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Original Research Article

Optimal Rotation Time and Fire Risk Interaction in Mountain-Forest Ecosystems: The Case of Uludag National Park

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ABSTRACT

Natural resources are alive and inanimate beings in the physical environment and can be used for human needs. The management of each of them presents differences in the economy. The management of natural resources has many different features. Because while many features of natural resources can be explained with market prices, many features cannot be explained with market prices, and there are big problems in their use, allocation, and leaving them at least as much as they are today for next generations. Natural resources can belong to a region (forests), a country (rivers) and even the whole world (atmosphere). Therefore, natural resource management problems arise both on the country's agenda and on the world agenda; these are known as environmental problems. Forest resource management and managerial failures are important environmental problems. The aim of this study is to explain the importance of land valuation in forest management. The Faustmann approach is analyzed in current study and explains the importance of land value in forest resource management theoretically. The results of this provide implications for environmental management as well. While numerical approach explains the total value of forest resources with the forest growth function; changing rotation intervals are closely related to the success of correct environmental management. Numerical analysis of the study will be carried out for Uludag National Park, Bursa. The results of the study reveal that the policies related to urbanization, industrialization and re-determination of municipal adjacent areas in Turkey also cause important environmental problems.

Keywords: Forest management, Faustmann approach, optimal rotation, environmental economics

INTRODUCTION

Natural resource economics examines the analytical framework of the effective allocation and use of natural and environmental resources (Karacan 2007). However, there are many factors that prevent the efficient allocation of natural resources and their rational use. These factors are classified as factors arising from the characteristics of the natural resource itself and anthropogenic (caused by human beings) effects. In this context, ecosystems constitute the environment in which living beings continue their lives and interact with each other. This interaction process takes place in the accompaniment of certain cycles within certain ecosystems. Man's production, shelter, nutrition, growth and expansion, etc. efforts increase the pressure on natural resources. These pressures may be due to effects at the local level, as well as in the form of transfers from other countries or transfers from other continents. Therefore, in order to reveal the micro and macro level pressures on natural ecosystems, the values of their natural resource values within a certain time period should be analyzed. If natural resources are under the control of human beings, their pollutants, consumers and finally their managers will also be human beings. At this point, the concept of correct and rational management gains importance.

Mountainous areas that contain forest areas around the world are accepted as important regions for the continuity of the regional ecosystem (Gret-Regamey et al. 2012). The mountain and forest ecosystem supports a wide range of ecosystem services such as energy, water, food, shelter, medical reserves and cultural ecosystem services; it is a significant resource for human needs (Huber et al. 2013). With its regulatory function, it plays a role in carbon sequestration and ensuring the continuity of the hydrological cycle (Kroupova et al. 2016). In addition, these areas provide an opportunity to generate income through tourism carried out by people who come to visit to participate in cultural ecosystem services. In this direction, sustainable management principles of mountainous ecosystem areas should be put forward and various management methodologies should be developed to protect and develop their natural resources.

Mountain-forest ecosystems provide direct use and indirect use benefits to human beings. It can be said that the direct use benefit is the main forest wood supply value. Other direct use values will be of lesser value besides providing wood. Environmental services are included in the indirect use benefit. Forest management will be considered successful if the benefits that can be obtained from the forest system are maximized. Because managerial failures cause social welfare losses. Therefore, a successful forest rotation model is always needed.

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The aim of this study is to explain the importance of land valuation in mountain-forest management with a theoretical approach. As stated above, human-induced pressures on mountain-forest ecosystems are gradually increasing, and deviations from rational management occur due to increasing pressures. Uludag National Park (UNP), which is the subject of the study, is an important natural resource for Bursa province and Turkey. It contains almost all of the direct and indirect use values. However, the increasing number of visitors and administrative problems in recent years cause the expected benefits from UNP to not be achieved and social welfare losses. The population and industrial development of Bursa is a separate problem for such natural resources. Because the increasing pressures and the overvalued land value are also challenging the management of the UNP. The Faustmann approach analyzed in the study provides theoretical implications in forest resource management (Brazee 2001). With the Faustmann approach, the correct estimation of the forest rotation time, that is, the optimum rotation period, can be determined. With a certain tree growth function, the mountain-forest value per hectare is determined.

While many researchers working with the Faustmann approach mostly perform analyzes with changes in the discount rate (Koskela and Ollikainen 1997; Parks and Murray 1994; Bulte and van Soest 1996; Crabbe and van Long 1989), in this study, which is examined specifically for the UNP, land value valuation and excessive risk of forest fire due to visitor use and its reflections on the rotation periods will be examined.

In this direction, the study has expected to make important contributions to the literature. It integrates forest rotation systems and the fire risk in the natural resource valuing. Although there are many sources emphasizing forest resources value and forest rotation time, there is no study examining the effect on forest rotation time and fire risk interactions within the scope of ecological factors. Also, essential implications are made for regional decision-makers and UNP forest management.

MATERIALS AND METHODS

Many researches have been carried out on the resource values of the UNP mountain-forest ecosystem, which is the material of the research. With an area of 12 762 ha, 71% of the UNP is forest, 28% is grassland and rocky areas, 0.4% is open areas, 0.1% is water-covered areas, 0.8% is are residential areas. Uludag has a very rich habitat diversity such as woodlands, maquis, peatlands, subalpine heaths, alpine steep cliffs and open areas. There are 1320 plant species in Uludağ, which is a plant diversity center, and it is home to a total of 171 endemic species, 33 of which are Uludağ and 138 are Turkey endemics. In addition, Uludağ constitutes the habitat of 3 globally endangered species and 54 endangered species in Europe (Özhatay et al. 2003; Daşkın 2008).

The annual number of visitors to UNP is approximately 1,697,000 people, and about 75% of the visitors reach the national park through freeway and 25% by cable car. 50% of these visitors visit the national park in the summer season, 35% in the winter season, and 15% in the spring. Winter sports can be done in Uludag for an average of 4 months. Uludag is open to camping, mountaineering, hiking, picnic recreation activities in summer. UNP has two development zones. 1. there are 18 private sector tourism facilities and 12 public facilities in the Development Zone. In the 2nd Development Zone, four tourism facilities belonging to the private sector provide service. Also, there are two public facilities in Kirazlıyayla locality. There are 22 mechanical facilities (teleski-chair lifts) serving ski tourism in the Hotels Region. The tourism and public facilities in the National Park mostly serve for winter tourism. During the Summer Season, the guests can accommodate in Sarıalan and Cobankaya Camping and Day-trip Areas. Twelve country houses are serving in the summer season in the Sarıalan Camping and Day-trip Areas, and there are 300 tent camping areas (BOBM 2020).

In UNP, an area of 9 061 hectares is forest area; The area of 12 762 hectares, together with the remaining area, is a mountain-forest ecosystem(Uzel and Gurluk 2022). With the use of UNP by humans, its natural resource value is also increasing. Because, it is very important to know the total economic value together with the travel expenses made to reach the UNP, the expenses in the UNP and their non-use values. However, the annual change value in the natural resource values of the UNP changes for reasons that are not due to its ecological cycle characteristics. The fact that it is an ecosystem with excessive visitor demand and the increasing land pressure of the population in its vicinity causes the value of the land in the region to be appreciated. In addition, fire risk, which is an important risk factor other than natural disasters, constitutes the environmental problems of UNP in recent years.

The Faustmann approach made important contributions to natural resource management and especially to the economic analysis of mountain-forest ecosystems in the middle of the 19th century. Faustmann-based Hartman solution algorithm was used in forest land management in order to use the value of water resources related benefits in UNP management and make it more meaningful. Faustmann's model mainly has a single rotation and a specific tree growth function. It is predicted that the amount of lumber to be harvested will change over time as the tree grows. The beginning of the Faustmann analysis indicates the amount of lumber in the rotational age T with q(T) in m^3 form. If it is assumed that there is a homogeneous tree group in the whole tree (stand) (such an assumption will be used for UNP) Q(T) shows the whole timber amount of the stand. The nq(T) = Q(T) equation is mentioned here, where n represents the number of trees in the stand. If the initial stock amount is shown with Q_0, it can be said that this value is the Q(T) value at T = 0. The stand's timber amount is related to the growth rate of biomass α and the bearing capacity of stand K. The growth rate varies depending on whether the tree structure is thin or thick. It is known that the growth rate of thick textured trees will be lower. The carrying capacity is the maximum timber volume that the stand can support. It relies on a temperate climate, rainy season, and soil quality. Based on these data, the model was developed through the following biomass lumber volume:

$$Q(T) = \frac{K}{1 + \left[\frac{K - Q_0}{Q_0}\right] e^{-\alpha T}} \tag{1}$$

Equation 1 indicates an "S" curve that remains at low levels initially for timber biological mass and increases up to the bearing capacity level in line with the rotation age. In the model, it is assumed that price, cost and interest rate (discount rate) to be used in the analysis are fixed under a fully competitive market. In the setup of the stand, a fixed price (S) is incurred at the beginning of the rotation. However, it is then assumed that the stand grows under a natural environment without incurring any costs. Harvest costs (C) and stamping price (p) are market prices. Here, two important costs have to be included in the analysis. The first one is the interest incomes that the expenses incurred for the stand during the growth period will be lost until the product is harvested. This cost will increase as the rotation interval becomes longer. This opportunity cost is reflected in the model with an interest rate (r). Naturally, the present value of the T-aged stand can be brought up to date with a reduction factor (e^{-rT}). The initial planting cost, S, is not subjected to reduction. At this point, the equation giving the net present value of harvested stand in T rotation length will be as follows:

$$N(T) = (p-C)Q(T)e^{-rT} - S \tag{2}$$

$$V(T) = [(p-C)Q(T)e^{-rT} - S] + V(T)e^{-rT} \tag{3}$$

The following equation can be written here:

$$V(T) = \frac{(p-C)Q(T)e^{-rT} - S}{1 - e^{-rT}} \tag{4}$$

In line with community interests, Equation 5 needs to be maximized. Thus, an economically inefficient natural resource management will be against society. The equality that maximizes V(T):

$$MAX_T : V(T) = \frac{(p-C)Q(T)e^{-rT} - S}{1 - e^{-rT}} \tag{5}$$

For the maximization problem, the first derivative bound to V(T) should be equalized to zero.V(T*):

$$\frac{(1-e^{-rT^*})[(p-C)Q_{T^*}e^{-rT^*} - re^{-rT^*}(p-C)Q(T^*)]}{(1-e^{-rT^*})^2} - \frac{re^{-rT^*}[(p-C)Q(T^*)e^{-rT^*} - S]}{(1-e^{-rT^*})^2} = 0 \tag{6}$$

The expression of QT in the equation indicates that the first derivative based on the T rotation period is considered. The expression T* indicates the optimal rotation year. An easier form of Equation 6 can be written as follows:

$$\frac{(p-C)Q_T}{(p-C)Q(T)-S}=\frac{r}{1-e^{-rT}} \tag{7}$$

Equation 7 is called the Faustmann formula, which shows the optimal rotation length (Amacher et al. 2009; Faustmann 1849). The easier representation of Equation 7 as a calculation tool can be given as follows:

$$(p-C)Q_T=r\left[\left(p-C\right)Q(T)+V(T)\right] \tag{8}$$

Equation 8 explains that the effective rotation period of stand will occur if the rate of change in forest value is equal to the rate of return to be earned by converting trees and forest land into capital. In an economic sense, the left side of equation is the marginal product value of timber that is allocated for the stand growth. The right side of the equation is the sum of the capital (opportunity cost of this choice) due to the capital used by growing timber if the land is not used for further purposes.

In the model designed for UNP, 9 061 hectares of stands were taken into account, as explained in the material section. It is assumed that the tree density is homogeneous. The initial value of biomass Q was taken as 0.5m3/ha (Burges 2000). The carrying capacity K used in temperate forests has been accepted as 763 m^3/ha (Evans 1992). Tree growth rate was accepted as α=0.10 in the study; The changes were observed by simulation. The planting cost is assumed to be 100 USD/ha and the harvesting cost is 25 USD/m^3. These two cost values have been evaluated by considering current market prices in Turkish conditions. The stamping price has been taken into account as 63 USD/m^3 (417 TL/m^3) (OGM 2020). The reduction ratio (r) used in the study was accepted as (r) 0.05. However, changes were observed in the simulations. In particular, the reflection of the fire risk is closely related to the reduction ratio (Englin et al. 2000).

There are various studies on integrating fire risk into the mountain-forest ecosystem model. In the literature on the inclusion of fire risk in mountain-forest ecosystem management, there are studies that model fire risk with optimization models, such as Möllmann and Möhring (2017), as well as studies that associate fire risk with climate change, Subramanian (2008). This study considers fire risk as a probability (luck) variable. The probability of loss of forest land is taken into account regardless of the age of the stand, and it is clear that no other benefit can be obtained from the land if the forest land is lost by fire. The disappearance of all possible incomes in case of mountain-forest ecosystem loss is expressed by an equation:

$$V(T)=(p-C)Q(T)+(p-C)Q(T)e^{-\theta T}(1-\lambda)^{T}+(p-C)Q(T)e^{-2\theta T}(1-\lambda)^{2T}+...+(p-C)Q(T)e^{-\theta T}(1-\lambda)^{nT}+... \tag{9}$$

If the expressions are normalized to their initial values, since θ is a positive function and T=0 then =1. If the relationship between the reduction rate and the risk factor is designed as above, the probability of increased fire risk can be associated with visitor density. If the fire risk = 1%, the risk reduction ratio will be θ = 0.0043, if the risk = 5%, the risk reduction ratio will be θ = 0.022. Here, it is accepted that the discount rate related to reflecting the risk is exponential with a fixed rate (Newman et al. 1985). In this case, it can be said that the reduced form of the effect on all parameters will be as follows:

$$p(T)=p_0e^{\theta T},C(T)=C_0e^{\theta T},S(T)e^{\theta T}\quad 0\le\theta<r \tag{10}$$

Accordingly, the maximization problem that takes into account the fire risk will be as follows

$$MAX_T:V(T)=\frac{(p_0-C_0)Q(T)e^{-(r+\theta)T}-S_0}{1-e^{-(r+\theta)T}} \tag{11}$$

The Faustmann formula, which takes into account the risk of fire, has been redesigned. Adapted as effective reduction ratio. It indicates that a higher fire risk will show a lower rotation period.

RESULTS AND DISCUSSION

The software of the study was carried out with the help of "Microsoft Excel Spreadsheet". Numerical values mentioned above were taken into account in the initial model of the research results. When Table 1 showing the results of the basic model is examined, the UNP needs to be renewed at 48-year intervals. In the 48th year, a value of 1 177 USD/Ha is reached. The left side of Equation 7, which shows the optimal rotation length of the UNP, is shown in Figure 1 with a red line and the right side of the equation with a blue line. It has been concluded that this value is dependent on the changes in the bare land value in accordance with Equation 7. If this value (V(T)) is taken as zero, the rotation interval becomes 43 years. If the bare land value becomes positive and starts to appreciate, it is clear that the rotation interval will be lower so that the 0.05 reduction ratio (r) remains the same. In the UNP model, while the rotation interval was 43 years in the first condition (V(T)=0); It was observed that when the V(T) value increased by 20%, the rotation interval regressed to the 41-year band. The stand value in this year is 1 104 USD/ha. The decreasing direct use value (wood biomass) of UNP brings into question other ways of saving forest assets economically. In other words, removing the forest will make more sense economically. The policy to avoid this situation is to fully determine the non-wood (timber) values of the UNP and make it usable in UNP management. Another point is related to the prevention of excessive, untimely and unplanned valuation of the land value. Unplanned urbanization, the need for industrial space, and the effects of large infrastructure projects on land value also pose a problem for environmental management. There are many studies that describe the drawbacks related to the misuse of agricultural lands and the lack of planning of urban development (Dirim et al. 2009; Karakayacı 2010).

Table 1. UNP maximization condition calculated with Faustmann's model (basic model).

				Faustmann Maximization Condition			Timber	Stand
Rotastion Years	**Biological Mass(Ton)**	**dQ(T)/Dt[1]**	**Discount Rate(r)**	**[(p-C)*[dQ(T)/dT)]**	**[(p-C)Q(T)]+V(T)**	**Maks[2]**	**NVP[3] N(T)**	**NPV V(T)**
0	5,00	0,50	0,05	18,81	NA	NA	90,00	NA
5	8,19	0,81	0,05	30,61	954,97	0,032	142,39	643,73
10	13,36	1,30	0,05	49,42	1036,29	0,048	207,97	528,54
15	21,65	2,07	0,05	78,72	1370,03	0,057	288,70	547,15
20	34,73	3,23	0,05	122,80	1929,39	0,064	385,46	609,78
25	54,79	4,88	0,05	185,38	2777,69	0,067	496,47	695,82
30	84,33	7,01	0,05	266,41	3996,33	0,067	615,05	791,70
35	125,33	9,39	0,05	356,87	5643,07	0,063	727,59	880,62
40	177,73	11,46	0,05	435,31	7695,19	0,057	814,02	941,43
41	189,34	11,76	0,05	447,04	8143,42	0,055	826,26	948,34
42	201,24	12,02	0,05	456,93	8600,40	0,053	836,45	953,17
43	213,38	12,23	0,05	464,81	9064,09	0,051	844,48	955,82
44	225,69	12,38	0,05	470,51	9532,32	0,049	850,26	**956,21**
45	238,12	12,47	0,05	473,93	10002,81	0,047	853,71	954,29
46	250,61	12,50	0,05	475,00	10473,21	0,045	854,78	950,03
47	263,10	12,47	0,05	473,70	10941,18	0,043	853,47	943,45
48	275,52	12,37	0,05	470,05	11404,37	0,041	849,80	934,58
49	287,82	12,21	0,05	464,13	11860,56	0,039	843,80	923,49
50	299,93	12,00	0,05	456,05	12307,60	0,037	835,55	910,27
100	497,76	0,22	0,05	8,46	18942,62	0,000	27,45	27,63
200	500,00	0,00	0,05	0,00	18900,85	0,000	-99,14	-99,14

[1] Timber biological mass change
[2] (p-c)*[Dq(T)/Dt]/(P-C)Q(T)+V(T)
[3] Net present value

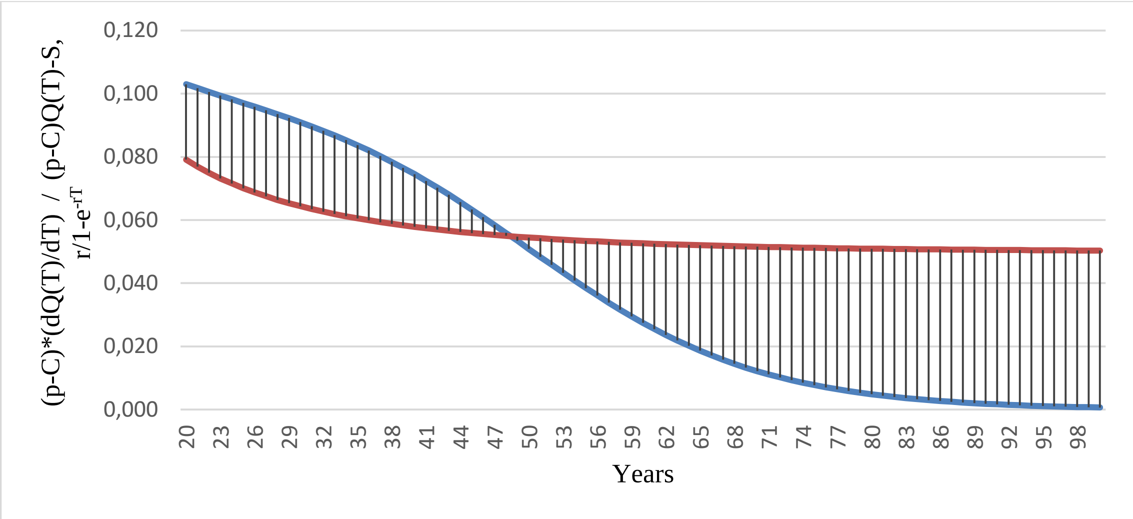

Figure 1. UNP optimal rotation length.

Another natural resource problem observed with population pressure in recent years is the unrestricted number of visitors (Gürlük et al. 2012). Especially the areas within the municipality contiguous area are opened to unlimited access with the effect of the relevant municipality decisions. One of the problems observed at UNP in recent years is the problems brought by the density of visitors. It has been declared that the number of visitors of UNP in 2019 is 1 697 000 (BOBM 2020). In cases where the number of visitors is so high and uncontrolled, various risks arise. These can be examined in two groups: The damages caused by the visitors to themselves and the damages caused by the visitors to the nature. The most important damage to nature is the risk of fire. In this study, to reflect the fire risk to the model, and therefore its parameters were taken into account. Here, it is predicted that the fire risk is at the level of 1%. In order to observe the change, the situation where the fire risk increased to 5% was also examined.

According to the results, it was observed that the stand value decreased as the risk factor increased. Similarly, it was observed that the rotation length decreased from 43 to 33 years as the risk factor increased. The conclusion to be drawn from this is that the model tends to eliminate risk. In a higher risk environment, forestry activity is terminated (Table 2).

Table 2. Rotation lengths of the UNP according to varying forest fire risk ratios.

Risk ratio	**λ=0**	**λ=%1**	**λ=%5**
V(T)	956USD	796 USD	305 USD
Rotation(T)	43 year	42 year	33 year

CONCLUSIONS

Due to its proximity to large residential areas such as Bursa and Istanbul, the increasing human use and pressure in Uludag increases the search for "area protection and rational use". It is obvious that a resource valuation study that will be integrated with environmental management plans is necessary to make the Uludag ecosystem healthier and more sustainable. Natural resources with poorly determined resource values are exposed to excessive consumption or pollution. The increasing use of Uludag causes various major problems such as environmental problems, legislation, infrastructure, transportation and accommodation. Pressures on resource values can create hard-to-repair damages in Uludag's ecosystem; can create environmental costs and degrade the ecological and economic value of the region.

If a qualified data flow can be provided, all non-wood values can be included in the model in future studies for UNP. A benefit flow function that takes these values into account will affect the optimum conditions, including rotation intervals, and allow more qualified policies to be designed with different perspectives on UNP.

On the other hand forest ecosystems are faced with massive forest fires. Good management practices gain importance at this point. Implementation of an effective prevention system depends on a reliable knowledge of factors effecting fire behaviour. At this point, as a result of the interviews with the local officials, it is seen that the national park management does not currently have an fire action plan. Along with the prepared management plan, it is necessary to make regional risk maps and land use plans. Sensitive lands that are open to danger should not be opened to settlement.

In order to extend the rotation period of the area, there is a need to plan a methodology for fire risk management. The first step in determining the forest fire hazard is characterization and mapping of the area. Next, the typology must be related to other hazard-characterizing parameters such as fuels, the probability of fire ignition or risk exposure of the population to wildfires.

With increasing fire risk, value of the ecosystem has been decreased. At the optimal rotation time the value of UNP is 956$/ha but in the fire risk this value is 305$/ha level. Therefore, at the next step integrated with ecosystem values, fire modelling systems can be very useful for predicting fire behaviour by analysing fire regime and the management of fire risk.

Proper use of any fire modelling depends on educated users with knowledge and expertise on fire simulation. But weak environmental awareness in various segments of the society and the evaluation of environmental impacts as a luxury concept in developing countries like ours, and the absence of expert personnel who can conduct analyzes can be considered as factors that may limit the use of methods in our country. However, with the necessary legal regulations, the need for specialists in the field will be met by establishing units that can carry out such analyzes in each region and conducting in-service training activities in these areas.

In the future, if environmental goods and services are included in the national accounting systems, it can be said that the protection and development of the environment will be made an economic necessity different from a limited environmental movement. Since the benefits of mountain-forest ecosystems in Turkey are not reflected in national accounts, the share of such ecosystems in the country's economy is not known exactly. With the further studies to be carried out in this context, the non-use values that cannot be determined will be expressed in monetary terms and relations with ecosystem risk parameters like fire risk will be share in the national economy and expressed as accurately as possible.

REFERENCES

Amacher GS., Ollikainen M. and Koskela E (2009). Economics of Forest Resources. MIT Press, Cambridge. 424p.

BOBM (2020). Bursa Regional Directorate of Forestry Management Plan. Bursa.

Brazee R (2001). The Faustmann formula: Fundamental to forest economics 150 years after publication. Journal of Forest Science, 47(4): 441-442. Access Adress: https://search.proquest.com/docview/197721570?pq-origsite=gscholar

Bulte E and Soest D (1996). International Transfers, Price Uncertainty and Tropical Deforestation. Environment and Development Economics, 1(3): 281-287. doi:10.1017/S1355770X00000620

Burgess JC (2000). Economics of Tropical Forest Land Use. Doctoral Thesis. University College London, Department of Economics.

Crabbe PJ and Long NV (1989). Optimal Forest Rotation under Monopoly and Competition. Journal of Environmental Economics and Management, 17: 54-65. doi: 10.1016/0095-0696(89)90036-3

Daşkın R (2008). Uludağ Florası. Doktora Tezi. Bursa Uludağ Üniversitesi Fen Bilimleri Enstitüsü, Biyoloji ABD.

Dirim S, Aksoy E and Özsoy G (2009). Remote Sensing and Gis Applications For Monitoring Multi- Temporal Changes of Natural Resources in Bursa-Turkey. Journal of Biological and Environmental Sciences, 3(8): 53-59.

Evans J (1992). Plantation Forestry in the Tropics. Oxford University Press. 403p.

Englin J, Boxall, P and Hauer G (2000). An empirical examination of optimal rotations in a multiple-use forest in the presence of fire risk. Journal of Agricultural and Resource Economics, 25(1): 14-27.

Gürlük S, Atanur G and Turan Ö (2012). Economics of limiting congestion in urban forest recreation areas. Scandinavian Journal of Forest Research, 27(5): 449-459.

Gret-Regamey A, Brunner SH and Kienast F (2012). Mountain Ecosystem Services: Who Cares? Mountain Resources and Development, 32(s1): 23-34. doi: 10.1659/MRD-JOURNAL-D-10-00115.S1

Huber R, Rigling A, Bebi P, Brand FS, Briner S, Buttler A, Elkin C, Gillet F, Gret-Regamey A, Hirschi C, Lischke H, Scholz RW, Seidl R, Spiegelberger T, Walz A, Zimmerman W and Bugman H (2013). Sustainable land use in mountain regions under global change: synthesis across scales and disciplines. Ecology and Society, 18(3): 36. doi: 10.5751/ES-05499-180336

Karacan AR (2007). Environmental Economy and Politics. Ege University Publishing. İzmir, Türkiye, 763s.

Karakayacı Z (2010). Tarım Arazilerinin Amaç Dışı Kullanımının Sürdürülebilir Kalkınma Açısından Değerlendirilmesi. Ziraat Mühendisliği, 2010 (355): 48-53.

Koskela E and Ollikainen M (1997). Optimal Design of Forest Taxation with Multiple-Use Characteristics of Forest Stands. Environmental and Resource Economics, 10, 41-62. doi: 10.1023/A:1026472622826

Kroupova ZZ, Havlikova M, Halova P and Maly M (2016). Economic Valuation of Mountain Landscapes and Ecosystems: A Meta-Analysis of Case Studies.Agris on-line Papers in Economics and Informatics, 8(3): 103-112. doi: 10.7160/aol.2016.080310

Möllmann T and Möhring B (2017). A practical way to integrate risk in forest management decisions. Annals of Forest Science, 2017: 74-86.

Newman D, Gilbert C and Hyde W (1985). The Optimal Forest Rotation with Evolving Prices. Land Economics, 61(4): 347-353.

OGM (2020). Orman Genel Müdürlüğü İnternet Sayfası. Access Adress: https://www.ogm.gov.tr/ekutuphane/TomrukCinslerineGoreAASEmvallerinFiyatlari/Forms/AllItems.aspx

Özhatay N, Byfield A. ve Atay S (2003). Türkiye'nin Önemli Bitki Alanları. Doğal Hayatı Koruma Vakfı Yayınları. İstanbul, Türkiye. 88s.

Parks PJ and Murray BC (1994). Land Attributes and Land Allocation: Nonindustrial Forest Use in the Pacific Northwest. Forest Science, 40(3): 558-575. doi: 10.1093/forestscience/40.3.558

Subramanian N, Nilsson U, Mossberg M and Bergh J (2018). Impacts of climate change, weather extremes and alternative strategies in managed forests. Journal of Ecoscience, 26(1): 53-70.

Uzel G, Gurluk S. (2022). Economic Values of Supplier Resource Products in Mountain Forest Ecosystems: The Case of Uludag National Park. J. Biol. Environ. Sci, 16(47): 9-21.