

September 2019

The learning objectives for the economics section in the IMDS module are:

1. to gain an understanding of basic principles as the basis for understanding financial implications/decisions in forest management.
2. to understand economic principles and evaluate economic efficiency at the project level and the appropriate analysis at the Forest Planning level.
3. to gain familiarity with application of tools and modeling techniques. This includes basic economic principles such as supply and demand, interest rates, discount rates, NPV, IRR, BCR, financial and economic efficiency, tools for economic analysis and evaluating alternatives, tradeoff analysis and opportunity costs of no action, integrating biologic, economic and social issues.

There is a lot to cover in the two sessions we have for economics. Plan to hit the ground running.

This packet is a preview of some of the material that we will cover in the IMDS economics module. It may have been many years since you learned this material in your undergraduate forestry programs. For some of you, this may be entirely new material – particularly if your degree was not in forest management. If that is your situation, you may find the following references helpful as you work through this packet:

Online (*free*) Textbook:

Bullard, Steven H. and Straka, Thomas J., "Basic Concepts in Forest Valuation and Investment Analysis: Edition 3.0" (2011). *Faculty Publications*. Paper 460. (<http://scholarworks.sfasu.edu/forestry/460>)

Textbooks:

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 Pearse, P.H. 2011. *Forest Economics*. Vancouver, BC: University of British Columbia Press. Chapter 3.

On the last pages of this handout, you will find a “pre-work” assignments. They are due on Monday, September 16th.

Good luck and see you in September!

If you have questions as you work through this packet, please feel free to contact me by email at olli-pekka.kuusela@oregonstate.edu

Simple compounding or **future value equation** → Use this equation to answer the question “If I invest (or borrow) some amount of money **today**, V_0 , in an asset (or loan) that earns an annual average or interest rate of $r\%$, how much money will it be worth (or will I have to pay back) at the **end of t years**, V_t ?” Note: write $r\%$ in decimal form so $6\% = 0.06$

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

*Pr. (1) You borrowed **\$10,000** from an aunt to pay off your school loans. You agreed to pay her back at the end of **5 years** plus interest of **3.5% per year**. How much must you pay her? (answer \$11,879)*

*The simple compounding equation can be manipulated to answer other types of questions as well. For example, use **simple discounting** or **present value equation** to answer the question “What is the most you would be willing to pay for an asset today, V_0 , that will be worth some amount of money, V_t , at the end of t years if your next best alternative is to invest that money in an asset that earns $r\%$ per year in interest?”*

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

*Pr. (2) You are thinking of buying a **30-acre** stand of 20-year-old Douglas-fir today. You plan to sell the timber and land in **25 years**. At that time, the standing volume of timber will be **35 mbf per acre**. You think that you could sell the timber for **\$350 per mbf** and the land for **\$500 per acre**. Using an alternative rate of return of **5%** (discount rate), what is the highest price you would be willing to pay today for this land and timber? (\$112,953)*

You can also use this equation to compute **internal rate of return** (IRR) for a very simple investment that involves a cost today, V_0 , and a one-time single sum pay-off, V_t , in t years. That requires that you solve the simple compounding equation for r .

$$\text{Step 1: } (1 + r)^t = V_t/V_0$$

$$\text{Step 2: } 1 + r = \sqrt[t]{V_t/V_0}$$

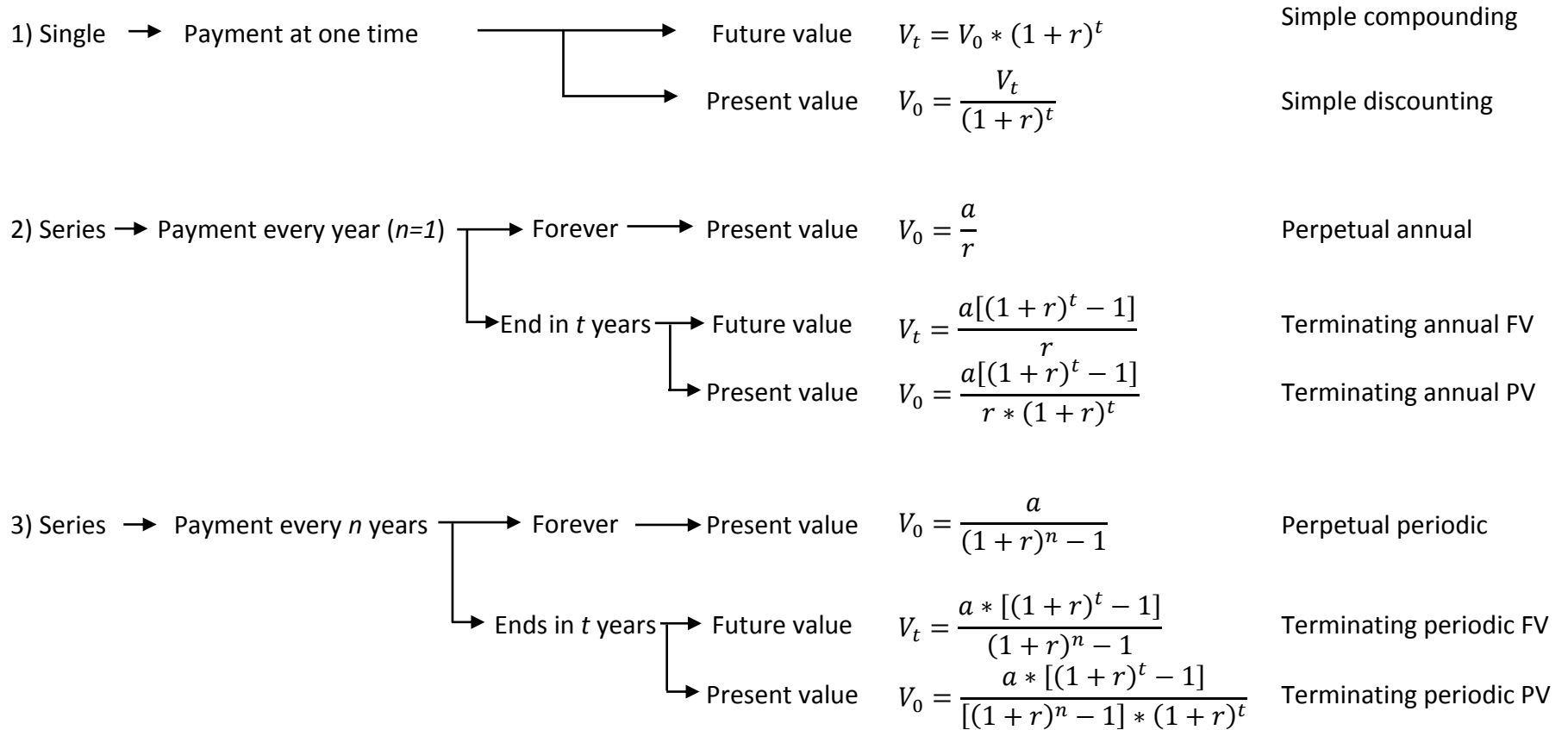
$$\text{Step 3: } r = \sqrt[t]{V_t/V_0} - 1$$

*Pr. (3) You have **\$50,000** that you want to invest. You are thinking of purchasing some real estate in Montana as an investment that you expect to be able to sell for **\$75,000** net of taxes and other land holding costs at the end of **5 years**. What is the annual rate of return on that real estate investment? (assuming that you get no recreational or other benefit from owning the land) . (8.45% per year)*

You can also use the simple discounting equation to answer the question “How long will it take for a \$5000 asset to be worth \$10,000 if it earns an average annual rate of return of 7% per year?” This is a little more complicated, but just so you can see it:

$$V_t = V_0(1 + r)^t \Rightarrow \ln(V_t/V_0) = t \ln(1 + r) \Rightarrow t = \frac{\ln V_t/V_0}{\ln(1 + r)} = \frac{\ln 2}{\ln 1.07} \approx 10.2$$

Equation Tree



V_0 is the value today ($t = 0$).

V_t is the value at time t .

r is annual discount rate, alternative rate of return, interest rate.

t is length of time horizon in years.

a is amount of recurring payment, cost, or revenue.

n is the number of years between payments.

Series Equations: The simple compounding equation can also be manipulated so that it can be used to compute the present or future value of series of payments (or revenues) that recur over constant intervals. These equations are summarized in the equation tree on the previous page. To use it, let a be the constant payment or revenue that recurs every n years. The last payment occurs in t years. To use this tree, ask yourself a sequence of questions:

1. **Lump Sum:** Is there only one payment? If yes, answer next the question. If no, go to (2). If there is **one** payment, t is when the future payment occurs.
 - a. If you want to compute a **future** value of a payment today, use **simple compounding**.
 - b. If you want to compute the **present** value of a single payment in t years, use **simple discounting**.
2. **Series:** Do the payments occur every year? If yes, the series is **annual** and $n=1$. This makes the series equations a lot simpler. If no, the payments are **periodic**. Go to (3).

Do the payments go on forever? If yes, (e.g. annual property taxes) there is no “last payment” and the equation is a perpetual annual series. There also is no “future value” since it goes on forever, so there is only a present value equation. This is the simplest equation of all!

Do the payments stop at some time in the future? If yes, the last payment is at the end of the t^{th} year.

- a. You can compute the present value to answer the question “How much money would I need to put in the bank today at $r\%$ interest in order to make t annual payments of a dollars?” You can also answer the question “How much money should I invest each year, a , in a retirement account earning $r\%$ so I can retire in t years with a nest egg of V_t ?”
- b. Or you can compute the future value to answer the question “How much money will I have at the end of t years if I put a dollars in the bank at the end of every year earning $r\%$ interest?” Or “What will my annual payments be on a t -year loan of V_0 if the lending rate is $r\%$?”

3. If the payments occur every n years, the series is periodic.

Do the payments go on forever? If yes, there is no “last payment” and the equation is a perpetual periodic series. There also is no “future value” since it goes on forever, so there is only a present value equation.

This equation is very important in even-aged forestry. It is the basis of the famous “Faustmann equation” for determining optimal rotation length. When it is applied to compute the value of land in even-aged forest management, it is known as the land expectation value (LEV) equation.

Do the payments stop at some time in the future? If yes, the last payment is at the end of the t^{th} year. If you have 5 payments that occur every $n=6$ years, the last payment is at the end of $t=30$ years.

- a. You can compute the present value to answer the question “how much money would I need to put in the bank today at $r\%$ interest in order to make payments of a dollars every n years for t years?”
- b. Or you can compute the future value to answer the question “how much money will I have at the end of t years if I put a dollars in the bank at the end of every n years earning $r\%$ interest?” These are the most complicated of the series equations.

Investment Analysis Criteria

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

Rule: Do investments for which $NPV > 0$. This criterion is appropriate for comparing mutually exclusive investment alternatives because it tells you which alternative will yield the highest return to the fixed resource. In forestry, that is the land and you want to select the silvicultural regime that generates the highest value per acre for a site. NPV assumes that you select a discount rate that represents your next best alternative rate of return (i.e. the opportunity cost of capital)—you can invest unused resources elsewhere and earn the discount rate.

- **Benefit-Cost Ratio (BCR)** = present value of benefits \div present value of costs.

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

- **Internal Rate of Return (IRR)** is the discount rate that sets the present value of the benefits equal to the present value of the costs. (Revisit problem 2 on page 2.)

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 investment instruments which may vary in risk. One reason TIMO's or “timber investment management organizations” are popular now is that, although forestry yields a relatively low rate of return on average, it is safer than most other financial instruments. That is because, during a recession, a company you buy stocks in may go bankrupt and then you will have nothing. But even though timber prices plummet, the trees are still there and, if you can be patient, timber prices will recover and the value of your investment will be restored when the economy recovers. IRR is tricky to compute for all but the very simplest investment—a current cost and either a one-time future revenue or a perpetual annual series of revenues. Most other investment streams require a computer algorithm to solve and many do not have a unique solution. We will not be using it in this workshop.

Example: You plant a stand of trees at a cost of \$200 per acre. You plan to sell the trees and land in 10 years and receive \$1000 per acre. Your alternative rate of return is 4% per year.

$$NPV = \frac{\$1000}{1.04^{10}} - \$200 = \$476/acre \qquad NPV > 0 \qquad \text{Do it!}$$

$$BCR = \frac{\left(\frac{\$1000}{1.04^{10}}\right)}{\$200} \qquad BCR > 1 \qquad \text{Do it!}$$

$$IRR = \sqrt[10]{\frac{\$1000}{\$200}} - 1 = 17.5 \qquad IIR > r \qquad \text{Do it!}$$

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

Comparing alternative silvicultural regimes

In your integrated group project, you will be asked to provide an economic analysis. To do this, compute and compare the NPV for your alternative silvicultural prescriptions. If your prescription involves repeated thinning on a regular schedule (uneven-aged management) or repeated clearcut harvest (even-aged management) you can use the equations for perpetual periodic series.

Here is an example for an even-age management regime with the following costs and revenues:

Revenue 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	\$1.50

Use a discount rate of 7%. It is best to do this in parts. Using the series equations

- 1) The annual hunting lease payments and annual costs can be computed using the perpetual annual series equation:

$$\frac{\$1.25 - \$1.50}{.07} = -\$3.57 \text{ per acre}$$

- 2) The remaining costs and revenues occur every 25 years, but they start at different points in time. The series equations assume that the first payment is at the end of the first period (in this

case, year 25). So, if you use the series equations, you must account for that by compounding all of them to year 25 before using the series equation.

$$\frac{\$750}{1.07^{25} - 1} + \frac{\$175 * 1.07^{10}}{1.07^{25} - 1} - \frac{25 * 1.07^{25}}{1.07^{25} - 1} - \frac{20 * 1.07^{24}}{1.07^{25} - 1} - \frac{15 * 1.07^{22}}{1.07^{25} - 1} = \$178.58$$

3) NPV of the site under this management prescription is:

$$\$178.58 - \$3.57 = \$175.01$$

Alternatively, you can use simple discounting in a spreadsheet. This example is shown on the next page.

Non-Market Values and the Opportunity Cost

Industrial forest companies are interested in financial costs and benefits – those that are bought and sold in markets. You, however, are managing public forests on behalf of society. There are many costs and benefits of forest management that are not only difficult (or impossible) to measure, they are also difficult (or impossible) to value monetarily because they are not bought and sold in markets. There is a branch of economics that deals with estimating nonmarket values. But the most common approach is to compute NPV for alternatives using money values and then consider the difference as a minimum value for nonmarket benefits. For example, suppose NPV is \$675 per acre for an industrial regime that maximizes financial value and NPV is \$450 per acre for a regime that produces timber but also protects some visual amenities. The “opportunity cost” of the visual amenities is \$675 - \$450 = \$225 per acre. By choosing the visual amenity regime, you forgo the opportunity to earn that additional \$225 per acre of financial value. People must value the visual amenities at least that much before it would be in the best interest of society to choose the visual regime over the timber-only regime.

Example of investment analysis in a spreadsheet

Annual				Periodic			
<i>t</i>	cost or revenue	discount factor	Present value	<i>t</i>	cost or revenue	discount factor	Present value
0	-0.25	1	-0.250	0	-25	1.000	-25.0000
1	-0.25	0.934579	-0.234	1	-20	0.935	-18.6916
2	-0.25	0.873439	-0.218	3	-15	0.816	-12.2445
3	-0.25	0.816298	-0.204	15	175	0.362	63.4281
4	-0.25	0.762895	-0.191	25	750	0.184	138.1869
5	-0.25	0.712986	-0.178	25	-25	0.184	-4.6062
6	-0.25	0.666342	-0.167	26	-20	0.172	-3.4439
7	-0.25	0.62275	-0.156	28	-15	0.150	-2.2560
8	-0.25	0.582009	-0.146	40	175	0.067	11.6866
9	-0.25	0.543934	-0.136	50	750	0.034	25.4608
10	-0.25	0.508349	-0.127	50	-25	0.034	-0.8487
11	-0.25	0.475093	-0.119	51	-20	0.032	-0.6345
12	-0.25	0.444012	-0.111	53	-15	0.028	-0.4157
13	-0.25	0.414964	-0.104	65	175	0.012	2.1532
14	-0.25	0.387817	-0.097	75	750	0.006	4.6911
15	-0.25	0.362446	-0.091	75	-25	0.006	-0.1564
16	-0.25	0.338735	-0.085	76	-20	0.006	-0.1169
17	-0.25	0.316574	-0.079	78	-15	0.005	-0.0766
18	-0.25	0.295864	-0.074	90	175	0.002	0.3967
19	-0.25	0.276508	-0.069	100	750	0.001	0.8643
20	-0.25	0.258419	-0.065	100	-25	0.001	-0.0288
21	-0.25	0.241513	-0.060	101	-20	0.001	-0.0215
22	-0.25	0.225713	-0.056	103	-15	0.001	-0.0141
23	-0.25	0.210947	-0.053	115	175	0.000	0.0731
24	-0.25	0.197147	-0.049	125	750	0.000	0.1593
25	-0.25	0.184249	-0.046	125	-25	0.000	-0.0053
26	-0.25	0.172195	-0.043	126	-20	0.000	-0.0040
27	-0.25	0.16093	-0.040	128	-15	0.000	-0.0026
28	-0.25	0.150402	-0.038	140	175	0.000	0.0135
29	-0.25	0.140563	-0.035	150	750	0.000	0.0293
Sum			-3.319				178.576

NPV = -3.32 + 178.58 = 175.26 per acre

When payments go on forever, you must decide when to stop. As you can see, the further into the future the payment is, the smaller its present value. You can stop when PV becomes so small that it is irrelevant in your current decision. For example, PV of \$750 in 150 years at $r=7%$ is less than 3 cents!

Finding and Using Forestry and Economics Data on the Web

What interest rate should you use for investment analysis? What prices and costs? The “information superhighway” has made an enormous amount of data available at your fingertips that can help you make that call.

Getting started – web sites that I find especially useful.

www.census.gov – this site is a gateway to an enormous amount of the economic data collected by the U.S. government. At this site, you will find:

- Statistical Abstract of the United States – historical summary statistics for the US.
- Census 2000 – on-line access to the census of the population in 2000 and 1990
- Economic Census – 5 year census of businesses and manufactures
- City and County Data Book and USA Counties – county, state, SMSA-level data
- American Factfinder – a quick look-up of data at zip code, city, county, state level.
- Subjects A to Z – an index of data sources for specific topics like construction, prices, employment and so on.

<https://www.bls.gov/> – Bureau of Labor Statistics publishes inflation indices among many other indicators and measures.

<http://faostat3.fao.org/home/E> – Food and Agriculture Organization of the United Nations – collects data on land use and trade in agriculture and forestry for countries of the world.

www.fs.fed.us/research/rpa/ -- projections of future wood products markets, timber harvest, and state of the forest in the U.S. produced in compliance with the Resources Planning Act of 1974.

<http://www.srs.fs.usda.gov/econ/timberprices/> – this site has links to state agencies that report timber and log prices.

Pre-work part 1 and practice problems (from Gunther J.E. & H.L. Haney. 1984. Essentials of forestry investment analysis. Corvallis, OR: OSU Press). The problems highlighted in yellow are due on **Monday September 16th**. Show all the steps that you have used to reach the correct answer. You do not have to get them perfectly right, but you should try your best. The rest of the problems are for practice. **Answers in parentheses.**

- 1) You have \$1000 which can be invested at an interest rate of 5-1/2%; what will this amount be worth in 10 years? (\$1708)
- 2) If you loan \$300 for 6 years at 10% interest, how much will you receive if the interest is compounded annually? (\$531)
- 3) Suppose we have a lease that will be worth \$500 when payment is due in 3 years. At an interest rate of 6%, what is its value today? (\$420)
- 4) You have a pine plantation that will be worth \$8000 in 5 years. At 9% interest, would you sell it today for \$6000? (PV = \$5199, sell it)
- 5) A pine plantation will yield a net return of \$1250 at the end of a 30-year rotation. How much can an owner afford to pay for plantation establishment and earn a) 5% on the investment? b) 10%? (\$289; \$72)
- 6) A house was purchased for \$30,000 and resold five years later for \$44,080. At what annual rate of growth did the house appreciate? (8%)
- 7) Suppose we have a stand of sawtimber that was valued at \$475 four years ago. Today, it is worth \$646; what is the annual rate of increase? (8%)
- 8) If we 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 increase? (13%)
- 9) At 7% interest, what is the accumulated value of \$1.50 per acre annual property taxes after 15 years? 25 years? 50 years? ((\$38; \$95; \$610)
- 10) A potential gravel pit is discovered on land owned by the XYZ company during harvesting operations. The company buys \$10,000 worth of gravel per year on the open market to maintain its network of logging roads. If the pit is opened to replace the outside purchases, what are the accumulated savings at the end of five years when the pit plays out? Assume a 9% cost of capital. (\$59,847)
- 11) Christmas tree shearing costs average \$60 per acre per year for the third through the eighth years of an eight year rotation. At 9.5% interest these costs accumulate to how much by the time the trees are harvested? Assume that the costs occur at the end of the year. (\$457)

- 12) At 11.5% interest, what is the present value of \$3 per acre annual property taxes for 15 years? 25 years? 50 years? (\$21; \$24; \$26)
- 13) The annual costs of fire protection for a red pine plantation are \$0.25 per acre. If rotation age is 80 years and the interest rate is 8%, what is the initial value of this cost series for one rotation? (\$3.12)
- 14) Hunting lease payments of \$1 per acre per year on a tract of 3,000 acres will accumulate to how much at the end of 25 years, assuming 9% interest? These payments will have a present value of how much? (\$254,103; \$29,468)
- 15) A lumber company has the option of leasing 5000 acres for grazing at \$2 per acre per year for five years or accepting an initial lump sum payment of \$40,000. At 8% interest, which is the more attractive alternative? (PV = \$39,927. Initial offer more attractive)
- 16) An ornamental variety of tree species is planted in a nursery. It is ready for marketing in 5 years after planting. Net revenue per acre at the end of 5 years is \$700. At 8% interest, what is the future value at the end of 25 years for one acre consigned to growing this variety? (\$8723)
- 17) 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)
- 18) A woodlot will produce \$1,500 of net revenue every five years. At 9.5% interest, the revenue stream from 10 cuttings has a present value of how much? (\$2,584)
- 19) What is the present value in (18) if an additional ten cuttings are included in the revenue stream? (\$2612)
- 20) Assuming an interest rate of 8%, what is the present value of an asset which yields \$60 annually? (\$750)
- 21) Property taxes on a forest are expected to be \$2 per acre per year. What is the present value in perpetuity of this liability if the interest rate is 6%? (\$33.33)
- 22) An 80 acre tract of timberland that produces \$600 of net revenue per acre every 25 years has a bareland value of how much? The appropriate interest rate is 7%. (\$10,841)
- 23) A 40 acre Christmas tree plantation produces \$2,500 of net revenue per acre every 9 years. If the interest rate is 9.5%, what can you afford to pay for it? (\$79,163)
- 24) A 40 acre tract of timberland that produces \$300 of net revenue per acre every 30 years has a present value of how much just before a crop is harvested? Interest rate is 4.5% (\$300+\$109 = \$409 per acre or \$16371)

25) 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)

26) A \$25,000 grapple loader must be replaced in 6 years; assume no salvage value. Given 6% interest rate, calculate an annual sinking fund payment. That is, how much must you put in the bank at the end of each of the next 6 years to have sufficient funds to replace the loader. To answer this, use the “future value of a terminating annual series” equation. You know V_t . You must solve for the payment amount, a . (\$3,584)

27) Assume you take out a loan to buy a loader at a net cost of \$30,000 and a 12% interest rate. What would be the annual payment to retire this loan in 5 years? Here you know V_0 . Use the “present value of a terminating annual series” equation to solve for a . (\$8,322)

Pre-work part 2: due **Monday, September 16th**.

- You **do not** have to get this right to get full credit. Just give it your best try.
- Attempt all parts of the problem. We will walk through this exercise in class on Monday.
- Show your work clearly and explain what you are doing in words.
- If you use a spreadsheet, show the equations you use and explain your work in words.

Compute the opportunity cost of implementing a “wildlife management regime” designed to accelerate the development of forest structure associated with old growth forest and maintaining it for some period of time before final timber harvest. Do it in 4 steps as follows:

1. Compute **Net Present Value** for the following industrial forest management regime. Assume that the management regime will be repeated every 50 years forever. In fact, you are computing “land expectation value” for the site using this regime. Use discount rate of 7%:

Revenue:	Commercial thin	Age 40	15 mbf/acre at \$280/mbf
	Final Harvest	Age 50	35 mbf/acre at \$475/mbf
Costs in \$/acre:	Plant	Age 0	\$165
	Release	Age 4	\$40
	Precommercial thin	Age 15	\$100
	Fertilize	Age 35	\$90

2. Compute **Net Present Value** for the following wildlife management regime. Again, assume the regime will be repeated on this site forever. Use discount rate of 7%:

Revenue:	Commercial thin	Age 30	10 mbf/acre at \$200/mbf
	Commercial thin	Age 50	20 mbf/acre at \$300/mbf
	Commercial thin	Age 70	22 mbf/acre at \$300/mbf
	Final Harvest	Age 120	80 mbf/acre at \$520/mbf
Costs in \$/acre:	Plant	Age 0	\$100

3. What is the **opportunity cost** of adopting the wildlife management regime?
4. Now do (1) through (3) using a **discount rate of 3%**. How is your answer affected by using the lower discount rate? Try to explain the difference.