# DEVELOPMENT OF AN EXPERT SYSTEM FOR ENDEMIC POPULATIONS OF MOUNTAIN PINE BEETLE IN LODGEPOLE PINE FORESTS

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Expert Systems (ES) contain information about a specific area of interest. Currently, ES are being used more and more in the area of natural resources. These ES are an excellent way to organize existing knowledge for use by the land manager or research scientist. This paper details the approach we took in developing a basic ES.

Our ES deals with endemic (initial stages prior to outbreak) populations of mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins (Coleoptera: Scolytidae), in lodgepole pine, *Pinus contorta* Douglas var. *latifolia* Engelmann, stands. The scientists on the MPB project with the Intermountain Research Station, USDA Forest Service, furnished the expert information about MPB. We first developed an ES to organize existing knowledge and to identify areas of needed research. Our long-range goal is a detailed ES that can be used by land managers in the decision-making process.

We will examine each phase in the development of our ES: (1) knowledge acquisition; (2) programming rules induced from knowledge acquired; and (3) verification (Fig. 1).

## KNOWLEDGE ACQUISITION

We acquire facts, interrelationships, and predicted outcomes by extracting information from published literature and from experts. Because much of the knowledge used for successful decision making in natural resources has evolved through professional experience, and because ES programming allows us to incorporate this kind of qualitative, heuristic reasoning, we view skilled practitioners and researchers as sources of meaningful information for model building. We capture their thought processes and their knowledge of facts and how they interrelate those facts. This enables us to explain within the program how predictions or conclusions were generated (Fig. 2). Capturing knowledge from experts is difficult and time consuming and has been referred to as the "knowledge acquisition bottleneck" (Feigenbaum 1977). The main problem arises from the inability of experts to describe their own reasoning processes--they are not "expert" at articulating what they know (Shapiro 1987).

We are applying several techniques to cope with this problem: (1) interviewing experts about known and suspected MPB dynamics; (2) watching and questioning experts as they go about their work; (3) diagnosing actual situations or cases where conditions might be expected to result in MPB outbreaks and where they should not; (4) feeding information back to the experts in different formats, such as flowcharts, decision trees, and three-dimensional graphics to elicit additional information; and (5) supplying experts with knowledge acquisition software that helps elicit ideas and automatically derive decision rules.

## EXPERT SYSTEM PROGRAMMING

Programming the system is perhaps the most straightforward part of the process. However, providing human understandability within the ES design imposes an additional burden. The reasoning process of the automated program must be accessible to the user at run-time. He or she must understand confusing underlying questions asked during the consultation and provide feedback (Shapiro 1987). "Black box" programming will not meet the emerging norms of ES designers.

## VERIFICATION

How does one validate a system built on a combination of qualitative knowledge, intuition, and professional judgment? Defining the confidence we may have in ES predictions is a complex topic beyond the scope of this paper but is discussed by Parsaye (1988) and Shapiro (1987). However, as in any traditional research effort, we seek to verify by matching ES predictions against judgments of other experts or by how well they match with real-world behavior examined under controlled conditions or through field experiments.

We are incorporating the concepts and methods of ES programming in an attempt to structure knowledge that is not easily subject to quantification. Inductive techniques are used initially in anticipation of making better "guesses" within the domain of interest and to document the reasoning involved in the evolution of those guesses (Parsaye 1988). The ability to process heuristic knowledge may advance both theory and practice in natural resource management.

## REFERENCES


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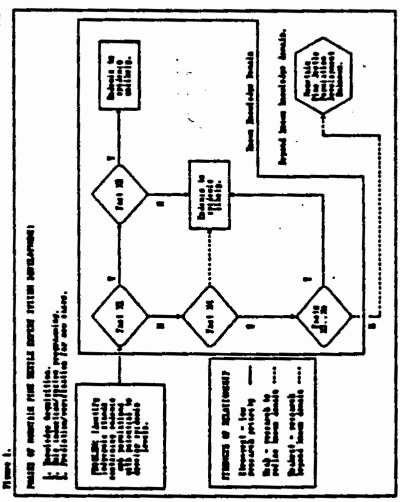

Figure 1.

Figure 2.
HYPOTHETICAL OUTPUT FROM MOUNTAIN PINE BEETLE EXPERT SYSTEM:
PREDICTING EPIDEMIC POTENTIAL FROM ENDEMIC MPB POPULATION

| | |
|---|---|
| Run Stand A. | |
| PREDICTION: | |
| MPB epidemic potential | is HIGH |
| FACTORS CONSIDERED: | |
| Mean stand diameter of dom/codominants | is >10 |
| Elevation of stand | is 6000-9000 |
| Distribution of endemic population | is <300 |
| Secondary beetle activity | is HIGH |
| Weather at emergence | is DRY |
| Temperature at emergence | is WARM |
| Run Stand B. | |
| PREDICTION: | |
| MPB epidemic potential | is RESEARCH NEEDED |
| FACTORS CONSIDERED: | |
| Mean stand diameter of dom/codominants | is >10 |
| Elevation of stand | is 6000-9000 |
| Distribution of endemic population | is <300 |
| Secondary beetle activity | is HIGH |
| Weather at emergence | is *VARIABLE-WET/DRY |
| Temperature at emergence | is *VARIABLE-COOL/WARM |

*contribution of factors requires more study

3.1.2.3 FY 89

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