

**May 18, 2026 EMC Initial Concept Proposal for:  
Updating the FORSEE Growth and Yield Software**

**Effectiveness Monitoring Committee Initial Concept Proposal**

**a. Date Submitted: May 18, 2026**

**b. Project Title:**

Updating the FORest Stand Evaluation Environment (FORSEE) Growth and Yield Software, Including the Underlying CRYPTOS and CACTOS Growth Models.

**c. Project #:**

To Be Assigned by EMC

**d. Principal Investigator:**

Bruce Krumland, RPF 1768

**e. Affiliation of PI and Address:**

Bruce Krumland, RPF 1768 (Independent Consultant)

[REDACTED]

**f. Applying Organization:**

Environmental Resource Solutions, Inc. (ERS)  
*Forestry & Land Management*

[REDACTED]

**g. Primary Contact Phone Number(s):**

Bruce Krumland

[REDACTED]

**h. Primary Email Contact of PI:**

Bruce Krumland, RPF 1768

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**i. Names and Affiliations of Collaborators:**

John W. Williams, RPF 1677 (Retired Environmental Resource Solutions, Inc.)

[REDACTED]

Environmental Resource Solutions, Inc.  
David Alexander Flores  
*Forestry & Land Management*

[REDACTED]

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**j. Project Description:**

**i) Project Duration:** Two Years, 4 Months (November 2026 through March 2029)

**ii) Background and Justification**

Long Term Sustained Yield (LTSY) modeling is a requirement for a Non-Industrial Timber Management Plans (NTMP), Sustained Yield Plans (SYP), and Working Forest Management Plans (WFMP) submitted to the California Department of Forestry and Fire Protection (CAL FIRE), however technical support for California specific models is severely limited. Currently, FORSEE is an accepted program by CAL FIRE for LTSY projection. FORSEE is an interface for CRYPTOS and CACTOS, which are growth and yield models for coast redwood and Sierra mixed conifer forests, respectively. Since its release in 2008, FORSEE has not received substantial technical support. FORSEE utilizes tree volume equations for California Conifers derived from California growth plot data. Growth and yield models provide baseline information for timber harvest modeling, carbon modeling, fuel modeling, seral stage modeling, hardwood occupancy, and economic decision making.

Developed independently by the California Growth and Yield Modeling Cooperative (CAGYM), FORSEE was a groundbreaking development in making cost-effective forest stand modeling available to forest consultants and others serving small, non-industrial timberland owners in addressing forest practice rule compliance of proposed timber operations. Larger industrial timberland owners typically have their own proprietary programs that are unavailable to the typical small timberland owner.

CRYPTOS and CACTOS have now been in use for 45 and 35 years respectively without analysis of their effectiveness and are showing their age.

1. Problems with projecting growth of small and large trees in certain stocking situations.
2. Hardwoods are under-represented in terms of past modeling efforts, primarily due to lack of data or poor measurements.
3. Long term (20+ years) validation is lacking.
4. Common measures of stand based tree competition (basal area, canopy cover) seem to affect conifers and hardwoods differently and not clearly identified.

Silvicultural systems must achieve Maximum Sustained Production (MSP) as required by the California Forest Practice Act and Rules to account for “biologic and economic factors...including but not limited to, recreation, watershed, wildlife... range and forage ... and aesthetic enjoyment” (14 CCR 913.11 (a)(1)). Growth and yield modeling helps achieve these goals in the context of LTSY by helping foresters make decisions about harvest intensity, location, and method.

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Updating CRYPTOS will increase the reliability of these programs and the accuracy of the tree stocking and volume predictions.

Providing support to foresters writing long-term forest management plans would improve analysis of biological and economic factors. In turn, this would help comply with forest practices rules by providing information on a wide range of beneficial forest resources. The need for updated growth and yield modeling, specifically FORSEE, is essential for Registered Professional Foresters (RPFs). The need exists not only to satisfy the requirements of the Forest Practice Rules, but also to better understand the relationship between growth and yield modeling, forest management, and wildlife habitat in California forests.

**iii) Objective and Scope:**

The main objective of this project is to provide an improved tool for analysis of Critical Themes Nos. 8 (Wildlife Habitat – Seral Stages), and 11 (Hardwood Values) through updating and improving the (FORSEE) Growth and Yield program and its underlying CRYPTOS and CACTOS growth and yield models.

This project will compliment and support the Board of Forestry Management Committee's goal in reviewing Silviculture Rules, particularly the review of Maximum Sustained Production (MSP).

We will:

1. Develop new CA individual tree growth model systems for approximately forty (40) species using Forest Service data models for DBH, crown, height growth, mortality, and crown occupancy.
2. Develop new California conifer volume equations.
3. Examine species growth differences by major ecological sections.
4. Provide documentation for others to use to make their own growth model program.
5. Update and enhance FORSEE to incorporate new models.
6. Document and consolidate publicly available tree growth data into one database.
7. Assimilate useable data from multiple sources.

The objective is to increase the understanding of the effect of MSP of high-quality timber products on forest structure and composition. We will document the difference between the effectiveness of the existing version and an enhanced version of FORSEE.

We will:

1. Test modeling retention and recruiting of trees into future Wildlife Habitat Relationships size classes, height, and canopy cover that will create late and diverse seral stage wildlife habitat components.

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2. This creation of these seral conditions will diversify forest resources by increasing the amount and distribution of late succession forest stands for wildlife.
3. Demonstrate the efficiency of FORSEE and the underlying CRYPTOS and CACTOS models.

**iv) Research Methods**

This is an observational study comparing the growth and yield model outputs from the 2008 version to the 2029 version of FORSEE.

1. Analysis of existing growth and yield outputs from approved NTMPs will be used to determine the impact on forest habitat.
2. Compare results of the projected forest structure.
3. Compare results of the silviculture methods used to manage forests in subsequent harvests.
4. Stand structure will be used to inform forest management strategies to achieve late successional and late seral stage stand structure.

Improvements made to the updated version of FORSEE will include:

1. Development of new California individual tree growth model systems for approximately forty species.
2. Integration of new and improved site index models (Krumland and Eng) to growth models state-wide.
3. Integration of public and private sources of data providing several decades worth of repeated growth measurements used for validation.
4. Development of models for major ecological sections through specific fits or calibration of meta-models.
5. Quantification of climatic effects, such as rainfall and drought.
6. Documentation of model update methods to maintain and improve future growth and yield model development.

Research methods will be supported by improving FORSEE.

**v) Scientific Uncertainty and Geographic Applicability, including identified monitoring location(s), and**

As the now-defunct California Forest Products Commission once declared in a poster promoting sustainable forest management: “Forestry is not rocket science – it is much more complicated than that”. While current modeling programs are considered accurate in projection of a forest stand’s development up to 20 years in the future, predicting stand and seral stage development over 100 years, as required by current Forest Practice Rules, has not been validated with actual data and is at best an unverifiable best guess. Among the variables that can affect the result are quality of the underlying inventory, suitability of the species volume equations used, accuracy of the site index measurements, and others. The enhanced modeling program, FORSEE, will be generally applicable

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to California coniferous forests with the CRYPTOS program applicable to the California Redwood Region and CACTOS to the interior mixed conifer forests. Suitability to model hardwood forest stand development, such as the California black oak and Oregon white oak woodland will be enhanced with the incorporation of Forest Inventory Analysis growth plot data.

While there is evidence to show that forest management strategies can lead to late seral stage forests, there is little evidence on the outcomes of management practices related to growth and yield model results. Growth and yield models directly influence forest management decisions by determining harvest intensity, location, and method. Models also inform decisions for tree retention, which directly impacts forest seral succession. The impact of these decisions on the distribution and recruitment of late succession forest stands is not well known.

This project is broadly applicable to forest practices throughout the state. A product will be to make the enhanced version of FORSEE publicly available. This project will incorporate data from a variety of sources for future studies.

**vi) Collaborators and Project Feasibility.**

**The principal Investigator** will be Dr. Bruce Krumland. Dr. Krumland, and assistants as required, will be responsible for correcting the known problems with FORSEE, CRYPTOS, and CACTOS, and implementing enhancements as appropriate. **Technical support** will be provided by ERS.

**k. Critical Question Theme, and Forest Practice Rules or Regulations Addressed.**

1. Theme 8: Wildlife Habitat
2. 14 CCR Sections 913.10, 933.10, 953.10 Timberland Productivity, Sustained Forestry Planning, Addendum
3. 14 CCR Sections 913.11, 933.11, 953.11 Maximum Sustained Production of High-Quality Timber Products
  - see 2026 FPRs pages 63, 64, 65

**l. Requested Funding: \$275,000**

2026-2027 Expenditure: \$80,000.00

Justification: Assimilate data from various sources, standardize data, preliminary data analysis, EMC reporting requirements for grant

2027-2028 Expenditure: \$135,000.00

Justification: Primary growth model analysis, develop volume equations, EMC reporting for grant

2028-2029 Expenditure: \$60,000.00

Justification: Model testing, model result reporting, validate software, documentation of process (formatting and equation tables), develop user instructions, EMC reporting requirements for grant