U.S. Department of Agriculture

Community Biomass Handbook

Volume 4: Enterprise Development for Integrated Wood Manufacturing

Eini C. Lowell, Dennis R. Becker, David Smith, Marcus Kauffman, Dan Bihn

Forest Service

Pacific Northwest Research Station

General Technical Report PNW-GTR-953

March 2017

Nondiscrimination Policy

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program infor¬mation (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov .

USDA is an equal opportunity provider, employer, and lender.

Authors, Sponsors and Collaborators

Lowell, E.C., Becker, D.R., Smith, D., Kauffman, M., Bihn, D. 2017. Community biomass handbook volume 4: enterprise development for integrated wood manufacturing. Gen. Tech. Rep. PNW-GTR-953. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 46 p.

Authors

Eini C. Lowell is a research forest products technologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 620 SW Main St., Suite 400, Portland, OR 97205; **Dennis R. Becker** is director of the Policy Analysis Group and is an associate professor, University of Idaho, Department of Natural Resources and Society, 875 Perimeter Drive, MS 1134, Moscow, ID 83844-1134; **David Smith** is courtesy faculty, Oregon State University, College of Forestry, Department of Wood Science & Engineering, Corvallis, OR 97330; **Marcus Kauffman** is a biomass resource specialist, Oregon Department of Forestry, 2600 State St, Salem, OR 97310; **Dan Bihn** is an engineer-storyteller, Bihn Communications, LLC, 1200 NW Marshall St., Suite 1311, Portland, OR 97209.

All photographs are by Marcus Kauffman unless credited otherwise.

For more information, contact Eini Lowell at elowell@fs.fed.us, Dennis Becker at drbecker@uidaho.edu, or Marcus Kauffman at marcus.kauffman@oregon.gov.

Sponsors and Collaborators

The Community Biomass Handbook was developed in collaboration with the USDA Forest Service for assisting Collaborative Forest Restoration teams. Primary funding was provided by the USDA Forest Service, Pacific Northwest Research Station. Additional support was provided by the University of Idaho, Policy Analysis Group, University of Minnesota, Department of Forest Resources, Oregon State University, and Oregon Department of Forestry.

Product Disclaimer

The use of trade or firm names in this publication is for reader information and does not imply product endorsement by the U.S. Department of Agriculture of any product or service. All examples and decision support tools are for information and educational purposes only (e.g., project guidance, scoping, and feasibility assessment) and should not be used for investment purposes. The authors, USDA, and the Forest Service claim no responsibility for its use.

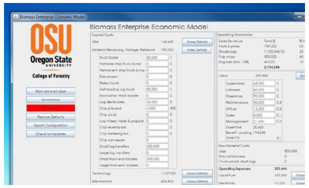
Table of Contents

Introduction | About This Handbook

The *Community Biomass Handbook Volume 4: Enterprise Development for Integrated Wood Manufacturing* is a guide for creating sustainable business enterprises using small diameter logs and biomass. This fourth volume is a companion to three *Community Biomass Handbook volumes: Volume 1: Thermal Wood Energy; Volume 2: Alaska, Where Woody Biomass Can Work; and Volume 3: How Wood Energy is Revitalizing Rural Alaska*. This volume is designed to help business partnerships, forest managers, and community groups rapidly explore and evaluate integrated manufacturing opportunities. The handbook is particularly relevant to communities and business near public lands and identifies the types of information needed when considering biomass utilization, and walks users through the initial stages of project scoping and design by:

Creating mutual understanding—from start to finish, communication is critical. This handbook illustrates how the interests and expertise of key stakeholders—forest managers, business entrepreneurs, and community partners—enables project success. This section of the handbook includes detailed information about the types of knowledge needed at each step of an integrated wood manufacturing process, and which stakeholders can provide assistance.

Integrated approach to biomass utilization—businesses configured to produce multiple products allow merchandizing of biomass to its highest value. This section of the handbook helps users identify viable combinations of complementary, integrated product manufacturing that makes financial sense and helps agency partners structure projects to support existing and emerging markets.



Biomass Enterprise Economic Model—the model introduced in this handbook provides an interactive platform to match conversion technologies to easy-to-understand scenario testing based on feedstock quality and quantity, raw material costs, capital expenses, finished product values, and more. By putting this knowledge at the fingertips of local partners, informed decisions can be made early in the planning process to increase the chances of success.

Mobilizing to create action—one outcome of using this handbook is a plan identifying the types and amount of material available, matched with realistic business options. Another outcome is a coordinated effort to invest in the local economy through sustainable biomass utilization that enhances forest health and reduces wildfire risks. This section of the handbook will help you to identify specific outputs to keep your project moving.

Introduction > Who Should Use This Handbook

Forest collaboratives composed of entrepreneurs, forest managers, and community partners are looking for ways to turn the byproducts of forest restoration into profitable enterprises. Developing product markets would provide a means to enhance forest health while creating local jobs. It's a win-win scenario. But not without some hard work and a diverse team of partners.

This handbook can help even the most seasoned entrepreneur and forest manager understand the nuances of working with local partners, identify approaches for resolving common challenges, and equip forest collaboratives with the knowledge to succeed. This starts with having the right people at the table:

- ❑ Local businesses and entrepreneurs
- ❑ Regional economic development specialists
- ❑ Community organizations and stakeholders
- ❑ Nonprofit organizations
- ❑ Project developers and consultants
- ❑ State and federal forest management agencies
- ❑ Industry and trade associations
- ❑ Equipment manufacturers and distributors

Introduction — How to Use This Handbook

This handbook serves as an initial resource for businesses, forest managers, and communities seeking opportunities to match resource characteristics with appropriately scaled conversion technologies. It can help project partners ask the right questions to quickly narrow the range of utilization options. It will help set objectives, define project scope, and conduct a preliminary financial appraisal of a range of integrated wood utilization options using the *Biomass Enterprise Economic Model*.

Starting with input on feedstock, users can begin estimating capital investment and operations expenses, revenue, and jobs created, which can significantly reduce early-stage planning costs. Fundamental to this exploration process is matching your biomass supply to your product at a scale suited to local community development goals.

- ❑ Resource availability—the volume and consistency of supply—governs the scale of processing economically feasible for a given area. Variations in tree size, age, distribution, and species dictate the range of products possible.
- ❑ Viable markets and proven technology must exist for without them there is no outlet for products or financial capital to stimulate investment.
- ❑ Utilization options must be matched with community desires, expectations, and experiences to be truly sustainable.

Companion Multimedia Case Stories

The Oregon Department of Forestry produces a series of companion multimedia case stories that deliver thought-provoking insights from real collaborative projects in the West. Click the icon on the right to view.


Creating Mutual Understanding

Creating Mutual Understanding

Coordination starts at the source of the raw material and follows all the way through to business plan development and eventually project implementation. But this isn't just the responsibility of the business entrepreneur. Forest managers and community partners have a responsibility. Why? Because public land managers and their community partners heavily influence the location, duration, and type of forest management. These decisions affect business profitability and investor willingness to assume the financial risks that go along with achieving the common goal of restoring forests. Working together fosters greater business certainty, mutual understanding, and sustainability—of the resource base, financial investments, and community development.

This section discusses the three types of knowledge required in an integrated wood manufacturing process. Each one of these individuals—forest managers, business entrepreneurs, and community partners—have unique knowledge and expertise they can bring to the table to improve business and agency planning.

Forest Knowledge

Forest managers and planners have a responsibility to provide robust and timely estimates of the potential quantity, quality, timing and location of the byproducts from forest restoration treatments and timber sales.

Business Knowledge

Business entrepreneurs and investors have a responsibility to provide fair and accurate information to forest managers and community stakeholders on the type and scale of wood conversion enterprises being considered.

Community Knowledge

Community partners have a responsibility to highlight concerns and facilitate education and outreach. They can help businesses scale operations to meet local needs and expectations. They can help design projects to meet multiple and potentially conflicting objectives.

Forest Knowledge

Forest managers and their staff have an incredible collection of knowledge and expertise. They're trained in hydrology, remote sensing, silviculture, economics, fisheries, fire ecology, wildlife, and many other areas that require time and coordination to incorporate into forest plans. Mobilizing this vast knowledge improves utilization options through enhanced understanding of tree properties, site and stand-level characteristics, and resource supply and availability. A biomass enterprise can't succeed without this knowledge.

- ❑ Tree Properties
- ❑ Site and Stand-Level Characteristics
- ❑ Resource Supply and Availability
- ❑ Project Staging and Seasonality

Tree Properties

Oak flooring, Douglas-fir lumber, pine moulding—you get the idea—some tree species are associated with specific products because of the way they perform or the way they look. To produce those products, you not only need a certain species of tree but also one with certain properties. Matching products to the trees you have available is essential.

For structural applications, attributes like size, number, and position of knots or number of rings per inch are relevant. For appearance graded products such as door and window trim, clear wood without knots is preferred. Wood density is another important property both for structural and energy applications. For example, if you are planning on manufacturing fire logs or briquettes, knowledge of heat rates associated with different wood densities is helpful.

Consumer preference plays a big part in whether your product is marketable or not. Blue stain pine and knotty pine are good examples of using what some people consider a product defect as a design attribute to appeal to consumers when used in products like paneling or rustic furniture.

Site and Stand-Level Characteristics

Management activities, or lack thereof, influence tree growth and consequently wood quantity and quality. Trees in heavily thinned forests tend to retain more of their live crown (green branches) resulting in larger knots. They also may have more taper, making them unacceptable for certain wood products. Trees from densely stocked forest stands often have suppressed growth because of competition for water, nutrients, and sunlight. These trees may be stressed and more susceptible to insect and disease mortality. They also may be shorter, and produce fewer logs than trees growing in a healthy forest.

Site characteristics such as soil type, moisture availability, aspect, and elevation also influence tree growth. It's good to keep in mind that not all trees in a stand are the same size and species. Your available supply may include sawlog material at the upper end of the value chain to logging slash at the lower end.

It is also good to be aware of operational limitations associated with a site. Slope may dictate the harvesting system used, which can significantly influence delivered log or biomass costs. Distance to processing facilities or to end markets is typically the most significant expense.

Resource Supply and Availability

Matching the availability of local forest resources, both in volume and quality, is a necessary step toward sustainable business development. Supply issues determine the types and flow of material, affecting the range of utilization options. There must be a sufficient quantity of trees, of sufficient and appropriate quality, consistently accessible for the life of the project, and at a competitive cost for the appropriately scaled utilization option.

The most basic of these issues being resource accessibility—who gets what forest resources, how much volume, how close, when, and at what price. Don't forget to address whether there are existing or potential competing uses of the resource in the area you are considering.

Land ownership will also influence availability and timing. Maybe state regulations affect the level of harvesting in stream buffers. Or it could be that local community pressures dictate which areas are harvested, or not, because of fire risks or recreational uses of the forest. Physical terrain, property boundaries, access, proximity to sensitive areas, and many other factors affect your supply.

Project Staging and Seasonality

A year-round biomass processing facility requires a year-round, steady supply of affordable feedstock. If fluctuations in supply occur, storage capacity may be needed. What might interrupt your supply? Harvesting operations are often limited during rainy periods or when fire danger is high. Your inventory needs to carry through times when harvesting isn't possible.

Maybe the product you are manufacturing is seasonal, such as firewood. Can you get the wood when you need it most and demand is highest? Conversely, what happens to your suppliers if you shut your doors during the off season? Strained relations could result.

Working with landowners to ensure you have the volume you need, when you need it, at the price you can pay, for the projected years of operation is a major part of your business plan.

Business Knowledge

Business entrepreneurs require a diverse suite of skills and knowledge. They need to understand the forest resource, its physical characteristics, and how to turn biomass into a value-added product. They need to be savvy about consumer markets and product durability, and be able to negotiate pricing with distributors to get their products to market. They need to secure financing for start-up capital and business operations. And they need to time all this to the availability of biomass. The proposition is that entrepreneurs will make these capital investments, sometimes in the millions of dollars, in return for wood fiber that may be of marginal value, and the timing of which might be out of their control. Reducing risk is the name of the game.

- ❑ Product markets
- ❑ Investment plans
- ❑ Resource requirements
- ❑ Infrastructure needs

Product Markets

Without markets, there would be no utilization. Unfortunately, markets for forest restoration material, the slash and small-diameter trees that are not suitable for traditional uses, are limited. Plenty of product options exist, but their low value relative to the cost of removal requires a thoughtful approach to business plan development. Important questions about product markets for any business to ask, but especially a new biomass enterprise, include:

- ❑ How big is the market sector?
- ❑ Are there opportunities for market expansion?
- ❑ How mature is the industry?
- ❑ Are alternative products readily available?
- ❑ What is the future of the industry?
- ❑ Are production technologies changing rapidly?
- ❑ What are the barriers to market entry?
- ❑ Is there competition?
- ❑ What are the capital costs to participate in this market sector?

Equipped with basic knowledge about target markets, including their durability and resource needs, forest managers and community partners can help businesses plan for feedstock disruptions, navigate regulations, train workers, identify product niches, and gauge local consumer demand and attitudes.

Business Plans

Regardless of whether a business is selling pellets to Asia or landscape timbers to the local building center, they need to be aware of how industry trends and seemingly unconnected events influence product demand. National or global events can influence monetary policy, which may affect consumer confidence and in turn product prices. Weathering inevitable market fluctuations requires a sound business plan. Government grants can help fledgling ideas but are not a long-term solution for a profitable enterprise.

Sound planning also requires providing some level of transparency to community partners who may increase access to capital, or help identify risk-sharing propositions. Community stakeholders—those residents and landowners, harvesters, employees, and customers—have a vested interest in the success of the enterprise. Thinking of them as stakeholder investors, whether or not as actual financial contributors, can create mutually beneficial investment opportunities.

A biomass business plan should include these elements:

- ❑ An assured local and adequate supply of biomass for a defined amount of time.
- ❑ Target markets willing to pay a fair price for biomass-derived products.
- ❑ A manufacturing plan including site acquisition, establishing the facility, producing the products, and quality control.
- ❑ Create a community outreach plan for building local support.

Resource Requirements

Talk to ten people and you'll get ten reasons why biomass businesses fail. Many don't even get off the ground. Feasibility studies are commissioned but go nowhere. Product markets materialize then fizzle away.

One culprit is a lack of guaranteed raw material supply. Where public lands dominate, the conventional wisdom is that the efforts of federal agencies to prepare decision documents that will lessen the likelihood of litigation will lead to protracted planning, which may impede an industry's efforts to amortize investments.

An insufficient supply of raw material spawns mistrust and risk aversion. No bank still in business is going to lend millions of dollars without some assurance of resource availability. Look for multiple feedstock suppliers.

There is great pressure on forest managers to develop long-term supply contracts. But the responsibility also resides with entrepreneurs to size operations to the available supply, and to keep forest managers apprised of resource needs. Revenue generation might be the entrepreneur's goal, but sustainable forest practices guide agency decision making. Matching resource availability with product markets is a tricky proposition, but it's made less so when forest managers and businesses work together to create mutual understanding.

Infrastructure Needs

Many rural communities that were previously dependent upon the forest products industry have infrastructure still in place that could accommodate new industrial activity. Rail access, buildings, road infrastructure, water, and high-voltage lines are valuable assets that can entice new investment. Some of the best sites are recently closed mills, which are often close to forests and have surrounding communities with an under-employed but skilled workforce with a strong forest industry heritage. But these industrial sites also come with their own challenges. Costly remediation may be required to remove contaminants. Utilities and buildings may require upgrading.

Industrial parks and business incubators are an alternative, and may provide some form of tax incentive. Local community development organizations can provide the necessary information and help identify appropriate locations and possible business partnerships.

Community Knowledge

The grand challenge in biomass utilization is to structure business investments to ensure sustainability and maintain economic viability. The rewards are significant—increased pace and scale of forest restoration treatments, hazardous fuels reduction, enhanced water quality and wildlife habitat, and local jobs and income for rural communities.

The pace of project development can be frustratingly slow and the risk of failure high if the community lacks trust in the project or the individuals involved. Community members have a responsibility in this partnership to state expectations of local businesses, to help forest managers design projects to meet ecological and community needs, and to provide the skills and infrastructure necessary to facilitate business development.

Community Capacity

Community capacity provides the cache of resources and abilities to complete a project. It includes the natural resource base and physical infrastructure, as well as the unique skills, education, and experiences of residents. Tapping into community capacity is critical to project success and requires mobilizing a broad range of skills of landowners, loggers, truckers, wood products manufacturers, agency administrators, local business groups, and conservation organizations—to mention just a few.

History and Project Familiarity

History has a way of repeating itself, or at least that's what some in the community may fear. Do they have a reason to be skeptical? Past experiences play an important part of project success. Some experiences may need to be overcome while others can positively shape a project. Communities with a history of forest products manufacturing are more likely to be familiar with and support related projects.

Attitudes and Beliefs

Attitudes are the sum of one's beliefs about a behavior and evaluation of expected outcomes. Do you have a positive attitude about using biomass because you believe it contributes to wildfire risk reduction? A belief, which is the acceptance that something is true or real, is generally shaped by past experiences and rooted in how we react to new situations or ideas. Do you believe that burning biomass creates unacceptable levels of air pollution? Attitudes towards a business proposition may evolve, but our beliefs are durable and unlikely to change.

Project Scale and Impact

The scale of a project can make all the difference. If it's too big, some will be concerned about impacts to forests, or the number of logging trucks driving through town. If too small, project finances won't work or the ability to reduce hazardous fuels will be insufficient. "Right-sizing" balances local concerns with financial and ecological realities. Unfortunately, identifying the right size can be an ever-changing target.

Integrated Approach to Biomass Utilization

Dan Bihn

Integrated Approach to Forest Material Utilization

Businesses who make a single biomass product may not be as financially viable as *integrated* operations that merchandize biomass to its highest value in multiple products. The companion *Biomass Enterprise Economic Model* allows users to compare conversion technologies and finished products to assess the viability of different scenarios. It enables project partners to identify combinations of complementary products that make ecologic and economic sense, and helps forest managers understand how to structure restoration contracts to support related enterprises.

This section of the handbook will help you consider pairing feedstock supply with appropriate conversion technologies. While not exhaustive, the following topics will help users of the *Biomass Enterprise Economic Model* understand key parameters and some common product options suitable for small-diameter trees in the Western United States.

Supply Characteristics

Supply characteristics refer to the tree species and size, quality of material available, and material form (e.g., logs, chips, hogfuel). All are important considerations when assessing product options.

Quantity and Timing

Quantity and timing of raw material supply has a significant impact on processing scale. Consider how the flow of material, which may be seasonal, affects productivity and how to match output to seasonal consumption patterns.

Conversion Options

Conversion options abound. Narrowing them is an important first step. Too few options and you limit possibilities, and too many can be confusing. Selecting an optimal pathway requires attention to supply characteristics, quantity and timing, and market demand.

Supply Characteristics

Supply Characteristics

Most people are familiar with the traditional uses of biomass—hog fuel, firewood, posts and poles—and there are many more. Each use has raw-material specifications that affect value, which in turn requires close attention to quality. Integrated operations having more than one product require balancing quality considerations across those products.

Some species are well known for their physical properties and lend themselves to being used for a specific product. Red cedar, recognized for its aromatic properties and natural decay resistance, is commonly used in fencing. Douglas-fir is prized for its stiffness, an important mechanical property in the production of structural graded lumber and engineered wood products like glue-laminated beams.

Post and pole operations require a steady supply of straight, low-taper softwoods (often lodgepole pine). What size of logs are readily available, and are they the “right” species? For example, hop poles need longer lengths (up to 25 feet) with little taper, while vineyard posts may be from 6 to 12 feet. It’s also important to consider your equipment capacity in relation to your resource. Make sure your log peeler can handle the size of logs available to you.

And remember, whatever the primary product, there will be byproducts. For example, with a post and pole operation, you will generate shavings, sawdust, and bark. If you cannot find a use for this material, you’ll need to dispose of it—often at a cost.

Quantity and Timing

Quantity and Timing

The amount of feedstock and the available form needed for the scale of planned operations is an important question. But just as important is resource consistency, the stability and timing of raw material availability.

Say a pellet business needs 125,000 dry tons of biomass per year, and their deliveries to regional distributors are due in September. That works fine if the bulk of harvesting happens early in the year, but what happens if resource contracts are inconsistent? Maybe the local forest scales back environmental planning or a series of legal appeals delays implementation. The business needs to act quickly to find alternative sources, perhaps at a much higher price and farther away. If the business can't find an alternate supply, it may temporarily close, lay off employees, and lose hard-earned distributor relationships. How much do you need? And what impact does that have on a community? It's one thing if the business needs ten log loads per week; it's another thing if they need ten log loads per day.

Conversion Options

Conversion Options

Do you have a product idea for small-diameter trees or harvest slash? Or maybe you want to expand current operations. As the variety and availability of wood products expand, the challenge is establishing competitive and sustainable markets. Product differentiation, price competitiveness, and anticipating consumer demand are critical, and perhaps the most underdeveloped and elusive aspects of a biomass enterprise.

The kinds of products produced from forest biomass depend on its form when delivered to the conversion facility. Once it has been ground into hog fuel, the options are pretty limited. About the only things that can be done with it are burn it, use it for landscape mulch, or run it through some kind of a reactor to convert it into a form of bio-crude for chemical or biofuel production. Hog fuel is the lowest value product and is always part of the mix, because some of the biomass inevitably ends up in that form. However, if more care is taken in the field, the potential of biomass to be converted into higher value products can be preserved.

The concept of a biomass processing center or cluster focuses on receiving logs and merchandizing them for complementary products. This could be an industrial site equipped with a suite of material handling and manufacturing technologies that allows for the simultaneous production of multiple solid wood products. Another strategy is to simultaneously process forest slash and low-grade logs into heat co-located with industries requiring process heat like a greenhouse, microbrewery, or food processor.

Product Matrix

The first challenge in starting a biomass business is matching the resource base to the appropriate technology options, a function of tree physical properties and what your supply material looks like. Fortunately, technological advances increasingly allow small-diameter wood to be used for a greater variety of applications, and entrepreneurs are always coming up with new ideas and uses. The following table illustrates a few of the many products available along with their resource considerations.

Products from forest biomass	Applications	Preferred species	Supply material form
Rough lumber, boards	Structural, appearance, pallet or fruit box stock	Douglas-fir, hemlock, spruce, ponderosa pine, lodgepole pine, oak, maple, madrone, Western juniper, others as market might accept	Whole logs
Grade logs	Structural lumber	Douglas-fir, hemlock, spruce, ponderosa pine	Long logs with minimal defects
Post and poles	Fencing posts and rails, hop poles, vineyard stakes, architectural accents	Lodgepole pine preferred; other softwoods possible	Straight, small-diameter logs with minimal taper or defects
Pulp chips	Pulp and paper	Softwoods	Logs, mainly debarked, but some market for “dirty” chips with bark
Firewood	Residential and commercial heating	Douglas-fir, pines, oak, maple, others	Logs, large branches
Wood pellets (premium)	Home and commercial heating	Most softwoods and lower density hardwoods	Chips and clean residuals from other processing
Wood pellets (industrial)	Industrial and process heating	Most softwoods and lower density hardwoods	Chips and clean residuals from other processing

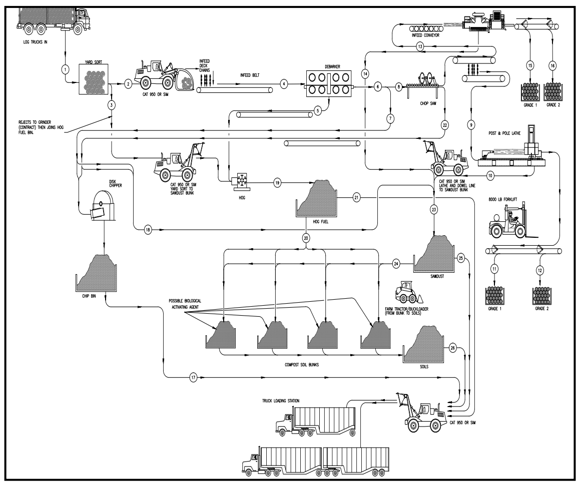
Products from forest biomass	Applications	Preferred species	Supply material form
Fire logs	Residential and commercial heating	Douglas-fir, pines, oak, maple, Western juniper, others	Chips or clean grindings
Fire briquettes	Residential and commercial heating	Douglas-fir, pines, oak, maple, western juniper, others	Chips or clean grindings
Bulk shavings and sawdust	Pellets, particle board, animal bedding	Western softwoods	Clean, bark-free residuals from other processing
Fuel chips	Residential and commercial heating	Douglas-fir, pines, oak, maple, western juniper, others	Logs, large branches
Decorative bark	Landscaping	Douglas-fir, hemlock	Logs
Biochar	Soil amendment, water filtration, soil reclamation	All	Field grindings or residuals from other processing
Mulch/compost	Landscaping	All	Residuals from other processing
Hog fuel	Industrial or utility power boiler fuel	All	Field grindings or residuals from other processing
Thermal energy	District or commercial space heat, or industrial process heat	All	Field grindings or residuals from other processing
Electricity production	Power	All	Field grindings or residuals from other processing

Successfully making salable products from biomass takes careful planning and a solid business plan. The Biomass Enterprise Economic Model can help you compare options and analyze the economics of biomass utilization early in a project's planning process, before costly commitments are made. It is designed to help users rapidly explore and evaluate appropriately scaled biomass utilization enterprises. You can combine raw material characteristics, conversion technologies, and finished products to compare "what if" scenarios on key factors such as capital expenses, raw material cost and quantity, operating costs, and finished product values. Users can examine complementary product options and ways of maximizing financial return through biomass utilization. Comparing scenarios is an important part of the planning process to maximize both business and forest restoration goals.

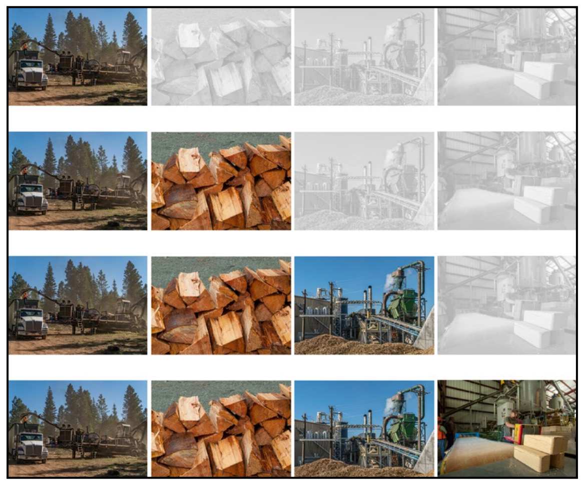

Biomass Enterprise Economic Model
Dan Bihn

Biomass Enterprise Economic Model

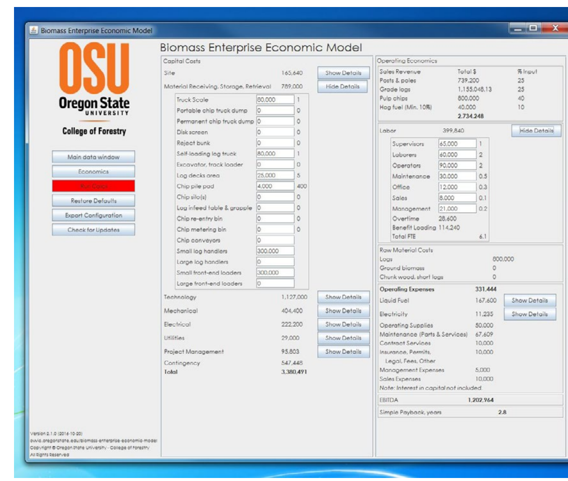
The Biomass Enterprise Economic Model is maintained by the College of Forestry at Oregon State University. Click the link to access it. To use the model, download it to your computer, then open it using Java, a free software application compatible with most operating systems. Step-by-step instructions are provided. Be aware that the model is updated from time to time, so return to the link to be sure you've downloaded the latest version.



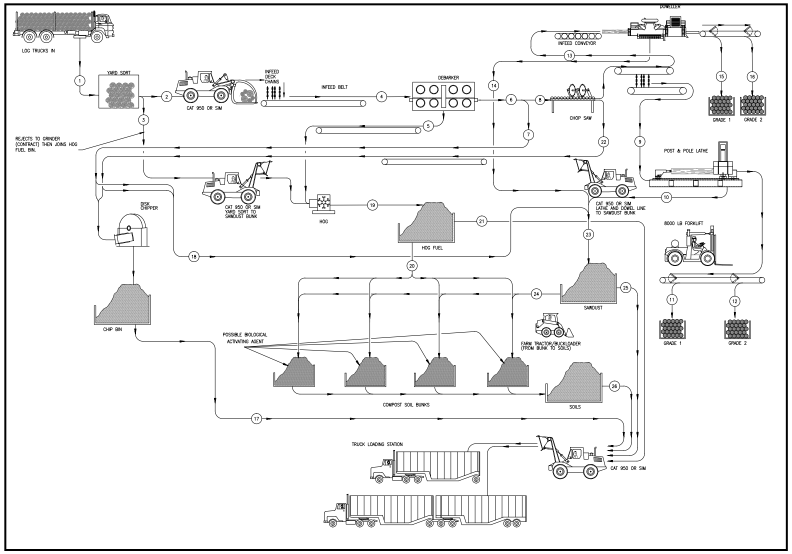
Planning a Biomass Enterprise



Growing a Biomass Enterprise



The Model in Action



Post and pole mill process flow diagram (prepared by Evergreen Engineering, Inc. Eugene, Oregon)

The first and most important requirement is a good understanding of how much and what kind of biomass is available, at what price, and that you have an adequate and assured supply of feedstock. This can be a problem if local landowners or agencies are reluctant to make long-term commitments, are constrained by laws, or unable to predict sufficient future volumes to ensure financial viability.

Then you must remember that species, form, and quality of the biomass could limit the kinds of products that can be made from it. Pulp chips and firewood are best made from low-grade logs, but not all species are suitable. While pulp chip buyers usually prefer conifers, hardwoods like maple or alder make better firewood. Straight, small-diameter pine logs make the best posts and poles. A small specialty sawmill could be a choice if a supply of desirable hardwood logs is available. Tree tops and branches are difficult to transport, so are best processed in the field. Field ground biomass, or hog fuel, is usually only good for burning in a boiler, but can be converted into biochar or processed into higher value products like fire logs or briquettes.

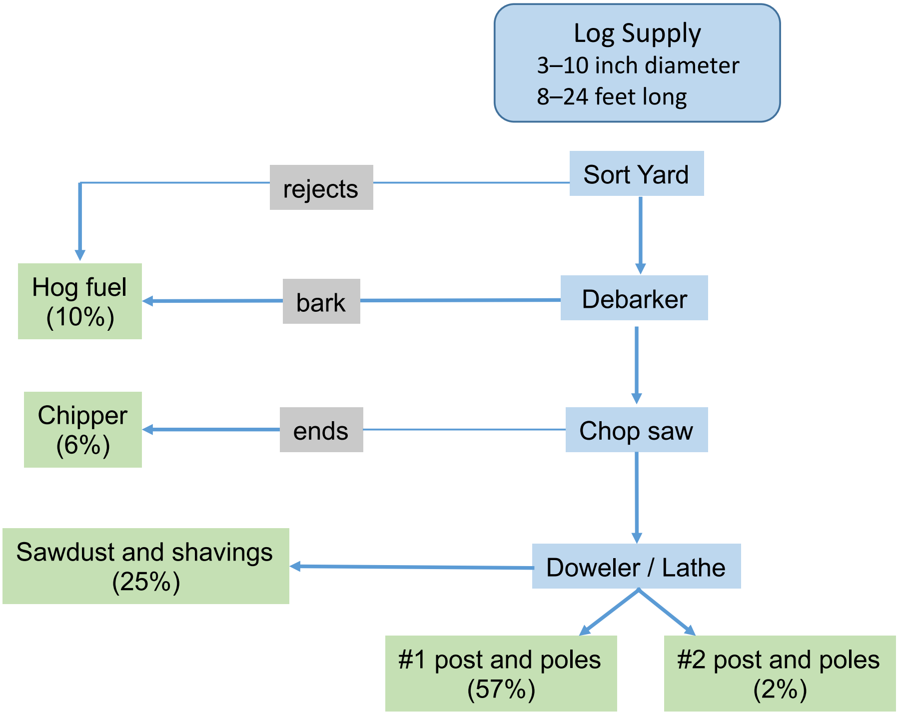
The volume of material processed has a huge impact on the economic viability of the enterprise. Generally speaking, the larger the better. The margins between production costs and sales prices will always be narrow. So smaller scale operations will find it difficult to generate enough revenue to justify much of a capital investment. They have to focus on only one or two products and doing them well. Larger operations, those processing tens of thousands of tons of biomass per year, are in a better position to tool-up to make multiple products and employ a capable, permanent work force.

Dan Bihn

Dan Bihn

Understanding Yield and Byproducts

It is very important to understand yield and byproducts. A small sawmill or post and pole operation will generate a lot of sawdust or shavings in addition to the primary products. They can also use off-cuts and short logs to make pulp chips, but only if configured to do so. And every operation will have downfall and rejects that need to be removed from the site or burned as hog fuel. This figure is an example of a typical "material balance" for a post and pole mill.



Growing a Biomass Enterprise

Phased Approach

Sometimes a phased approach of starting small with a sound, low-risk business plan and expanding as supply becomes available. As supply increases, so can complexity and the capital investment in technologies needed for the enterprise to produce a wider range of products to more fully actualize the value of the biomass. There is also opportunity to capture more value by integrating product lines or clustering your manufacturing operations. The Biomass Enterprise Economic Model can also be used to evaluate if a phased approach might be a good way to go.

Phase 1: Small-scale operation—designed to accumulate chip-quality logs at an industrial site that periodically brings in a portable chipper equipped with a flail debarker to produce pulp chips and hog fuel.

Phase 2: Medium-scale operation—expands on the satellite chipping operation in Phase 1 to include buildings, log yard, rolling stock, and installed equipment that is designed to sort logs and increase production through conversion to chips, firewood, and hog fuel.

Phase 3: Large-scale operation—builds on the dual-product options presented in Phase 2 and might include a boiler, kiln, and packaging line allowing for the sale of kiln-dried and bundled firewood.

Phase 4: Major-scale operation—integrates several technology lines to produce wood briquettes, biochar, and salable heat, in addition to pulp chips, seasoned and kiln-dried bundled firewood, and hog fuel with an increase in production facilities.

Satellite Chipping Operation

The facility is designed to process 5,000 to 10,000 bone-dry tons (bdt) per year of low grade logs into pulp chips. Unprocessed bark and other residuals are collected for sale as hog fuel or pellet/particleboard furnish.

In its simplest form, the physical plant consists of a truck scale, yard area to deck the logs, a mobile chipper with flail debarker, a front-end loader, and a van loading station. The economics work best when operated as a satellite facility connected to a larger operation that already owns the mobile chipper and loader, and can provide operating and management personnel as needed on a part-time basis.

Logs would be delivered, sorted, and decked by self-unloading log trucks. The chipper and loader would be brought to the site periodically, when log inventory is sufficient to warrant economical operation, to make and ship chips and hog fuel.

Here's how the Biomass Enterprise Economic Model estimates the economics of a 10,000 bdt/year facility:

Capital Establishment Cost: $874,000

Annual Revenue: $880,000

EBITDA: $162,000

Pulp Chips and Seasoned Firewood Production

The facility is expanded to process 10,000 to 20,000 bone-dry tons per year of low-grade logs. Downfall from the operation is accumulated and sold as hog fuel. The ratio of pulp chips to firewood can vary with market conditions and log/species suitability.

The operation might employ a small permanent staff, but is most efficient when management and maintenance is shared with a larger organization. It should be equipped to handle logs with a mobile loader, buck them to length, and direct them to appropriate sort bins and processing lines. The chipper line could include a debarker, disk chipper, and various conveyors and controls for automatically feeding logs and transporting unscreened pulp chips to an overhead truck bin for load-out and sale.

The firewood line would include log in-feed conveyors, an automated processor for bucking and splitting, and a discharge conveyor to baskets or a pile for hand-stacking on racks or pallets, then transferred to covered storage for seasoning prior to sale. Additional conveyors would collect and deliver bark and downfall to a size-reduction hog, and on to a pile for load-out and sale.

Here's how the Biomass Enterprise Economic Model estimates the economics of a 20,000 bdt/year facility:

Capital Establishment Cost: $3,790,000

Annual Revenue: $1,895,000

EBITDA: $156,000

Pulp Chips and Kiln-Dried, Bundled Firewood Production

The facility is expanded to receive 20,000 to 50,000 bone-dry tons per year of low-grade logs, converting them to pulp chips, seasoned and kiln-dried firewood, and hog fuel. The permanent staffing level increases from 3 or 4 to about 12 employees, and can now be run efficiently as a stand-alone business. The full facility could operate on a 5-day per week schedule, one or two shifts per day.

The mobile log and material handling fleet is expanded to serve an expanded log bucking line, with multiple sort bins, decoupled from the chip and firewood processing lines. A small hog fuel boiler/gasifier could be added to use the self-generated waste wood and bark to make steam for the firewood kiln. The kiln could be used to dry and sanitize the firewood, allowing it be bundled for sale outside the region. It is estimated that 40 to 50 percent of the biomass logs by weight could be processed into pulp chips, 20 to 30 percent into seasoned firewood for local markets, and 20 to 30 percent into bundled firewood for sale to urban markets, along with 15 to 20 percent hog fuel.

Here’s how the Biomass Enterprise Economic Model estimates the economics of a 50,000 bdt/year facility:

Capital Establishment Cost: $10,726,000

Annual Revenue: $5,184,000

EBITDA: $1,108,000

Integrated Operation

This expands on Phase 3 to receive 50,000 to 150,000 bone-dry tons per year in the form of both low-grade logs and field-processed slash (tops and branches). It could operate as a stand-alone enterprise with a permanent staff of about 20 employees including managers, operators, maintenance specialists, and laborers. To operate most efficiently, the boiler and biochar systems would run on a fairly continuous basis, and the various other production lines will schedule shifts as material supply and market demand warrant.

The facility could be equipped to sort out some higher grade logs for resale, and have sufficient combustion capacity to be able to sell thermal energy as steam or hot water to other nearby operations. It would have the flexibility to adjust the product mix to match market demands. With inputs of 80 percent logs and 20 percent field-ground tops and branches (slash), a good balance of salable product outputs fall in the ranges of 20 to 40 percent pulp chips, 5 to 10 percent grade logs, 20 to 40 percent kiln dried or seasoned firewood (sold either bundled or as cords), 5 to 20 percent briquettes, 5 to 20 percent biochar, 5 to 10 percent hog fuel, and 5 to 15 percent thermal energy, some of which would be used to heat the processes.

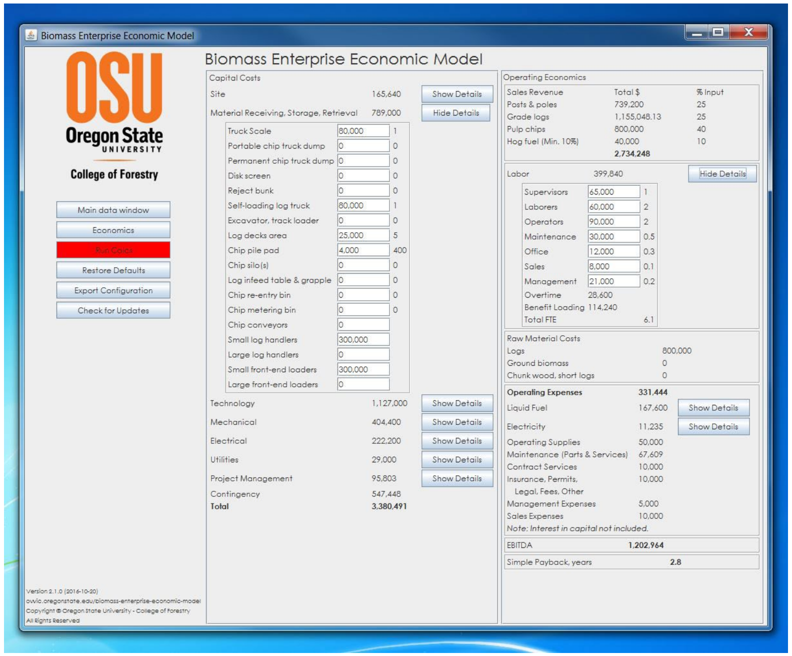
Logs would be sorted for either chipping or firewood. Sawdust and fall-down from the firewood processing line could be accumulated in a pile along with fines from the chipper. These materials, and excess chips, would be used to make briquettes and biochar. The briquette press line could produce short fire logs, packaged in boxes. The field-ground biomass would be used for making biochar, sold as hog fuel, or used internally to fuel the boiler or biochar pre-dryer. Biochar could either be densified into briquettes, or loaded into super sacks for bulk sale.

Here’s how the Biomass Enterprise Economic Model estimates the economics of a 100,000 bdt/year major-scale operation:

Capital Establishment cost: $22,421,000

Annual Revenue: $13,450,000

EBITDA: $5,843,000



The Model in Action

The kinds of operations the model can describe are limited to chip mills, fire-wood processors, small sawmills, post and pole plants, and integrated facilities making briquettes, biochar, and energy.

The key model outputs are **capital establishment costs** (how much it will cost to build the facility), **annual revenue** (using either default or user-entered sales prices), **annual operating costs** (detailed by category), **EBITDA** (earnings before income tax, depreciation, amortization), and **simple payback** (years to repay capital). The user is given flexibility to modify the capital estimate by selecting one of three “construction strategies” around used equipment, or by changing some default equipment costs to reflect currently available assets.

It should be made perfectly clear that this is NOT an optimization model. It does not determine what the “best” mix of products are to make from the available forest biomass, or what the optimum “size” of the facility should be. It simply estimates the establishment costs and annual cash flow of the enterprise as defined by the user. However, this doesn’t mean that the user can’t change the inputs and run multiple iterations to compare the economics of different configurations. Each particular configuration can be named and downloaded as a separate file. In this way, the user can explore various configuration options to see how changing capacity or product mix influences plant costs and performance.

Let’s take a look at how the model evaluates the phased approach scenarios.

At a Glance

The foregoing examples described how an entrepreneur could start small and grow a biomass enterprise to major scale over time as raw material and financial resources become available. The Biomass Enterprise Economic Model was used to estimate key economic characteristics at each stage of development. This table summarizes the details.

Plant Size		Small	Medium	Large	Major
Raw material input, bdt/year		10,000	20,000	50,000	100,000
Sales revenue (dollars)					
	Pulp chips	850,000	600,000	2,000,000	3,000,000
	Hog fuel	30,000	80,000	200,000	200,000
	Seasoned firewood	—	1,216,947	—	—
	KD firewood	—	—	1,352,163	2,028,245
	KD bundled firewood	—	—	1,634,615	3,269,231
	Briquettes	—	—	—	3,024,000
	Biochar	—	—	—	1,575,000
	Thermal energy	—	—	—	357,000
	Total revenue	880,000	1,896,947	5,186,779	13,453,476
Operating expenses					
	Raw material	500,000	1,000,000	2,500,000	4,800,000
	Labor	99,540	399,840	779,100	1,246,350
	Electricity	56	11,235	154,980	381,675
	Liquid fuel	78,240	167,600	238,160	381,120
	Operating supplies	10,000	50,000	100,000	200,000
	Maintenance supplies	17,478	75,790	214,510	448,419
	Services, permits	10,000	20,000	50,000	80,000
	SG&A	3,000	15,000	40,000	70,000
EBITDA (revenue-expenses)		161,686	157,482	1,110,029	5,845,912
Capital establishment cost (new)		873,907	3,789,523	10,725,517	22,420,948
Simple payback, years		5.4	24.1	9.7	3.8
Employees (FTE)		1.5	6.1	12.0	19.5

Estimated Economics for Biomass Enterprises

Dan Bihn

Accuracy of the Model Estimates

The Biomass Enterprise Economic Model was developed by the Department of Wood Science & Engineering and the College of Forestry at Oregon State University. It uses look-up tables and calculation logic developed through case studies of actual enterprises, equipment and service vendor input, and industry-proven estimating techniques. It has been reviewed and validated by Evergreen Engineering, Inc., Eugene, Oregon.

The accuracy of the "Capital Costs" estimate is limited by general assumptions of site-suitability and owner expertise. It is based on itemized lists of all the new equipment, buildings, services and other improvements needed to operate a viable facility with the various capabilities and scales supported by the model. It estimates and totals all the individual costs for each item, then adds a 20 percent "contingency fund" to cover unlisted items and risk. The overall accuracy of the model's estimate of the capital cost for building a **new** facility is probably within a 30 percent range of actual project costs. The model also provides selection of different "Construction Categories" to adjust the capital estimate downward through allowance for used equipment and in-house installation labor. Users can also view and edit individual cost items to allow for existing assets, or better price information.

The "Operating Economics" side of the model uses default values for product prices, wages, and salaries, and supplies. In some cases, these values can be edited by the user to reflect better market data or supply costs.

Users should accept the model outputs with caution. It is designed to give an early, high-level look at the economics of a potential project. It is useful for showing how scale and complexity influence both establishment costs and operating margin. Experience has proven that the most common reasons that projects like these fail are undercapitalization and overly optimistic performance assumptions.

Mobilizing to Create Action

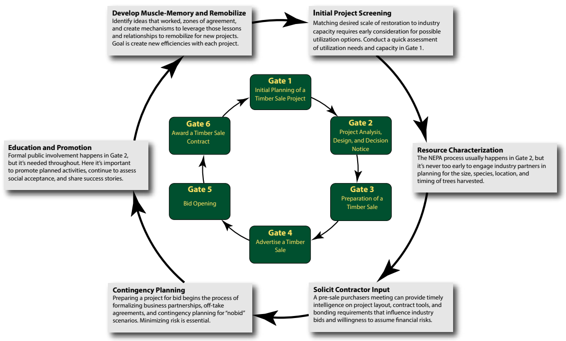
Dan Bihn

Mobilizing to Create Action

Mobilizing knowledge—of the forest, business operations, and community expectations—is the next step to realizing a sustainable business solution. Now the real work begins. Applying this knowledge to mobilize agency planning, business investments, and community assets requires patience and understanding of the processes at work. It requires understanding the decision space for collaboration and opportunities to affect outcomes.

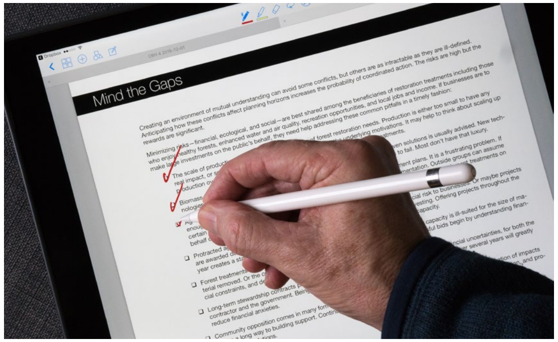
Managing community expectations, matching business and forest planning expectations, and realizing outcomes in a timely manner are not easy. But increasing awareness of business and forest planning realities can increase the chances of success. The following pages highlight agency planning processes and timelines, pitfalls to avoid, and project development outputs that can help you accomplish your objectives.

Agency Planning



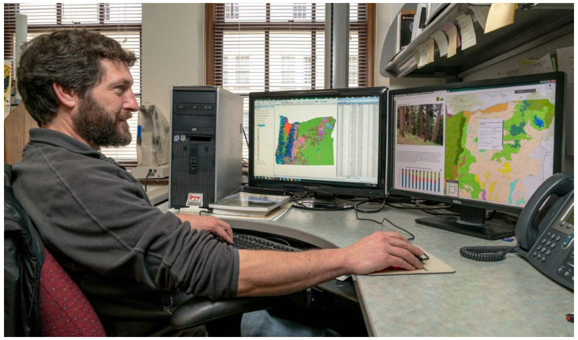
Project planning dominates federal agency thinking. Forest plans, National Environmental Policy Act (NEPA) analysis, and internal project tracking systems guide managers when designing, prepping, and implementing timber sales and forest restoration treatments. Understanding the lingo and key steps will help you navigate agency planning processes.

Mind the Gaps



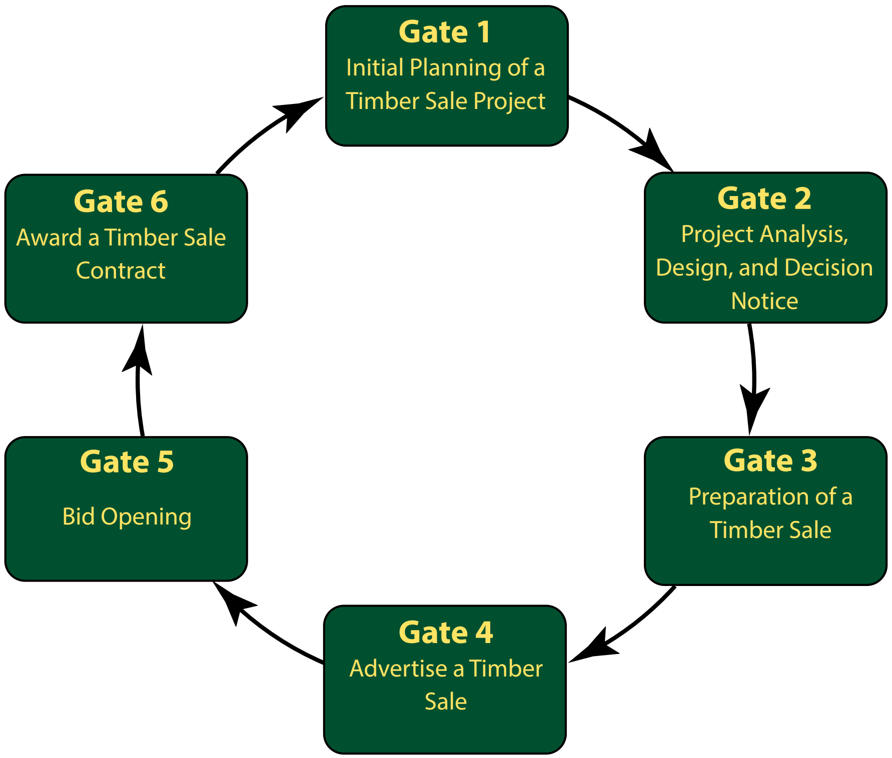
Mind the gaps because many things can and will go astray. It's inevitable given the complexity of decisions and range of interests involved. But there are things you can do to keep your project on track. Remember, time is of the essence.

Project Development Outputs



Project development outputs can range from simple lists of community assets to complex forest planning documents with geographic information system (GIS) layers and prioritized treatment plans. All are important. Identifying which outputs are needed at which stage of the process and how to mobilize action will define success.

Agency Planning



Gate System Activities for Planning Timber Sales and Forest Restoration Projects

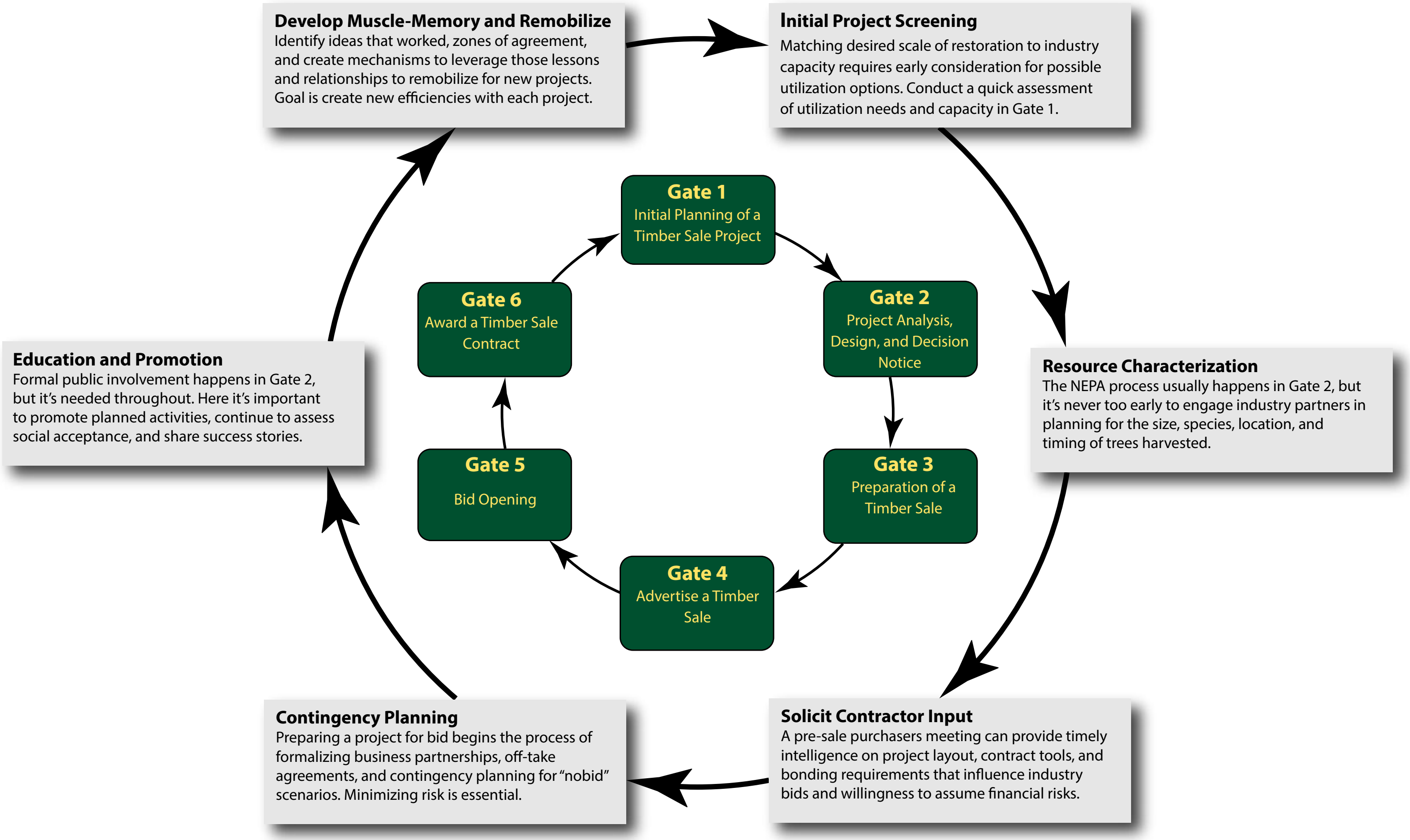
The “gate” system is an example of an internal Forest Service process used to track project planning. But as much as it’s a formal planning process, it represents points in time to actively engage business and community partners in agency planning. Procedures exist at each step that defines the decision space for collaboration and opportunities to affect the final outcome. It’s used here to illustrate how and when to engage partners in designing, preparing, and implementing projects.

Managing expectations and matching timelines is a crucial part of project planning. Businesses operate on an annual cycle defined by cash flow, market deliverables, and employee payrolls. In contrast, agency planning might require considerably more time to complete environmental analysis, draft decision documents, solicit public input, and finalize decisions. Only then is the agency able to proceed with project layout, sale, and award announcement.

And even then there is no guarantee of a successful bid, or that treatments can be implemented any time soon because of delays caused by harvest scheduling or litigation. Synchronizing project planning horizons with business investments is difficult. But increasing mutual appreciation for business and agency realities can help manage expectations and leverage action.

Partner Engagement

In the figure below, the inner circle represents the formal gate process, information required, and project planning documents produced. The outer circle represents corresponding opportunities for partner engagement and the types of information that could be solicited.



Gate No.	Gate Name	Process	Key Activities	Title of Certification Report
1	Initial Planning of a Timber Sale Project	Timber Sale Project Development	Scoping, timber sale project plan development, silvicultural exams, area logging and transportation analysis, financial and economic analysis, budgeting, scheduling, and line officer certification.	Timber Sale Project Plan
2	Project Analysis, Design, and Decision Notice	Timber Sale Project Design	Environmental, financial, and economic analysis, if needed; resource reviews; project transportation/ logging analysis; decision-making; project activity plan preparation; silvicultural prescriptions; and line officer certification.	Timber Sale Project Design
3	Preparation of a Timber Sale	Timber Sale Project Implementation	Identification of individual timber sales in the timber sale project; completion of all field layout activities; documentation of items for use in preparing appraisal, contract preparation, offering; and line officer certification.	Timber Sale Summary
4	Advertise a Timber Sale	Final Package Preparation, Review, Appraisal, and Offering	Preparation of appraisal, sample contract, bid form, prospectus, K-V plan, salvage sale fund plan, and brush disposal plan; advertisement of the timber sale; and line officer certification.	Timber Sale Report
5	Bid Opening	Bid Opening	Opening of sealed bids, conduct of auction, review bids, identification of apparent high bidder, preparation of bid abstract, and certification by Forest Officer or Contracting Officer.	Timber Sale Bid Opening
6	Award a Timber Sale Contract	Sale Award	Completion of award activities.	None

Source: Forest Service Handbook 2409.18, Chapter 10

Mind the Gaps

Creating an environment of mutual understanding can avoid some conflicts, but others are as intractable as they are ill-defined. Anticipating how these conflicts affect planning horizons increases the probability of coordinated action. The risks are high but the rewards are significant.

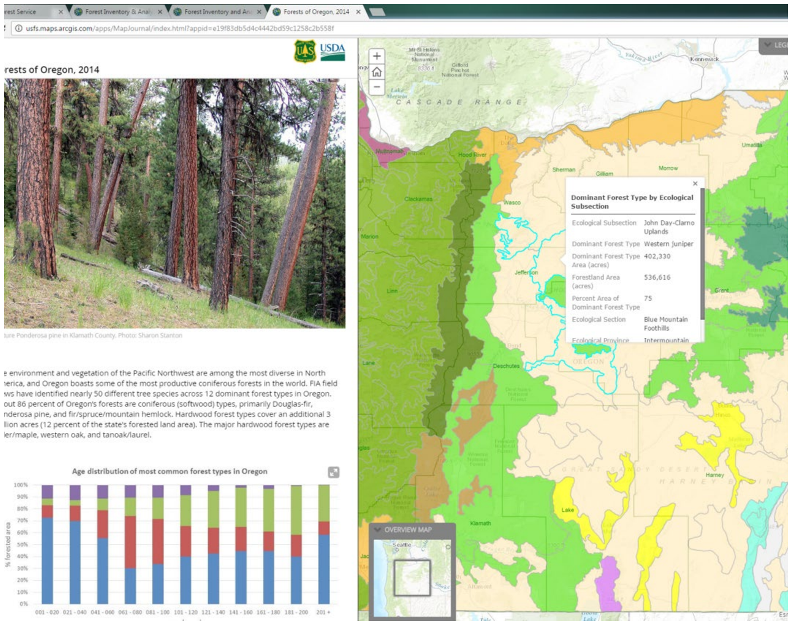
Minimizing risks—financial, ecological, and social—are best shared among the beneficiaries of restoration treatments, including those who enjoy healthy forests, enhanced water and air quality, recreation opportunities, and local jobs and income. If businesses are to make large investments on the public's behalf, they need help addressing these common pitfalls in a timely fashion:

- ❑ The scale of production is mismatched to the scope of forest restoration needs. Production is either too small to have any real impact, or so large that it triggers community mistrust in the underlying motivations. It may help to think about scaling up production over time, and leveraging cross-boundary projects to coordinate treatments.
- ❑ Biomass technology is changing fast with enticing possibilities, yet sticking to proven solutions is usually advised. New technologies often require substantial investments that are hard to come by, specialized skills, and a willingness to fail. Most don't have that luxury.
- ❑ Forest treatments aren't structured for successful bids. Maybe local wood processing capacity is ill-suited for the size of material removed. Or the cost of removing small trees exceeds the market value. Successful bids begin by understanding financial constraints, and designing projects that leverage local capacity.
- ❑ Agencies lack resources of staff, time, expertise, or budget to execute forest treatment plans. It is a frustrating problem. If enough resources were allocated for planning, there might not be enough for implementation. Outside groups can assume certain responsibilities, like states using the Good Neighbor Authority enacted in the Farm Bill to implement treatments on behalf of the federal government.
- ❑ Protracted agency planning creates uncertainty of supply, which increases the financial risk to businesses. Or maybe projects are awarded during the wrong time of the year, causing a several-month delay in harvesting. Offering projects throughout the year creates a stable flow of material necessary to build and sustain local utilization capacity. You can also consider sourcing feedstock from both public and private landowners.
- ❑ Long-term stewardship contracts provide some surety of raw material. But they are fraught with financial uncertainties, for both the contractor and the government. Being able to forecast the size and volume of trees harvested over several years will greatly reduce financial anxieties.
- ❑ Community opposition comes in many forms. Whatever the concern, transparent planning and honest evaluation of impacts will go a long way to building support. Continue to engage community members and monitor their concerns throughout project implementation and proactively find solutions.

Project Development Outputs

Dan Bihn

This handbook emphasizes the importance of matching forest resource characteristics with appropriately scaled technologies suited to local community goals and capabilities. Mobilizing partners and knowledge across these areas can leverage assets in a variety of ways. The following pages highlight key outputs of the planning process and how they can facilitate project development.

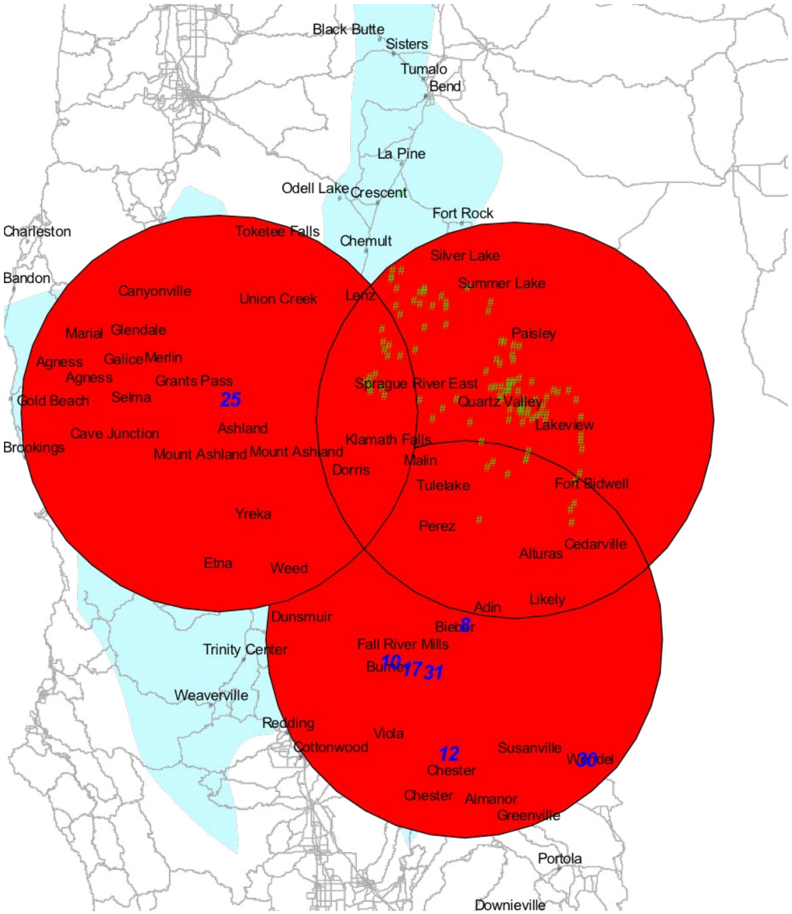


Forest Resource Planning Outputs

- ❑ GIS data layers and corresponding environmental analysis includes preliminary estimates of the volume and size of trees removed under different treatment scenarios. These documents are used in NEPA planning, but are valuable communication tools for working with potential businesses and community partners. Example tools include the ILAP and Forest Vegetation Simulator, which estimate the effects of treatment scenarios over time.

- ❑ A prioritized treatment plan can be developed once desired projects and locations are identified. Such a plan might identify the proximity of projects by ownership, scheduled treatment timelines, and related information that would help partners envision project implementation.

- ❑ Harvest plans include more detail about the volume of trees by species, size, and harvest unit. This informs harvest unit layout, sale prep, and contracting. The greater the detail the easier it is for businesses and community partners to anticipate outcomes. Example tools include the Forest Service Timber Sale Feasibility Tool, which is used to estimate project revenues and administrative cost impacts and tradeoffs by proposed treatment plan.



Technology and Product Development Outputs

- ❑ The outputs of forest planning are used by businesses to forecast harvest volumes in order to make financial decisions about the type, size, and location of processing facilities. Choice of technology, market opportunities, and product choices are layered on top of that information. These decisions might be informed by screening tools like the companion Biomass Enterprise Economic Model, engineering studies, detailed financial modeling, marketing and business plans, procurement plans for raw material supply, and sales plans. Several iterations of these plans may be required, but the goal is to decrease uncertainty and corresponding financial risks.

- ❑ On the raw material side, a number of tools are available to help estimate harvest costs. Examples include the Forest Residue Trucking Model, Machine Rate Calculator, ST Harvest, HCR Estimator, and BioSum.

- ❑ On the product development side, several marketing guides are available to help with your business planning such as the “Value-Added Wood Products Marketing Guide for Manufacturers and Entrepreneurs.”

Sustainable Community Planning Outputs

- The outputs of community planning are just as important as a business plan or NEPA decision document. County and city zoning plans dictate the types and location of acceptable industrial activity. Strategic development plans outline community investment priorities, and may include an evaluation of local assets like infrastructure (roads, utilities, water, sewer) and workforce skills. This information is critical for prospective businesses.

- A community outreach plan is another important output. An effective plan addresses concerns about the scale of operations both at the wood processing facility and in the woods. It's an opportunity to formulate messaging for different audiences, create outreach materials, and solicit feedback throughout project planning and implementation.

- A monitoring plan will evaluate agency and business actions. In the community, it can help answer questions about the number of jobs created, level of pollution generated from wood processing, traffic impacts, and overall social and economic impacts. In the woods, a monitoring plan can track changes in fire risk, and ecological impacts to riparian areas and forest health. Most importantly, a monitoring plan provides information that can guide future forest treatments and community actions.

Pacific Northwest Research Station

Website	http://www.fs.fed.us/pnw/
Telephone	(503) 808-2592
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890