Effectiveness Monitoring Committee

Full Project Proposal

Submission July 23, 2025

Project #: Date July 22, 2025

Project Title: Adjacency – is it a relationship that remains necessary?

Principle Investigator: Kevin Boston, PhD, JD, PE, RPF (Calif)
University of Arkansas, Monticello,
[redacted]

Project Duration: 24 months

1. Background and Justification

Background and Justification:

Adjacency is a constraint in many forest regulations. Versions of this rule are included in California, Oregon, and Washington. It is a component of the Sustainable Forestry Initiative (SFI) and is incorporated into many regional standards within the Forest Stewardship Council (FSC) certification guidelines.

The ecological goals of the maximum opening size constraint, as outlined in California Forest Practice Rules 913.1, 933.1, and 953.1, specifically Regeneration Methods Used in Even-aged Management, also known as the green-up constraints, are unclear. This constraint imposed on forest managers limits the size of the opening to five years or until the trees have an average height of five feet using even-age forestry. Some suggest that limiting the size of the openings limits erosion that can occur in a concentrated place. However, modern logging equipment and practices, such as operating on slash mats and developing low-impact logging systems, including shovels, harvesters, and forwarders, have significantly reduced ground impact. Additionally, mitigation of the sites has limited their production. The widespread adoption of complex riparian buffers further captures the surface runoff from harvesting units. Others have noted that the adjacency restrictions maintain a closed-canopy forest, providing a suitable habitat for wildlife. Boston and Bettinger (2006) demonstrated that smaller openings more quickly fragmented the forest than larger openings when the goal was to maximize sustained yield harvest targets. However, the economic impacts were considerable, with a significant decrease in harvest volume as the spatial restrictions became binding. The road system is the largest source of sediment from forests (MacDonald & Coe 2008). Under a management scenario designed to maximize the sustainable harvest of material, we hypothesize that the smaller green-up constraint requires more of the transportation network to be accessible for trucks, rather than being placed in a state that minimizes sediment production and delivery.

2. **The Objective and Scope:**

The objective and Scope will demonstrate the impact of the maximum opening size constraint on the ecological process in working forests. The Scope will be to demonstrate the impact of the maximum opening size on the miles of road required to be open to support management, as well as the impact of the rule on the fragmentation of mature, closed-canopy forests. The planning period will be 30 years.

The results will demonstrate the impact of various opening size constraints on the miles of open roads when harvested at a sustained yield rate, which contributes sediment at a higher rate than a closed road. Finally, the model will illustrate the fragmentation of the closed canopy forest resulting from the dispersed cutting pattern.

Data sets will be obtained from organizations in the northern and coastal zones to demonstrate their geographic applicability throughout California.

3. **Critical Question:**

Is the dispersed harvesting pattern forced by the maximum opening size constraint and the minimum harvesting age? Does the result of this dispersed cutting pattern result in more miles of open roads and defragmenting the forest more rapidly than if large maximum opening sizes were used? Are more miles of roads required to be open to support the distributed harvesting pattern, which can lead to increased chronic sedimentation from forest roads?

The second question is: What are the economic impacts of such a constraint? Economic returns will be modeled using discounted net revenue and volume flow under the various opening sizes applied in the model.

4. **Forest Practice Rules and Regulations:**

California Forest Practice Rules 913.1, 933.1, 953.1,(a)(2): The regeneration harvest of even-aged management shall be limited to 20 acres for tractor Yarding. Aerial or Cable Yarding may cover up to 30 acres. Tractor Yarding may be increased to 30 acres where the EHR is low and the slopes are < 30%. The RPF may propose increasing these acreage limits to a maximum of 40 acres, and the Director may agree where measures contained in the THP provide substantial evidence that the increased acreage limit does any one of the following:

The following types of regeneration methods are designed to replace a harvestable stand with well-spaced growing trees of commercial species. Evenaged management systems shall be applied with the limitations described by this rule:

(a) Timber stands harvested under an even-aged regeneration method shall meet the following standards:

(1) Where a regeneration step harvest of evenaged management will occur on stands younger than 50 years of age for Class I lands, 60 years of age for Class II and III lands, or 80 years of age for Class IV and V lands, or equivalent age of trees, based on height as determined according to the appropriate site class, the RPF preparing the THP or SYP must demonstrate how the proposed harvest will achieve MSP under 14 CCR § 913.11 [933.11, 953.11](a) or (b) provided, however, that the Director may grant an exemption from this section based upon hardship.

(2) The regeneration harvest of evenaged management shall be limited to 20 acres for tractor Yarding. Aerial or Cable Yarding may cover up to 30 acres. Tractor Yarding may be increased to 30 acres where the EHR is low and the slopes are < 30%. The RPF may propose increasing these acreage limits to a maximum of 40 acres, and the Director may agree where measures contained in the THP provide substantial evidence that the increased acreage limit does any one of the following:

A) by using additional on-site mitigation measures, reduces the overall detrimental effects of erosion, thereby providing better protection of soil, water, fish, and/or wildlife resources; or 48 CALIFORNIA FOREST PRACTICE RULES 49

(B) provides for the inclusion of "long corners"; or

(C) create a more natural logging unit by taking maximum advantage of the topography; or

(D) will increase long-term sustained yield; or

(E) Provide feasible off-site mitigation measures that can be incorporated into the plan to restore or enhance previously impacted resource areas or other environmental enhancements, resulting in demonstrable net environmental benefits within the planning watershed. These measures may include, but are not limited to, Watercourse restoration, soil stabilization, road surface stabilization, road out-sloping, road Abandonment, road reconstruction, enhancement of wildlife habitats, and vegetation management. To qualify for an exemption, the plan submitter is not required to demonstrate that other feasible options are not available.

(3) Even-aged regeneration units within an ownership shall be separated by a logical logging unit that is at least as large as the area being harvested or 20 acres, whichever is less, and shall be separated by at least 300 ft. in all directions. (4) Within ownership boundaries, no logical logging unit contiguous to an evenaged management unit may be harvested using an evenaged regeneration method unless the following are met:

(A) [Coast] The prior evenaged regeneration unit has an approved report of stocking, and the dominant and codominant trees average at least five years of age or average at least five ft. tall and three years of age from the time of establishment on the site, either by the planting or by natural regeneration. Suppose these standards are to be met with trees that were present at the time of the harvest. In that case, there shall be not less than five years following the completion of operations before adjacent evenaged management may occur.

(A) [Northern and Southern] The prior evenaged regeneration unit has an approved report of stocking, and the dominant and codominant trees average at least five feet tall, or at least five years of age from the time of establishment on the site, either by the planting or by natural regeneration. Suppose these standards are to be met with trees that were present at the time of the harvest. In that case, there shall be not less than five years following the completion of operations before adjacent evenaged management may occur.

5. Research Methods

This project aims to utilize a spatial harvest scheduling model with varying adjacency constraints, ranging from 20 to 120 acres in 10-acre increments. The model will be deployed on various spatial data sets provided by companies throughout California. The model will analytically vary the size of the adjacency constraint and determine how many additional miles of roads must be open to support the harvesting. A vehicle routing model will be incorporated into the harvest scheduling algorithm to determine the most efficient route for log delivery. In addition to the length of open roads required, the model will estimate the impact of the various maximum opening sizes. It will determine the area in mature, closed-canopy forests and the fragmentation of these forests by measuring the edge length between mature and closed-canopy areas.

Meta-heuristics have been used to solve spatial harvest scheduling algorithms for over 25 years and have found solutions to large, nonlinear combinatorial problems that cannot be solved exactly within 5% of the optimal solution. The algorithm combines multiple heuristic techniques, such as simulated annealing, tabu search, and genetic algorithms, to solve this challenging class of problems (Boston and Bettinger, 1999, 2002).

Analysis of the data will include both tabular and spatial analysis, utilizing the results from the heuristic optimization procedure. It will compute the degree of fragmentation found in the forest for closed-canopy forests. Additionally, the miles of road open in each period of the harvest scheduling will be tracked. The economic impacts will be measured using both volume and discounted net revenue, with local prices displayed. The goal is to provide policymakers with a comprehensive view of the economic and environmental impacts of the policy under the maximum opening size constraint.

The algorithm will be developed using the “C” language and will be publicly available following completion of the project.

6. Collaboration and Project Feasibility

Dr. Kevin Boston will be the principle investigator and is responsible for project oversight.

He is a Registered Professional Forester in California with over 40 years of experience. He has specialized in developing and testing spatial harvest scheduling algorithms with embedded transportation networks for over 30 years and has published extensively in this area.

7. Project Deliverables

1. Validate the harvest scheduling algorithm.
2. Completion of analysis for coastal area describing the impact of opening size, length of opening, miles of road, and fragmentation measures for a range of opening sizes from 20 to 60 acres with a length of restriction from two to 10 years. Minimum harvest ages will vary from no requirement to 100 years. Delivered June 2026
3. Completion of analysis for coastal area describing the impact of opening size, length of opening, miles of road, and fragmentation measures for a range of opening sizes from 20 to 60 acres with a length of restriction from two to 10 years. Minimum harvest ages will vary from no requirement to 100 years. Delivered June 2027
4. Prepare the Manuscript for submission to a leading forestry journal.

8. Detailed Project Timeline

Task	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Validate data from cooperators	X							

Link harvest units and the transportation network		X						
Growth and Yield Analysis		X						
Algorithm modification and validation		X	X					
Analysis of Coastal Region			X	X				
Analysis of Northern Region					X	X		
Prepare the Manuscript and final reports.							X	X

9. Request for funding

BUDGET - UADA-AES		**Date:**	
Proposed to (Sponsor):	US Endowment for Forestry and Communities		
Proposed Start & End Dates:	8/5/2025	to	10/31/2025
UADA Lead Investigator:	Sagar Chhetri		
Lead Dept/UADA:			

SALARIES & WAGES	Base Salary	Type Appointment	Person-Months CAL/AY	Person-Months SMR	Cost Share	Year 1 Sponsor	Year 1 UASDA	Spo
Kevin Boston		9 mo. NonCL			0%		0	
PI, summer salary		Sum			0%	20,000	0	20
Kevin Boston		9 mo. NonCL			0%		0	
Co-PI #1, summer		2 mo. Sum			0%		0	
Co-PI #2		9 mo. NonCL			0%	0	0	
Co-PI #2, summer		Sum			0%	0	0	
Co-PI #3		9 mo. NonCL			0%	0	0	
Co-PI #3, summer		Sum			0%	0	0	
Co-PI #4		9 mo. NonCL			0%	0	0	
Co-PI #4, summer		Sum			0%	0	0	
[Fill in position as needed]		12 mo. NonCL			0%	0	0	
Postdoctoral Associate		12 mo. NonCL			0%	0	0	
Research Associate (staff)		12 mo. NonCL			0%	0	0	
Research Assistant or Tech		12 mo. NonCL			0%	0	0	
Graduate Assistant (Ph.D.)			mo. @		0%	0	0	
Graduate Assistant (Master's)			mo. @		0%	0	0	
Hourly, non-student(s)			hrs @		0%	0	0	

Hourly, enrolled student	hrs @ 0%	0	0	
Total S&W		*20,000*	*0*	*20*
FRINGE BENEFITS	Institutional Rate:			
Faculty/staff academic / calendar salary	30.80%	0	0	
Faculty summer salary	16.50%	3,300	0	3
GRA(s)	1.00%	0	0	
Hourly, non-student	7.10%	0	0	
Hourly, enrolled student	0.10%	0	0	
Total FB		*3,300*	*0*	*3*
Total Salaries + Benefits		**23,300**	**0**	**23**
TRAVEL - Domestic				
TRAVEL - Foreign				
MATERIALS & SUPPLIES (not *fees or services, which are "Other"*)				
JOURNAL PUBLICATION FEES		1,500		
OTHER DIRECT COSTS *(Itemize by type; insert extra rows if needed.)*				
Contractor for Life Cycle Assessment				
Subtotal Other Direct Costs		**0**	**0**	
Modified Total Direct Costs (above subtotal costs subject to F&A Cost)		*24,800*	*0*	*23*
F & A COST (MTDC x RATE):	**10.0%**	**2,480**		**2**
F & A COST (UNRECOVERED):	**47.0%**		**0**	
F & A COST (COST-SHARE):	**0.0%**		**0**	
Modified Total Direct Costs (first $25K of each subaward)		*0*		
F & A COST (MTDC x RATE)SUB(S):	**0.0%**	**0**		
(Direct Costs not subject to F&A Cost, with the exception that the first $25K of each subaward is subject to F&A):				
GRA TUITION	# Credit Hours: Rate: $285		0	
EQUIPMENT @ > $5000 each				
PARTICIPANT (TRAINEE) STIPEND				
PARTICIPANT (TRAINEE) TRAVEL				
PARTICIPANT (TRAINEE) SUBSISTENCE				
PARTICIPANT (TRAINEE) OTHER				
SUBAWARD #1, total	(Institution):			
SUBAWARD #2, total	(Institution):			
SUBAWARD #3, total	(Institution):			
SUBAWARD #4, total	(Institution):			
TOTAL DIRECT COST		**24,800**	**0**	**23**
TOTAL PROJECT COST		**$27,280**	**$0**	**$25**

10. References

Boston, K., & Bettinger, P. (1999). An analysis of Monte Carlo integer programming, simulated annealing, and tabu search heuristics for solving spatial harvest scheduling problems. *Forest science*, *45*(2), 292-301.

Boston, K., & Bettinger, P. (2002). Combining tabu search and genetic algorithm heuristic techniques to solve spatial harvest scheduling problems. *Forest Science*, *48*(1), 35-46.

Boston, K., & Bettinger, P. (2006). An economic and landscape evaluation of the green-up rules for California, Oregon, and Washington (USA). *Forest Policy and Economics*, *8*(3), 251-266.

MacDonald, L. H., & Coe, D. B. (2008). Road Sediment Production and Delivery: Processes and Management. In *Proceedings of the First World Landslide Forum, International Programme on Landslides and International Strategy for Disaster Reduction* (pp. 381-384). Tokyo, Japan: United Nations University.