 1: Map showing the 10 national forests where the cone count observations have been collected.

Interactive Visualization

We develop the **Diversity Map** (DM), a web-based visual-analysis tool that facilitates the collaborative visual inspection of distribution patterns in large multi-species data sets with a focus on temporal trends [2, 3]. The tool is useful in the early stages of data exploration and collaboration, prior to further statistical analysis.

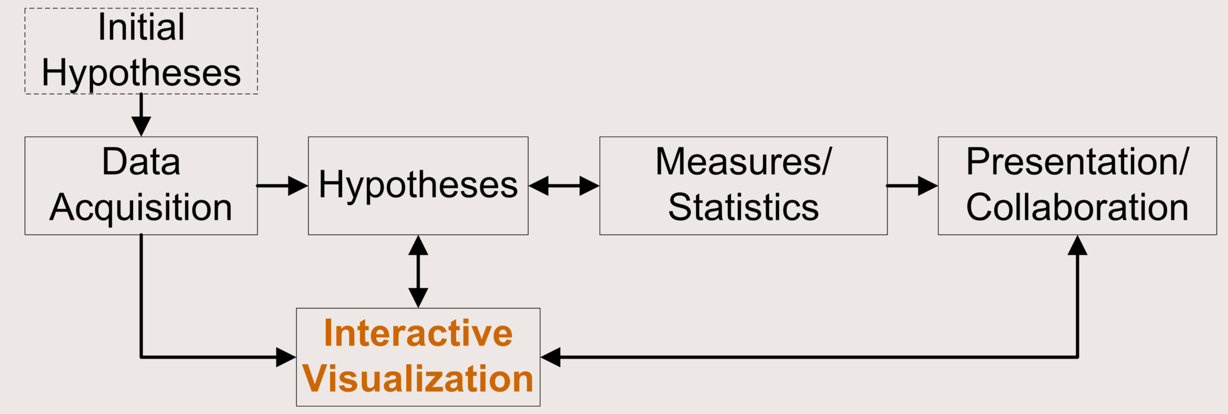

Fig. 2: The visualization driven data analysis process the DM tool aims to support its target users.

The tool supports multiple coordinated views augmented with a wide range of interaction features: **small multiple histograms views** are used to query data and to generate line series for **time-series line graphs** (see Fig.3 and Fig. 4).

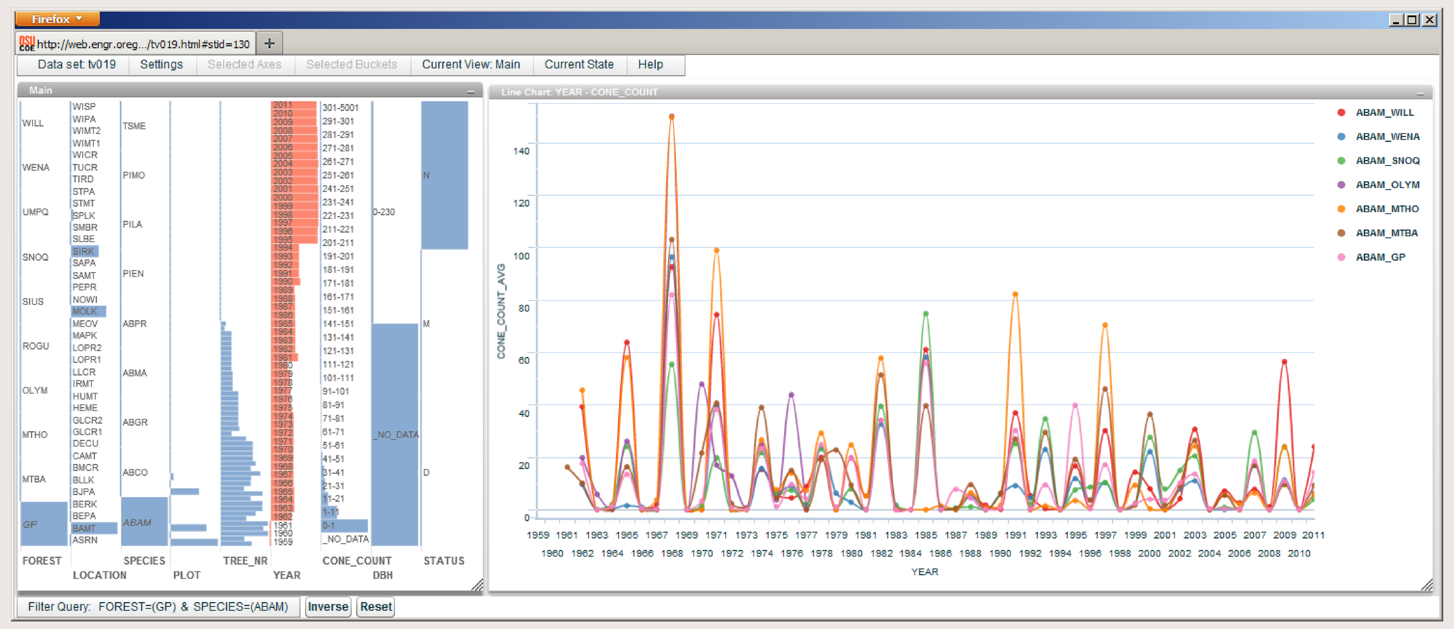

Fig. 3: The time series graph shows the very high degree of **synchrony** among cone crops of Abies amabilis (Pacific silver fir) in seven National Forests stretching from the Canadian border to the central western Cascades of Oregon, with an alternating 2- and 3-year cycle, and peak cone production in 1968. This graph suggests **hypotheses** about extrinsic factors, like climate, that may contribute to regional low cone production (e.g. in 1966-67, 1972-73, and 1983-84) and intrinsic factors, like energy expenditure in cone production, that may contribute to cycles.

Case Study

Ecologists use this tool to overview a dataset, examine and compare subsets of data in detail, and detect distribution patterns, temporal trends, and exceptions. Moreover, ecologists can asynchronously share views/hypotheses with others for further analyses.

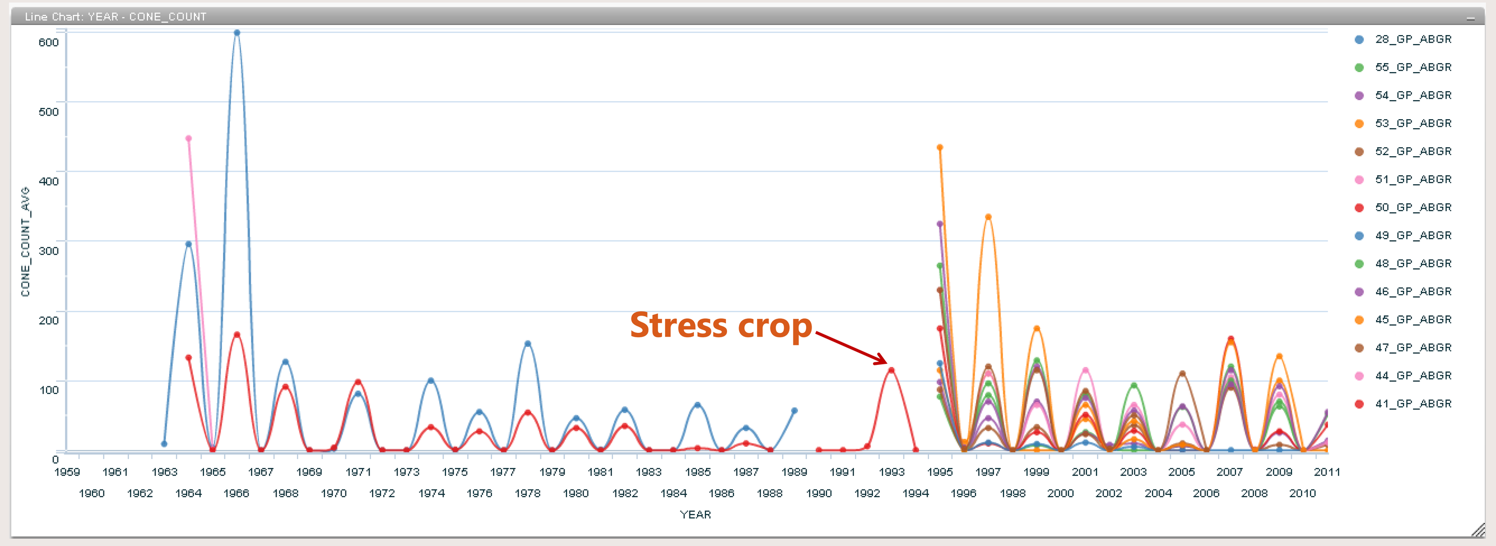

Fig. 4: This figure shows the high degree of synchrony of cone production among 14 individuals of Abies grandis (grand fir) at Peterson Prairie in the Gifford Pinchot National Forest. The time-series line chart suggests that cone production of Abies grandis occurs on a biennial cycle but skipped several years, for example, 1969-1970 and 1972-1973, the same years skipped by Abies amabilisi (Fig. 3), perhaps due to climate control. Tree 41 (red line) shows very little cone production from 1973-1992, and then a **stress crop** in 1993, just before the tree died.

To develop the tool, we have taken a user-centered design approach in which ecologists work closely with computer scientists during all stages of the design process.

References

[1] J. Franklin. Cone production by upper-slope conifers. *Res. Pap. PNW-60. Pacific Northwest Forest and Range Experiment Station*, US Department of Agriculture, 1968

[2] T. Pham, S. Highland, R. Metoyer, D. Henshaw, J. Miller, J. Jones. Interactive Visualization of Spatial and Temporal Patterns of Diversity and Abundance. In *Proceedings of Environmental Information Management*, pp. 104-110, Publisher of University of California, 2011

[3] T. Pham, R. Metoyer, and J. Jones. Interactive Online Visualization of Diversity: A Case Study with Ecological Data. *Submitted to Visualization/Information Visualization 2012*

Database and Demo

Database: J. Franklin. Cone production of upper slope conifers in the Cascade Range of Oregon and Washington. *LTER. Forest Science Data Bank*, Corvallis, OR.

http://andrewsforest. oregonstate.edu/data/abstract.cfm?dbcode=TV019

Visualization Demo: http://purl.oclc.org/diversitymap/cone

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Contact: Tuan Pham pham@eecs.oregonstate.edu

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HJA LTER Oregon State UNIVERSITY