NASP IMDS Economics Module: Pre-course review
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Hello all! I look forward to seeing you this fall, and I am excited to talk about economics. I know this might sound strange, but it was my love of forests that got me interested in economics. We have a lot to cover in just two short sessions, so this document is a bit of a head start. You may not have thought about these concepts since school – or maybe you use them all the time. We will cover these together, but a refresher beforehand will enable us to move faster through what we need to cover.

The learning objectives for the 2-day economics section of the IMDS module are:

1. Understand the basic principles of investment analysis and related decision criteria, and how they are used in forest management and planning;
2. Practice working through calculations related to investment analysis in forestry;
3. Understand how these techniques can be used to compare different management or silvicultural prescriptions;
4. Be familiar with SEV/LEV and understand its history in even-aged forest management;
5. Understand the many ways to think about values that forests provide, both market and non-market;
6. Understand the role that cost-benefit analysis can play in forest management and policy; and
7. Consider the multiple values and trade-offs at stake in management of complex forest systems.

As you review this guide, feel free to access any standard Forest Economics textbook to refresh your memory or help explain things. A free option is:

- Bullard, Steven H. and Straka, Thomas J., "Basic Concepts in Forest Valuation and Investment Analysis: Edition 3.0" (2011). *Faculty Publications* 460. Available at: https://scholarworks.sfasu.edu/forestry/460. This book walks through calculations step-by-step, but is short on broader economic concepts.

Other options:

- Davis, L.S., K.N. Johnson, P.S. Bettinger, T.E. Howard. 2001. Forest Management: to Sustain Ecological, Economic, and Social Values, 4th Ed. Boston: McGraw-Hill. Chapter 7, and pp 490-499.
- Klemperer, W.D. 1996. Forest Resource Economics and Finance. New York: McGraw-Hill. Chapters 5 and 6.
- Zhang, D. and P.H. Pearse. 2011. Forest Economics. Vancouver B.C.: University of British Columbia Press. Chapter 3.

On the last page of this handout are exercises to try. Please complete them before class. We will go over all the steps in class, so don't worry if you have questions – just give it a try.

Investment analysis

Investment analysis is a widely used and powerful tool in all kinds of financial decision making, including forestry. It can look and seem complicated, but it builds off basic blocks that we use without thinking all the time. For example: Suppose you put $100 in the bank at a 3% annual interest rate. How much will be in the account in a year? Maybe you can easily answer, $103. That is simple compounding. It is the foundation for investment analysis and the formula looks like this:

$$V_t = V_0 * (1 + r)^t$$

Where: V_t = value at time t

V_0 = value at time zero (now)

r = interest rate[1]

t = time

In other words, your value at time zero (now) is what you put in the bank, $100. Your interest rate is 3%, or 0.03. So your value in one year, when Vt = 1, is $100 * $(1.03)^1$ = $103.

That is the formula for simple compounding or *future value* formula. It answers the question: what is the *future value* V_t of a current single payment or return V_0? If we re-arrange it to isolate the value at time zero, we arrive at the formula for simple discounting, or *present value*:

$$V_0 = \frac{V_t}{(1 + r)^t}$$

This is used to tell us what *the value to me today* is of a *future payment of amount* V_t.

We use both of these formulas extensively in forestry investment analysis. Another concept widely used is yet another re-arrangement of the same formula to isolate r, the interest rate. In this case, we might be interested in knowing what the rate of return, or the *rate of value growth*, is between a current value V_0 and a future value Vt (can you think of a forestry application?).

$$r = \left(\sqrt[t]{V_t/V_0}\right) - 1$$

[1] If you review various textbooks, don't get hung up on differences in notation. Some use i for interest rate rather than r. Just focus on the structure of the formulas and compare what each element is doing.

Summary:

Simple compounding / future value formula: what is the value tomorrow (V_t) of a one-time payment now (V_0)?

$$V_t = V_0 * (1 + r)^t$$

Simple discounting / present value formula: what is the value to me today (V_0) of a one-time payment in the future (V_t)?

$$V_0 = \frac{V_t}{(1 + r)^t}$$

Internal rate of return formula: what is the rate of value growth between a value now (V_0) and a value in the future (V_t)?

$$r = \left(\sqrt[t]{V_t/V_0}\right) - 1$$

Examples:

1. You borrowed $10,000 from a relative to fund your school pursuits. You agree to pay them back at the end of 5 years at an interest rate of 3.5%. How much will you pay overall?
   I need to know the value of this $10,000 payment 5 years into the future, with a 3.5% interest rate: future value or simple compounding.

$$V_t = V_0 * (1 + r)^t$$
$$V_t = \$10{,}000 * (1.035)^5$$
$$V_t = \$11{,}877$$

2. You are thinking of buying a 30-acre stand of 20-year-old Doug-fir. You plan to sell the land and timber in 25 years, when the volume will be 35 mbf/acre. You think you can sell the timber for $350/mbf and the land for $500/acre. Assuming a discount rate of 5% (the rate of return you could get in your next best investment), what is the maximum you are willing to pay today for that land?
   Here you need to know what the present value, value to you today, is of a future revenue (what you'll get when you sell the trees and land).

$$V_0 = \frac{V_t}{(1 + r)^t}$$

$$V_0 = \frac{((35\frac{mbf}{acre} * \frac{\$350}{mbf}) + \frac{\$500}{acre}) * 30\ acres}{(1.05)^{25}}$$

$$V_0 = \$112{,}953$$

3. If you buy a cabin in the woods for $50,000 and sell it after 5 years for $75,000 (net of taxes and any other costs), what was the rate of return on that investment?

$$r = \left(\sqrt[t]{V_t/V_0}\right) - 1$$
$$r = \left(\sqrt[5]{\$75{,}000/\$50{,}000}\right) - 1$$
$$r = 0.0845, 8.45\%$$

Many types of financial analysis can be run with variations on these very simple formulas. Some specific situations have formulas pre-calculated that saves us the trouble of running them over and over again. The equation tree on the next page shows these formulas.

a = payment or revenue
n = frequency of occurrence of the payment or revenue
t = time frame; when the last payment/revenue occurs

1. Is there only one payment? Yes = go to 1a. No = go to 2.
    a. Do you want to know the future value of a payment today?
       Use the future value, or simple compounding formula.

    b. Do you want to know the present value of a payment that will occur later?
       Use the present value, or simple discounting formula.

2. Do the repeating payments occur every year? Yes – n = 1, you have an annual series, go to 2a. No – n > 1, go to 3.
    a. Do the payments go on forever? Use the present value of a perpetual annual payment formula (there is no future value formula, since they never stop!)

    b. If the payments have an endpoint, you can calculate either the present value or the future value of that terminating series of annual payments. The last payment is at the end of the t^{th} year.

3. Repeating payments that occur at some frequency other than annual: you have a periodic payment.
    a. The payments go on forever: again, you can calculate the present value of that perpetual periodic series.

    b. The payments end: you can calculate either the present value or future value of that terminating periodic series.

The **present value of a perpetual periodic series** is used extensively in forestry. It can tell us the value today of an infinite series of forest rotations, when payment amount a is the net revenue of one rotation.

Equation Tree

1) Single	payment at one time		Future Value	$V_t = V_0 * (1+r)^t$	Simple Compounding
			Present Value	$V_0 = \frac{V_t}{(1+r)^t}$	Simple Discounting
2) Series	payment every year (n = 1)	Forever	Present Value	$V_0 = \frac{a}{r}$	Perpetual Annual
		End in t years	Future Value	$V_t = \frac{a[(1+r)^t - 1]}{r}$	Terminating Annual FV
			Present Value	$V_0 = \frac{a[(1+r)^t - 1]}{r * (1+r)^t}$	Terminating Annual PV
3) Series	payment every n years	Forever	Present Value	$V_0 = \frac{a}{(1+r)^n - 1}$	Perpetual Periodic
		End in t years	Future Value	$V_t = \frac{a[(1+r)^t - 1]}{(1+r)^n - 1}$	Terminating Periodic FV
			Present Value	$V_0 = \frac{a[(1+r)^t - 1]}{[(1+r)^n - 1] * (1+r)^t}$	Terminating Periodic PV

V_0 = value today (t = 0)
V_t = value at time t
r = annual discount rate, interest rate, alternative rate of return
t = length of time horizon in years
a = amount of recurring payment, cost, or revenue
n = number of years between payments

Investment Analysis Criteria

These are guidelines for using investment analysis to guide decision making. Each is slightly different, with different applications.

Net Present Value (NPV) = present value of benefits – present value of costs

Rule: Do investments for which NPV > 0. If you have multiple alternatives with an NPV > 0, you can choose the one with the highest value. This criterion is appropriate for comparing mutually exclusive investment alternatives because it tells you which alternative will yield the highest return for a fixed resource. In forestry, that fixed resource is the land, and you want to select the silvicultural regime that generates the highest value per acre for a site. To calculate NPV, you use a discount rate that represents you next best alternative rate of return – i.e., what else you could invest your money in.

Benefit-Cost Ratio (BCR) = present value of benefits ÷ present value of costs

Rule: Do investments for which BCR > 1. This criterion is often used by government agencies because they often considering an array of investments, but have a fixed budget. When you have a fixed budget, choosing the projects with the highest BCR will yield the highest overall return to your budget. Like NPV, BCR assumes you use a discount rate that represents your next best alternative rate of return.

Internal Rate of Return (IRR) = the discount rate such that, the present value of the benefits just equals the present value of the costs.

Rule: Do investments for which IRR > r, your next best alternative rate of return. Corporate investors often prefer IRR because it allows them to compare forestry investments to an array of alternative financial investments that vary in risk. One reason that TIMOs are popular now is that, although forestry yields a modest rate of return on average, it's safer than many other investments. Trees just keep on growing…and over the long-run, timber demand is tied to population and income, which is generally rising over time, which is safer than many other things.

IRR is tricky to compute for all but the very simplest investments – those with a current cost and either a one-time future revenue or a perpetual annual series of revenues. Anything but that might require computer algorithm to solve.

If an investment passes one criterion, it will always pass the other two.

Using investment analysis in decision making

Example 4: a yes/no decision using criteria:

You plan to plant a stand of trees at a cost of $200/acre, then sell the trees in 10 years for $1000/acre. Your alternative rate of return is 4%. Should you invest your money in this way or in your alternative option? Your cost is today, but the benefit is in 10 years' time – this needs to be discounted to today in order to combine with the cost.

$$NPV = \frac{\$1{,}000/acre}{1.04^{10}} - \frac{\$200}{acre} = \frac{\$476}{acre} \qquad NPV > 0 \qquad \text{Do it!}$$

$$BCR = \left(\frac{\$1{,}000/acre}{1.04^{10}} \Big/ \frac{\$200}{acre} \right) = 3.38 \qquad BCR > 1 \qquad \text{Do it!}$$

$$IRR = \sqrt[10]{\frac{\$1{,}000}{\$200}} - 1 = 17.5 \qquad IRR > r \qquad \text{Do it!}$$

You can compare between different alternatives, including between more complicated silvicultural regimes, by calculating the NPV of each. This will tell you two things: whether or not to do any one regime (e.g., is the NPV > 0), as well as which one to do (highest NPV). Economics makes comparing between management regimes easier by accounting for the time preference of money, and what else you could be doing with your money, through the use of the discount rate. Otherwise, it's hard to compare a management regime with an intermediate payout but less income at the end (e.g., one with a commercial thinning) to a plan with a delayed, but larger, final harvest (e.g., even-aged clearcut without intermediate treatment).

Below is a break down of calculating NPV of a possible management regime. Assume the land is bare right now and you will be keeping the land in forestry – in other words, we are considering a stream of infinite future rotations on the land and trying to assess which management regime is best. Prescriptions that involve harvests on a regular schedule, whether uneven-aged or even-aged systems, can take advantage of the perpetual periodic series equations to make these calculations.

Note that all costs and revenues here are in $/acre. It's important to keep track of what units you are calculating to be sure you end up with the number you want – whether per acre or the total amount for a stand (like example 2 on page 3).

Example 5: calculating the NPV of an even-aged management regime

Revenues in $/acre	Annual hunting lease payments	$1.25
	Thinning in year 15	$175
	Harvest in year 25	$750
Costs in $/acre	Site preparation in year 0	$25
	Planting in year 1	$20
	Release in year 3	$15
	Annual costs (taxes, management)	$1.50

Assume a discount rate of 7%

To calculate the net present value of this rotation in perpetuity, we can first pull out the annual payments, because the equation for the present value of a perpetual annual series is really easy: the payment / interest rate. Since we want the net and both are in per acre units, we can just combine the hunting lease (revenue) and the annual cost together:

$$\frac{a}{r} = \frac{\$1.25 - \$1.50}{0.07} = -\$3.57\ per\ acre$$

For the remainder, we are thinking about this as a perpetual series of rotations, but we have costs and revenues occurring at many points in time. We need to move all intermediate costs/revenues to the end of the rotation (year 25) using *simple compounding*. That then is our net payment at time t, and we can then use the perpetual periodic series to know the NPV of that stream of rotations:

$$\$750 + (\$175 *\ 1.07^{10}) - (\$25 *\ 1.07^{25}) - (\$20 *\ 1.07^{24}) - (\$15 *\ 1.07^{22}) =$$
$790.65/acre

That $790.65/acre is the value at time t of that entire rotation. Now we can use that value as our periodic payment (an infinite series of rotations):

$$\frac{a}{(1+r)^t-1} = \frac{\$790.65}{(1.07)^{25}-1} = \$178.58/\text{acre}$$

Now we have the present value of both the annual and the periodic series in dollars per acre, so they can be directly combined:

$$NPV\ of\ this\ regime = \$178.58 - \$3.57 = \$175.01/acre$$

Don’t worry if your numbers are a few cents different. Depending on how you calculate this, whether in multiple steps or all as one (with careful parenthesis) in your calculator, there may be slight differences due to rounding.

Non-Market Values and opportunity costs

Forests provide many, many values to society. Only a few are market values, things that are traded in a marketplace and thus have a price; many more are non-market. Public forests in particular are often explicitly managed for both market and non-market values. So how can you compare management that incorporates both? Estimating non-market values is a whole field within economics that we will only barely touch on here. But, you can use NPV as a way to at least estimate the opportunity cost of providing non-market values in forestry. For example, suppose the NPV of a timber fiber focused management regime is $675/acre. You can then calculate the NPV of a management regime that incorporates aesthetic values through longer rotations and only partial harvests, and compare the two. If the aesthetic regime NPV is $450/acre, the opportunity cost – or the revenue foregone to provide aesthetic values – is $675 - $450 = $225/acre. Determining the actual value to people of the improved aesthetics is more difficult, but from a social efficiency standpoint, you would do the aesthetic regime if society valued the improved aesthetics at least $225/acre.

Prices, discount rates, and data…

How do you run your own analysis? FVS will give you yield data, but you still need to estimate prices and determine a discount rate to use. Private companies will usually have their own guiding rate, but public land rates tend to be lower (we'll discuss more in class). For prices, the information available tends to vary by state. Some starting points:

www.census.gov – there's an enormous amount of data available through the U.S. Census Bureau. Finding what you're looking for can often be a bit tricky, but the "Surveys & Products" tab can get you to the Economic census, the Survey of Manufactures, and the American Communities Survey.

www.bls.gov – Bureau of Labor Statistics is the place for inflation indices, and employment and wage information.

http://www.fao.org/faostat/en - the Food and Agriculture Organization of the United Nations has data on land use and trade for agriculture and forestry, for countries around the world.

https://www.fs.fed.us/research/rpa/ - every ten years, the US updates the state of the forests in the U.S., along with projections of future wood markets and timber harvest.

https://www.srs.fs.usda.gov/econ/timberprices/ - The Southern Research Station has links here to state agency reports of timber prices (sometimes these are stumpage, sometimes mill gate or pond prices).

Pre-work practice problems – do these before our first class on Monday, September 11th. Write out all the steps. Try your best and don't worry if you can't get them all perfectly right. The answers are in parentheses to help you. It might take a few tries to get the process down!

1. You have $1,000 which can be invested at an interest rate of 5.5%. What till this be worth in 10 years? ($1,708)

2. If you loan a friend $300 for 6 years at 10% interest (they must be desperate!), how much will you receive if the interest is compounded annually? ($531)

3. You have a pine plantation that will be worth $8,000 in 5 years. At 9% interest, would you sell it today for $6,000? (PV = $5,199, sell it)

4. If you have a woodlot worth $255/acre now, that is expected to increase to $865/acre in 10 years, what is the anticipated annual rate of return? (13%)

5. A 40-acre Christmas tree plantation produces $2,500 of net revenue per acre at the end of every 8-year rotation. At 10% interest, what is the present value of five rotations? ($85,512)

6. A 100-acre stand of 50-year-old Douglas-fir is expected to yield $1,450 of net revenue at rotation age (60 years) and every 60 years thereafter If the interest rate is 7%, what is the present value? ($750)