IF IT WAS EASY, SOMEONE ELSE WOULD HAVE DONE IT!

Integrated Model For Evaluating Harvest Systems for Small-Diameter and Previously Non-Commercial Tree Species

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Introduction

Numerous factors affect harvest system choice and configuration. A common mistake is to look at these factors in isolation rather than recognize and understand how these factors interrelate and affect everything from sale layout to end-user products. Small diameter trees (less than eight-inches diameter, small end) and previously non-commercial tree species (such as western juniper and some hardwoods) are a particular challenge to harvest economically and in an environmentally acceptable manner. In most cases, many more pieces have to be handled to obtain the volumes necessary for an economic operation, stem form is less cylindrical, trees may have more and larger limbs, vegetative management goals often require additional measures to protect soils and residual stand conditions, and private business has an existing investment in equipment better suited for larger trees (greater than eight-inches diameter, small end).

A perfect harvest system does not exist for all regions and circumstances. Site-specific conditions and markets require adaptations, even for conventional systems involving chainsaws and skidders. A *Harvest Systems Evaluation Matrix* is attached to assist in conceptualizing a harvest system(1). It has two major categories: Critical economic and management factors, and harvest system component parts. In reality, the *Matrix* should probably be three-dimensional, with lines going from each box to all other boxes, but the author's computer graphic skills were lacking.

A short explanation is given of each critical factor and harvest system component part included in the attached *Matrix* (15 total). Discussion questions are provided to stimulate dialogue between affected and interested parties, and clarify assumptions about what will work or not work in a particular situation. The desired results of examining current and potential harvest systems using the *Matrix* and questions provided are public/private cooperative projects to test and evaluate new methods, and test and evaluate redesigned or new equipment.

Harvest Systems Evaluation Matrix - Critical Factors

Locally-Available Harvest Systems and Expertise - Most harvest contractors will try to use or adapt what they already own before investing in new equipment, or significantly changing their operation. It is necessary to understand the experience and baseline economics of existing systems and expertise before assessing or suggesting alternatives, most of which are dependent on existing primary processing infrastructure and markets.

Discussion Questions: Who has what within a 100-mi. radius of the planned project? Are any local companies interested or capable of harvesting the available material? Do interested parties have knowledge and expertise harvesting the available material? Are different techniques or equipment necessary or need to be tried to make operations economical? Is there sufficient supply and supply continuity to warrant capital investment in new systems?

Resource Inventory - Inventory categories and databases often lack key information needed by the wood products industry, especially for small diameter and previously non-commercial tree species. Besides more field plots, industry would like to know: "Quantity (by species)?" "Quality (diameters, heights, and fiber condition)?" " Location?" and "Accessibility (legally, socially, physically, and economically)?" Answers to these questions determine how much investment can be made, and will ultimately affect how much ecosystem restoration can be accomplished on public lands.

Discussion Questions: Are the inventory data gathered by government agencies compatible and comparable? Is there sufficient volume to warrant commercial harvest (i.e. will there be enough for a private business to payoff investments)? What is the species mix, size (diameters and heights), and condition of the fiber? Are potential harvest areas physically accessible given existing transportation networks and technology? What is the relationship of "accessible inventory" to costs and markets? Can potential niche market information be extracted from current inventory data categories (for example tight ring counts and one-inch diameter classes for small diameter trees)?

Ecosystems Management Prescription - The term "ecosystem management prescription" is used rather than silvicultural prescription because it encompasses the multiple resource objectives inherent in almost all current and planned harvest operations. The prescription determines the type of material removed, amount, timing, and other key factors. It may or may not take into account the economic component of a particular ecosystem, which includes harvest and processing infrastructure and economics. The sale of material obtained through ecosystem restoration management activities is necessary to at least partially defray costs of management.

Discussion Questions: Is there sufficient scientific knowledge to permit vegetative manipulation? What are the biological, social, and economic objectives and tradeoffs of the proposed management scheme? Are any of the tradeoffs controversial or sufficiently unknown to constitute management "red flags"? Are there current or projected commercial markets for the raw material which will result from ecosystem management or other commercial harvest activities? Are the proposed activities economically viable in the short-term and long-term, considering existing and expected industry infrastructure and markets?

Partnerships and Affected Interests - An important goal of the attached *Matrix* is to stimulate discussion between public and private entities about existing harvest methods and possible alternatives. Key interests must be represented to ensure meaningful dialogue and provide access to different knowledge and experiential networks. Shared concerns and cooperative efforts will yield longer-lasting results than if any one group "did it all on its own". Partnerships may be as small as a two or three cooperators, or as large as twenty or more. Partnerships formed to investigate harvest systems are most productive when focused on specific shared problems and results, such as equipment trials and demonstrations, or pilot projects. It is unlikely that all critical factors and harvest system components displayed in the attached *Matrix* can be addressed by any one group or project.

Discussion Questions: Who is directly affected or has a strong interest in removal and processing of woody material? Have knowledgeable individuals been consulted or contacted concerning ideas and suggestions to improve harvest systems for small diameter or previously non-commercial tree species? Can field trials or

demonstration projects be designed and implemented to explore environmentally- and economically-acceptable alternative methods and techniques? Who needs to be involved to help make field trials and demonstration projects happen? How will information be communicated to other interested or affected parties after projects are completed?

Harvest and Post-Harvest Planning and Layout - Projected sale volumes, log quality (diameters and lengths for example), and harvest cycles are examples of factors which affect private business decisions about type of harvest equipment needed and potential return on capital investment. There has to be sufficient volume over time, within some average annual range, to justify investment and training for highly-specialized harvest systems, such as those involving cable yarding, and high-capital investment equipment, such as cut-to-length and forwarder systems. Harvest and post-harvest planning has to take into account projected harvest system needs 10 to 20 years in the future, not just the current entry.

Discussion Questions: How many entries are needed or projected to accomplish land management goals? What type and volume of material will be removed? How often will entries occur? Are there markets for the type and amounts of material proposed for thinning or removal? Are Agency budgets and budget projections sufficient to accomplish sale layout and planning? Are critical factors such as existing harvest systems and expertise, and processing infrastructure, considered during the Federal planning and Interdisciplinary Team process? Is there expertise available to assist Agency personnel evaluate the physical and economic feasibility of proposed mitigation measures?

Contract Specifications and Scaling Requirements - Federal timber sale contract specifications are based on environmental review process results. Harvest system requirements and operational constraints (i.e. contract specifications) may or may not be economically feasible, and are often not explicitly considered during the planning process. The amount and type of scaling required are also direct costs, and should be considered part of the total economic feasibility picture. Most people are unaware that the amount and type of scaling required can indirectly affect processing costs. For example, if logs must be spread-out and scaled on an unpaved surface, breakage increases and additional rock and grit are introduced. Rock and grit increase unscheduled saw changes. On an aggregated basis, unscheduled saw changes can cost hundreds of thousands of dollars per year in lost production time in larger sawmills.

Discussion Questions: What operational constraints (e.g. soils; operating season; prescribed equipment) exist due to environmental concerns? What effect does this have on the type of harvest system needed? Are harvest system contract specifications realistic? What kind and amount of scaling is required, and where does it have to occur? Are scaling methods and sampling appropriate to type of material and markets? Have indirect costs of scaling been considered (e.g. log scaling in unpaved log yards introduces rock and dirt into primary breakdown systems, and causes unscheduled saw changes)?

Harvest Systems Evaluation Matrix - Harvest System Component Parts

Current and Expected Log and Chip Markets and Products - Current and expected log and chip markets and products are probably the most ignored aspect of harvest system research and analysis. Existing industry infrastructure and market prices determine how much of what is accepted and at what price. Logs are commonly sorted on the basis of species, size, and quality, and transported 60 to 100 miles to maximize operational efficiencies and maximize profit. Mill shutdowns change the flow of material and have indirect effects on some composite plants (such as particle board) and power generation plants which use biomass.

Discussion Questions: What are the capabilities and preferences of the existing harvest and processing industry infrastructure within at least a 100-mile radius (e.g. species; log diameters and lengths; chip or hog fuel markets)? How do capabilities and preferences change according to market trends? Are markets expected to change significantly prior to timber sale layout and harvest (e.g. sawmill, veneer, or composite plant closures;

retooling; new processing plants; drastic changes in market conditions [e.g. Asian market downturn])? How are primary processing residuals used? Are there untapped local or regional markets for primary processing residuals (e.g. low-grade trim ends for dunnage or pallet stock) or niche products (e.g. special sizes for local industry)? Is there a secondary processing industry? If so, how much and what is used for raw material? Where does it now come from? Can raw material be provided by a closer supplier?

Falling Needs and Constraints - It is a challenge for small diameter operations to meet production goals for an economic operation and minimize resource damage (such as to the residual stand). The equipment and methods used to put as many trees on the ground as quickly as possible often require far more capital investment and labor than can be justified for available markets. Although seldom considered, falling technique can make or break an operation, especially in the case of cable yarding. The Forestry Training Center (Forks, WA.) teaches a certain manual felling technique in conjunction with cable corridor design, which together can significantly decease production costs and residual stand damage in cable thinning units.

Discussion Questions: What type of falling method will produce results acceptable to resource objectives? Have falling method production costs been evaluated in terms of current and expected markets? Are there falling methods or techniques which have not been tried in a local area which will reduce overall harvest costs and resource damage?

Bucking Needs and Constraints - How a log is bucked (sawn into segments) is critical in determining yarding and processing requirements, and market value. Mills have different species, log length, and diameter specifications, and pay accordingly. Most mills do not want all species and sizes. One example of how bucked log length affects yarding requirements and market value involves export log lengths and sizes (e.g. 40-feet in length and 12-inch minimum small end diameter). Swing boom-equipped skidders may be necessary to yard the lengths necessary for highest market value (export market) and minimize residual stand damage. Federal harvest contract specifications rarely consider changing markets and industry infrastructure needs such as these.

Discussion Questions: What are current and expected markets and local processing needs for diameters and lengths of individual species (e.g. one mill may be able to handle large diameters [>24 in.], but only for a certain minimum length and species; another mill will take smaller diameters, but pays more for certain lengths and species)? How does this affect falling, bucking and yarding needs, and harvest contract specifications?

Delimbing Needs and Constraints - Delimbing can occur at the stump or on a log landing, depending on site-specific needs and existing conditions. Over the last 10 years there has been a decrease in use of chainsaws to delimb trees due to higher production needs, more acceptance of delimbing equipment, and decrease in average log diameter. There also appears to be a general increase in the amount of slash left to protect soils and increase nutrients. In some cases, such as western juniper woodlands, slash is probably the most important on-site tool for site restoration.

Discussion Questions: What are site-specific needs for slash disposal? Is there excess slash available and how will it be disposed of or used? How does delimbing location and method affect harvest economics? How will proposed delimbing methods affect end-product recovery (e.g. increase in blue stain in pine by removing more bark or loss in recovery because of fiber pull-out caused by mechanized equipment)?

Yarding Needs and Constraints - Yarding is probably the most discussed harvest system component. A major goal of this discussion is to highlight the importance of each harvest system component and how concentrating on just one component ignores important interrelationships. Everyone has heard of examples when helicopter yarding has been specified for material which has low value in the market place, and the timber sale receives no bids. It may be that helicopter logging is necessary, but it may also be possible to concentrate logs at landings on benches, using a "tractor swing" operation, which reduces helicopter cycle time and optimizes loads for more economical operations.

An example was previously given about how markets often reward longer log lengths. In some cases, longer

lengths can be yarded with minimal residual stand damage using a rubber-tired skidder equipped with a swing boom. Small diameter logs and previously non-commercial tree species present their own challenges - more pieces have to be moved and market values are less.

Discussion Questions: Which yarding alternatives appear both environmentally and economically acceptable (e.g. rubber-tired skidder with grapple vs forwarder; cable and roading vs helicopter logging)? How can existing yarding equipment and methods be modified to better meet resource management objectives, and still be economical? What methods, techniques, or equipment have not been tried and appear economically and environmentally acceptable? How will proposed yarding systems affect the manufacturing process and recovery (e.g. may want to consider forwarder system rather than skidding if rock is being introduced into the mill and contributes to unscheduled saw changes)?

In-The-Woods Processing Needs and Constraints - Some primary breakdown operations occur as close to the stump as possible. Primary breakdown may involve debarking and chipping for the "clean chip" market, or simply chipping whole trees for the hog fuel market. This category could also include small, portable sawmills, ranging from Economizer (R) types of units to portable band mills.

Discussion Questions: Does the nature of the resource and raw material markets warrant investment and use of in-the-woods debarking and chipping equipment? Does the nature of the resource and raw material markets warrant chipping and/or sawing on-site (e.g. chippers, portable sawmills, or some combination of the two [e.g. something like an Economizer(R) unit which both chips and saws])?

Log Landing Sorting and Loading Needs and Constraints - Different primary processing plants require different logs and raw material, which in turn affects how logs and chips flow within a region. It is common for companies to buy timber sales with the idea of selling or swapping logs with other companies for material which is better suited for their particular operation. Logs may be sorted at the landing or another location. Log landing design and size are far different for an operation which is sorting logs and chipping than for an operation which is simply decking and trucking.

Discussion Questions: Is there sufficient market differentiation, demand, and supply diversity to justify log sorting? Will landing locations and size permit log sorting on-site, or will it have to take place off-site? How will this affect costs of handling and breakage loss?

Transportation System Needs and Constraints - The transportation component of the harvest system includes how logs, chips, or other processing material (such as from a portable mill) are shipped once they are decked or produced at a landing. Chipping operations and chip vans require higher standard roads and landings than regular log trucks. Roading requirements and mitigation of such things as multiple stream crossings, may eliminate certain areas from consideration unless a transportation system is already in place. Lower cost, lower maintenance access methods have to be explored when dealing with low-value material. Road building and maintenance budgets, and expected volumes and prices may not correspond with transportation needs, and other transportation and processing alternatives may have to be considered.

Discussion Questions: What kind of physical access exists to a site? How will existing or proposed access be affected by the environmental review process? Is there sufficient economic payoff to invest in transportation system needs or requirements? Are there ways to process material on-site to reduce transportation system requirements?

Unloading, Sorting, and Reloading - Logs may be sorted at the harvest site, transported to a sawmill or other manufacturing facility and sorted, sorted at aggregation sites run by a separate entity, or sorted at a log yard set-up to handle multiple suppliers and purchasers. Each time a log is handled there will be a certain percent of breakage, especially when dealing with small diameters. There is also the issue of increased costs of handling.

Discussion Questions: Is it more economical and/or environmentally acceptable to sort logs off-site or nearer to

the harvest site? Are there reasons to consider a central log sort yard? How is the local situation similar and different than log sort yards elsewhere?

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Harvest Systems Evaluation Matrix for Small Diameter and Previously Non-Commercial Tree Species

CRITICAL FACTORS	**Locally-Available Harvest Systems & Expertise** • Interest? • Equipment? • Knowledge & expertise? • Capitalization?	**Inventory** • How much (by species)? • Quality (diameters; hts.; fiber condition)? • How accessible (legally; socially; physically; economically)? • Location?	**Ecosystems Mgt. Prescription** • Does the desired future state require harvesting trees? • Strength of science and scientific "red flags"? • Economic & social tradeoffs?

	Partnerships & Affected Interests
	• Interested/motivated:
	  ○ Landowners & mgrs.?
	  ○ Harvesters & processors?
	  ○ Local communities, scientists, environ. grps., non-profits, univ. extension, etc.?
		Harvest/Post-Harvest Planning & Layout
		• How many entries needed, for what & when?
		• Expected volumes, species, and fiber quality?
		• Budgets & market economics?
			Contract & Scaling Requirements
			• Operational constraints?
			• Amt., type, & location of scaling?
			• Impact of contract specs. & scaling requirements on costs & recovery?

HARVEST SY	**Current & Expected Log & Chip Markets/Products** • Species mix & projected volumes? • Diameter & fiber quality mix? • Distance to markets? • Current & projected market prices?	**Falling Needs & Constraints** • Production economics vs resource tradeoffs? • Production economics vs end-product economic tradeoff?	**Bucking Needs & Constraints** • Preferred diameters and lengths for highest-value? • Yarding and transportation constraints?
	Delimbing Needs & Constraints • Location and slash disposal? • Production economics vs resource tradeoffs?	**Yarding Needs & Constraints** • Production economics vs resource tradeoffs? • Production economics vs end-product economic tradeoff?	**In-The-Woods Primary Breakdown Needs & Constraints** • Production economics vs resource tradeoffs? • Production economics

S T E M P A R T S	• Production economics vs end-product economic tradeoff?		vs end-product economic payoff ?
	Log Landing Sort/Load Needs & Constraints • Production economics vs resource tradeoffs? • Production economics vs end-product economic tradeoff?	**Transportation System Needs & Constraints** • Layout needed for projected activities? • Easements & permits? • Budgets/market economics?	**Unload/Sort/Reload** • Handling & trucking costs vs added-value or raw material exchange payoff?

1. Matrix categories and questions were derived from over five years of trying to reduce costs, improve safety, and improve post-harvest site conditions in juniper woodlands. The categories and questions appear equally applicable to harvest of small diameter and other previously non-commercial tree species, such as tanoak and madrone.