<u>Place your name on the back of each sheet!</u>

SEFS 540 SP2013: Optimization Techniques for Natural Resources

Practice Midterm Test

Allotted time: 1 hr 20 mins

- This is an open-notes, open-book exam. You must work individually. Please manage your time very carefully.
- The total point value of the exam is 80 pts. Point values for individual questions are indicated in parentheses in bold. Partial credit will be given only if your work is clear and neatly organized.

---

1. Describe using your own words why we need to discount the future costs and benefits of a project to assess their present values? Please don't use mathematics. **(10 pts)**

2. What is the difference between the Land Expectation Value and Forest Value? Please explain why these concepts are useful in resource management and conservation. Please use your own words rather than mathematics. **(10 pts)**

3. On the next page (p. 3) is a linear program designed to help develop a management plan for a 5,000 acre forest. The forest consists of five age classes and two site classes, with the acreage in each analysis area listed in Table 3.1. The predicted yield per acre for each age and site class is listed in Table 3.2.

The linear program on page 3 minimizes the discounted cost of meeting certain volume production targets over a 40-year planning horizon, subject to an additional constraint on the average age of the forest at the end of the 40-year planning horizon. **Note that the variable Xsap represents the number of acres from site class s, initial age class a, that are assigned to prescription p.** For example, X231 represents the number of acres from site class 2 (Site II) and initial age class 3 (age 25 initially) that are cut in decade 1. Similarly, X320 represents the number of acres from the same initial age and site class that are not cut at all during the 40-year time period of the plan. The formulation does not allow for harvesting a given area twice during the planning horizon.

The problem minimizes discounted timber sale costs and re-planting costs. Timber sale costs are $50 per acre plus $0.10 per cord sold. Re-planting costs are $100 per acre. A real discount rate of 4% is used.

Pages 5 and 6 list the output from the LINDO LP solver. The questions on pages 3 through 4 (Questions 3.a through 6.f) test your ability to interpret the linear programming formulation of the forest management problem and its solution.

Table 3.1 Initial age-class distribution

Age Classes	Acres by site class	
	Site I	Site II
0 to 10	120	700
11 to 20	800	750
21 to 30	900	650
31 to 40	140	180
41 to 50	240	520

Table 3.2 Yield table

Age Classes	Cords per acre by site class	
	Site I	Site II
10	0	0
20	5	5
30	14	15
40	25	28
50	34	40
60	41	48
70	46	54
80	48	57

LINEAR PROGRAMMING FORMULATION FOR QUESTION 6

```
  MIN     123.2891 X111 + 83.56731 X112 + 56.79268 X113 + 38.64586 X114
       + 123.7 X121 + 84.06705 X122 + 57.20531 X123 + 38.87393 X124
       + 124.4398 X131 + 84.67784 X132 + 57.54292 X133 + 39.05133 X134
       + 125.3439 X141 + 85.17757 X142 + 57.8055 X143 + 39.17804 X144
       + 126.0836 X151 + 85.56626 X152 + 57.99306 X153 + 39.22872 X154
       + 123.2891 X211 + 83.56731 X212 + 56.8302 X213 + 38.72189 X214
       + 123.7 X221 + 84.12257 X222 + 57.31785 X223 + 39.02598 X224
       + 124.522 X231 + 84.84442 X232 + 57.76799 X233 + 39.22872 X234
       + 125.5905 X241 + 85.51073 X242 + 58.06808 X243 + 39.38076 X244
       + 126.5768 X251 + 85.95495 X252 + 58.29315 X253 + 39.45679 X254
  SUBJECT TO
         2)   X111 + X112 + X113 + X114 + X110 <=   120
         3)   X121 + X122 + X123 + X124 + X120 <=   800
         4)   X131 + X132 + X133 + X134 + X130 <=   900
         5)   X141 + X142 + X143 + X144 + X140 <=   140
         6)   X151 + X152 + X153 + X154 + X150 <=   240
         7)   X211 + X212 + X213 + X214 + X210 <=   700
         8)   X221 + X222 + X223 + X224 + X220 <=   750
         9)   X231 + X232 + X233 + X234 + X230 <=   650
        10)   X241 + X242 + X243 + X244 + X240 <=   180
        11)   X251 + X252 + X253 + X254 + X250 <=   520
        12)   5 X121 + 14 X131 + 25 X141 + 34 X151 + 5 X221 + 15 X231
           + 28 X241 + 40 X251 >=   25000
        13)   5 X112 + 14 X122 + 25 X132 + 34 X142 + 41 X152 + 5 X212
           + 15 X222 + 28 X232 + 40 X242 + 48 X252 >=   25000
        14)   14 X113 + 25 X123 + 34 X133 + 41 X143 + 46 X153 + 15 X213
           + 28 X223 + 40 X233 + 48 X243 + 54 X253 >=   26000
        15)   25 X114 + 34 X124 + 41 X134 + 46 X144 + 48 X154 + 28 X214
           + 40 X224 + 48 X234 + 54 X244 + 57 X254 >=   28000
        16)   35 X111 + 25 X112 + 15 X113 + 5 X114 + 35 X121 + 25 X122
         + 15 X123 + 5  X124 + 35 X131 + 25 X132 + 15 X133 + 5  X134 + 35
X141
         + 25 X142 + 15 X143 + 5  X144 + 35 X151 + 25 X152 + 15 X153 + 5
X154
         + 35 X211 + 25 X212 + 15 X213 + 5  X214 + 35 X221 + 25 X222 + 15
X223
         + 5  X224 + 35 X231 + 25 X232 + 15 X233 + 5  X234 + 35 X241 + 25
X242
         + 15 X243 + 5  X244 + 35 X251 + 25 X252 + 15 X253 + 5  X254 + 45
X110
         + 55 X120 + 65 X130 + 75 X140 + 85 X150 + 45 X210 + 55 X220 + 65
X230
         + 75 X240 + 85 X250 >=   175000
  END
```

a) Explain what the coefficient in the objective function on the variable X152 represents. Show exactly how it was derived (**5 pts**).

b) What is the desired minimum harvest volume for the second decade? (**5 pts**).

c) What minimum average ending age is specified in the LP for this forest? (**5 pts**).

d) Indicate the number of acres that the solution says to cut in each decade from site class I, initial age class 3 (ages 21 to 30). Also indicate the age of the acres at the time they are harvested (**5 pts**).

How many acres from this analysis area (site class I, initial age class 3) are <u>not</u> scheduled for harvest during the 40-year period?

Do not cut ________ acres

e) How much would the discounted cost of assigning one acre from site class I , initial age class 3 (ages 21 to 30) to be harvested in decade 3 have to be reduced before any acres would be assigned to this prescription (**5 pts**)?

f) By how much would it change the discounted cost of managing the forest to produce the target harvest volumes over the 40-year planning horizon (and meeting the target average ending age) if there was one more acre initially in site class II, age class 4 (age 31 to 40)? (**5 pts**)

LINEAR PROGRAMMING SOLUTION FOR PROB. 6: VARIABLE VALUES

LP OPTIMUM FOUND AT STEP 37

OBJECTIVE FUNCTION VALUE

1) 211472.20

VARIABLE	VALUE	REDUCED COST
X111	.000000	124.375200
X112	.000000	67.935010
X113	.000000	34.250830
X114	.000000	15.204920
X121	.000000	98.603360
X122	.000000	37.472860
X123	.000000	15.478080
X124	.000000	6.516393
X131	.000000	51.345480
X132	330.588200	.000000
X133	.000000	.316008
X134	69.915970	.000000
X141	.000000	23.806570
X142	140.000000	.000000
X143	.000000	19.226800
X144	.000000	26.117890
X151	123.529400	.000000
X152	116.470600	.000000
X153	.000000	34.737550
X154	.000000	48.483250
X211	.000000	124.375200
X212	.000000	67.935010
X213	.000000	32.445490
X214	.000000	11.946730
X221	.000000	98.603360
X222	.000000	33.967490
X223	.000000	10.062040
X224	628.336100	.000000
X231	.000000	56.489990
X232	.000000	.000000
X233	650.000000	.000000
X234	.000000	2.913613
X241	.000000	28.724050
X242	180.000000	.000000
X243	.000000	27.621510
X244	.000000	38.461490
X251	520.000000	.000000
X252	.000000	7.691807
X253	.000000	52.524080
X254	.000000	70.937960
X110	120.000000	.000000
X120	800.000000	.000000
X130	499.495800	.000000
X140	.000000	30.462160
X150	.000000	53.913590
X210	700.000000	.000000
X220	121.663900	.000000
X230	.000000	10.516070
X240	.000000	51.494300
X250	.000000	86.142900

LINEAR PROGRAMMING SOLUTION FOR PROBLEM 2: SLACK/SURPLUS VALUES AND DUAL PRICES

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	.000000	4.887262
3)	.000000	5.973320
4)	.000000	7.059378
5)	.000000	38.607600
6)	.000000	63.145080
7)	.000000	4.887262
8)	.000000	5.973320
9)	.000000	17.575450
10)	.000000	59.639740
11)	.000000	95.374390
12)	.000000	-5.453750
13)	.000000	-3.560883
14)	.000000	-1.842859
15)	.000000	-1.111407
16)	.000000	-.108606

NO. ITERATIONS= 37

4. Drink Unit is a 17,000 ac municipal watershed in the Deschutes National Forest east of Bend, OR. Since the Unit is the primary supplier of drinking water for the Cities of Bend and Sisters, it is important that low turbidity levels (sedimentation) are guaranteed downstream all year around. The big concern is fire. The City of Bend has had spikes in turbidity every spring and fall since the Bridge Creek Fire affected a small portion of the watershed in 1978. The fire made some of the soils unstable and during major rainfall events the City has to shut down the water intake for a couple hours to several weeks at a time if they can’t meet water quality guidelines. Further exacerbating the problem is the lack of logging activities during the last couple of decades that would have removed at least some of the fuel from the forest. The Deschutes National Forest wants you to identify a set of stands (or treatment units) for fuel removal (thin then pile slash and burn on site) to minimize fire risk in the Drink Unit. Since fuel treatments are expensive, and the Forest Service has budget constraints, only a small subset of the units can be treated. After studying the literature, you found that the maximization of total distance between treated units times the total area treated can, in effect, promote landscapes that are more resilient to catastrophic fires due to the dispersion of fuel management activities. Show how a linear integer programming model can be formulated with the above objective function. Provide clear definitions for the model variables and parameters and explain how the constraints work. **(30pts.)**