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Determining Temporal Changes of Annual Productivity of Bay Laural (*Laurus nobilis* L.) in the Yenikoy Planning Unit

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Abstract

The production of non-wood forest products (NWFPs) is performed with harvesting plans in Turkey. However, insufficient technical capacities, lack of locational data and the absence of site productivity in the plans threat the sustainability of NWFPs. The primary objective of this research is to analyze temporal changes of annual site productivity of bay leave in the Yeniköy planning unit, Turkey. The cover type maps, forest management plans (1972- 2003) and bay laurel harvest plans (1992-2013) were used as primary data. Temporal changes of bay laurel productivity were examined with a detailed analysis with GIS in terms of land use types, developing stages and canopy cover on bay laurel areas. The results indicated that there was a remarkable change for spatial distribution and productivity of bay laurel from 1974 to 2013 due mainly to the differences of inventory design causing underestimation of productivity. Appropriate sampling technique with the use of GIS may provide more realistic and accurate estimation of the productivity. The integration of NWFPs into forest management plans and sustainable production are possible with understanding the quantitative relations of NWFPs with the appropriate variables.

Key words: Non-wood forest products, L. nobilis, temporal change, productivity, harvesting plan.

Yeniköy Planlama Birimindeki Yıllık Defne (*Laurus nobilis* L.) Verimliliğinin Zamansal Değişiminin Belirlenmesi

Öz

Türkiye'de odun dışı orman ürünlerinin (ODOÜ) üretimi hasılat planları ile gerçekleştirilmektedir. Ancak planların yetersiz teknik bilgi ve eksik konumsal veri içermesi ve alan verimliliğini kapsamaması ODOÜ'nün sürdürülebilirliğini tehdit etmektedir. Bu çalışmanın amacı Yeniköy planlama biriminde bulunan defne alanlarındaki verimliliğin zamansal değişimini, 1972, 1994 ve 2013 orman amenajman planlarına ait meşcere haritalarını ve 1992 ve 2003 yılına ait defne hasılat planlarını kullanarak analiz etmektir. Arazi kullanım sınıfı, kapalılık ve gelişim çağı kullanılarak, defnenin yayılış gösterdiği alanlarda Coğrafi Bilgi Sistemleri (CBS) yardımıyla yapılan detaylı analizler sonucunda defne verimliliği belirlenmiştir. Elde edilen sonuçlara göre, 1974-2013 yılları arasında defne yayılış alanları ve verimliliği ciddi oranda artış göstermiştir. Bu planlama dönemleri arasındaki önemli farklılığın temel sebebi kullanılan envanter tasarımı farklılığıdır. Uygun örnekleme teknikleri ve CBS'nin kullanımıyla verimlilik tahminlerinin yapılması daha gerçekçi ve hassas olabilir. ODOÜ'nün orman amenajman planlarına entegre edilmesi ve sürdürülebilir üretimin sağlanması, ODOÜ'nün uygun değişkenlerle olan sayısal ilişkilerinin anlaşılabilmesiyle mümkündür.

Anahtar Kelimeler: Odun dışı orman ürünleri, defne, zamansal değişim, verimlilik, hasılat planı.

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1. Introduction

Laurus nobilis L. is one of the most important non-wood forest products (NWFPs) for Turkey. It is mainly distributed over the coastal area of Mediterranean, Aegean, and Black Sea region in Turkey and usually located around 600-800 meters in elevation. It is a shrub or evergreen tree and a characteristic member of Mediterranean vegetation cover. Its leaves and seeds contain some valuable essential oils and widely used in food, cosmetic and medicine industry (GDF, 2016a).

Turkey is the largest bay leave supplier providing nearly 90 percent of the demand in the world (GDF, 2016a). It enables to gain considerably high incomes. There is a great demand for bay laurel products from international market because these products have multiple uses. International trade of bay laurel leaf from Turkey has increased. International trade value of this product changed from about 1,700 $ to 2,850 $ /ton (average 2,250 $/ton) over the last two decades. Just in 2017, Turkey exported about 14 million kg bay leaves worth of 36.1 million $ (TUIK, 2018). In addition to that, bay leave production is mostly performed by forest villagers providing main income resource for them. Taking into account all of these, bay laurel areas can be under pressure and this situation can affect negatively its productivity, quality and sustainability. Thus, sustainable management of bay laurel like the other NWFPs is critical and determination of spatial distribution areas and estimation of productivity for these products are main components for planning of NWFPs.

Though planned forestry started in 1963, the integration of NWFPs into forest management plans was delayed due to inventory methods for each products and unknown site productivity. Specifically, variable inventory period, unknown sampling method, sampling size and shape for each species, necessity of repeated measurement and lack of experts are the major impediments for unplanned production of NWFPs. In Turkey the production of the majority of NWFPs are possible with harvesting plans. However, the technical and contextual deficiencies of existing harvesting plans cause unrealistic production endangering the sustainability of the NWFP. In these plans only few sample plots were taken and the average value of these plots was accepted as mean value of a planning unit. Thus, variation between environmental variables were not considered. The spatial distribution of products is only revealed through management plans or subsequent evaluations. Execution times of harvesting plans and forest management plans do not coincide. When the forest management plan is expired, the existing harvest plan is not used anymore. Since the data obtained from the temporary sampling areas in a single year, they cannot reveal the seasonal differences. Since these plans are independent from forest management plans, the long-term effects of the interventions on forest products cannot be predicted (Kucuker, 2014).

One of the most important problems for integration of NWFPs into forest management plans is the inability of quantifying the relations between products and stand, topographic and climatic variables. Nowadays, empirical models estimating the productivity of NWFP based on stand, climatic and topographic variables are built (Kucuker and Baskent, 2018). These models developed by Calama et al. (2007); Morales (2009) for nut weight, Mutke et. al (2005); Calama et. al (2008); Calama et. al (2010) for weight of cones, Bonet et al. (2008); Bonet et al. (2010) for weight of mushroom, Nanos et al. (2000); Nanos et al. (2001) and Spanos et al.(2009) for resin weight, Ihalainen and Pukkala (2001); Ihalainen et al. (2002); Ihalainen et al. (2003); Ihalainen et al. (2005) and Miina et al. (2009) for weights of berries, Riberio and Tome (2002) and Paulo and Tome (2010) for cork weights. Additionally, the spatial distribution areas of NWFP can be accurately predicted with Geographic Information Systems (GIS).

History of forest dynamics is important to evaluate for land use pattern changes in terms of spatial and temporal scales and to guide the forest management practices and policies. In the light of this information, land use changes can be determined in terms of both the distribution and productivity of NWFP. GIS is an appropriate tool to monitor changes in forest areas. Although lots of studies were carried out for spatial and temporal changes of forest ecosystems, (Cakir et al. 2007; Cakir at al. 2008; Keles et al. 2007; Mumcu et al., 2008; Sivrikaya et al. 2009; Sivrikaya et al. 2011; Baskent and Celik, 2013), there are very few studies specifically addressing the spatial and temporal changes of NWFP (Kucuker and Baskent, 2017a,b).

The primary objective of this study is to analyze temporal changes of annual productivity of bay leave in the Yeniköy planning unit, Turkey by using cover type maps from forest management plans between 1972 to 2003 and bay laurel harvest plans between 1992 to 2013. Temporal changes of bay laurel productivity were examined in terms of land use, development stages and canopy cover with a detailed analysis on bay laurel areas. By evaluating the changes in these periods, future planning strategies may be developed properly and the susceptibility of forest to further abrupt changes in the future can be examined.

2. Material and Method

2.1. Material

This study was conducted in Yeniköy Planning Unit which located the northwest part of Turkey. It is surrounded by Marmara Sea in the north, Bandırma Planning Unit in the south and southwest and Karacabey Planning Unit south and southeast. Altitude can be changed from 0 to 831 meters with average slope of 33%. Based on long term measurement from 1938 to 2015, mean annual precipitation of study area is 683.7 mm and mean annual temperature is 14.1 °C (TSMS, 2016). Its total area is about 11,150 ha consisting 91% forested areas which has 70 different stand type. Main tree species are Fagus orientalis, Quercus sp., Tilia sp. and Castanea sativa. Kurşunlu cooperative located on the study area and established in 2014 produces approximately 100 tons of dry bay leaves per year by processing about 500 tons of fresh leafy shoot. The production of bay laurel contributes serious secondary income for rural people in this area and there is no any problem for marketing of this product.

2.2. Method

In order to detect temporal changes, along with the spatial distribution areas and productivity of bay laurel, forest cover type maps were obtained from General Directorate of Forestry (GDF) belonging to 1974, 1994 and 2004 years. Then, stand type maps of 1974 and 1994 were digitized and the database was created using ARCInfo 10TM. The last database is provided by GDF in digitized format. Also, spatial distribution areas and the productivity of bay laurel were detected by the harvest plans belong to 1992, 1994 and 2013. Then spatial distribution and productivity information in each harvest plan were integrated into GIS databases of forest cover type maps for each planning period. The first bay laurel harvest plan was prepared in 1992 based on existing forest cover type maps for Kurşunlu and Dumanlıtepe series between 1974 and 1991 (GDF, 1994). Because the forest management plan was renewed in 1994, existing bay laurel harvest plan was updated and integrated into the current forest cover type map belonging to 1994-2003 (GDF, 1994). The current harvest plan was prepared in 2013 based on existing forest cover type maps belonging to 2004-2013 (GDF, 2013). Because the first bay laurel harvest plan belonging to related study area could not be found in the archives of GDF, the spatial distribution areas and productivity of bay laurel in the study area were adapted from the next bay laurel harvest plan of 1994 (Figure 1).

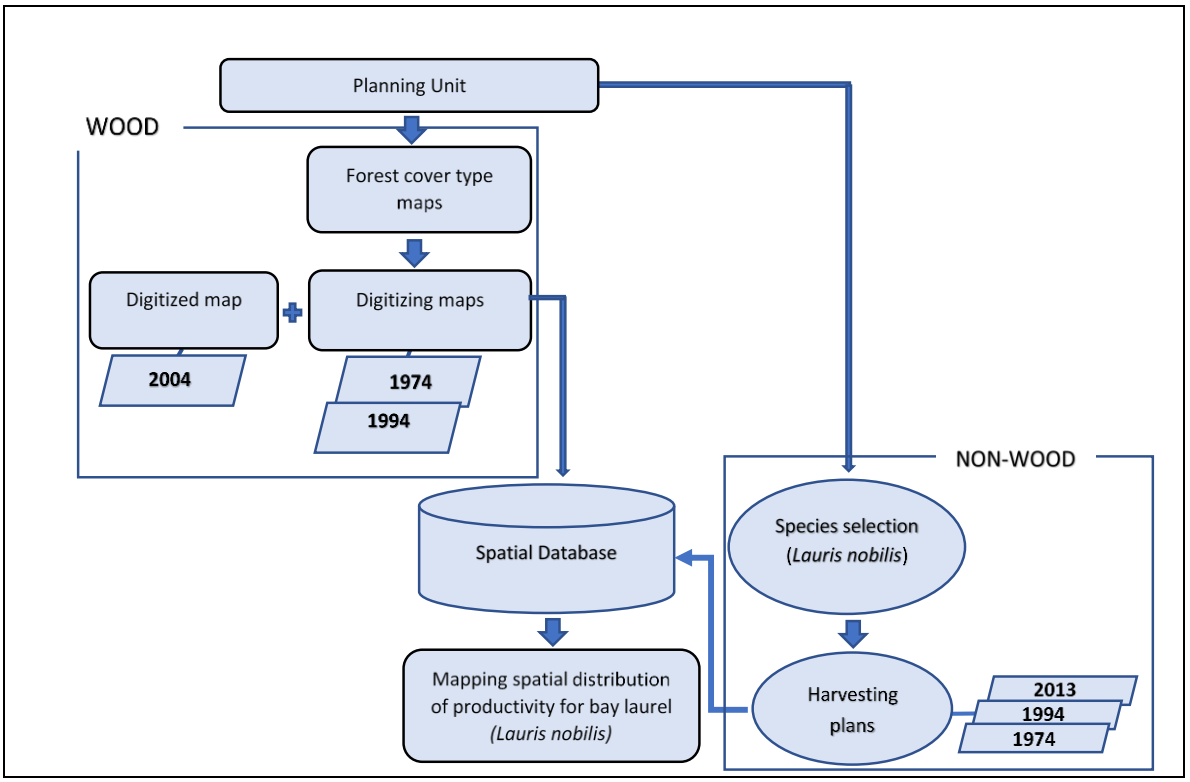

Figure 1. Flow chart of mapping spatial distribution of productivity for bay laurel (*Laurus nobilis*)

3. Results and Discussion

After the bay laurel harvest plans were incorporated into three different database, bay laurel productivity was mapped and the effects of some parameters such as crown closure, development stage and land use classes on bay laurel productivity and spatial distribution were evaluated separately.

3.1. Production of Bay Laurel Based on Three Different Periods in Yeniköy Planning Unit

According to rescript no 302 for principle of harvesting, marketing, inventory and planning of non-wood forest products (GDF, 2016b), bay laurel production can be possible every 2-3 years at the same area based on harvesting plan prepared for related product at the study area. Thus, the areas where bay laurel grows are divided three harvesting blocks have nearly equal productivity and each year only one block can be produced (Table 1). The first harvesting plan for bay laurel in the Yeniköy planning unit was prepared in 1992. Any inventory method was not used in determining of spatial distribution and productivity due to lack of information about inventory technique of bay laurel and having a heterogeneous distribution in different forms. In the process of preparing this harvesting plan, the distribution areas of bay laurel were determined by preliminary survey. In this planning period it was assumed that bay laurel distributes on the degraded areas. Spatial distribution areas of bay laurel were determined based on stand type map of forest management plans for 1974-1993.

Table 1. Total yield of fresh leafy shoot based on block number in harvesting plans of bay laurel.

Block No	1974-1993	1994-2003	2013-2026
1	23.24	15.55	6,106.17
2	22.93	16.45	6,138.91
3	27.91	17.1	6,553.88
Total yields (tons)	**74.10**	**52.76**	**18,798.96**

The harvesting plan of bay laurel was renewed in 1994 because stand type map was changed in the new forest management plans and this plan was applied between 1994-2003. After that, this plan was updated for 2004-2013 based on new forest management plan. In these harvesting plans it was used a traditional estimating equation to calculate bay laurel productivity without any sample plots. In this point the productivity of bay laurel was assumed 0.1 ton per hectare. The harvesting plan of bay laurel was renewed in 2013 by the regional department of non-wood forest product and services. For this purpose, first of all potential bay laurel areas were determined based on previous plans and experiences of some rural people and forest officers. In this point the bay laurel areas under vegetation as well as degraded areas were identified for sampling. Then at least one or two representative sample plots from each stand with bay laurel shrubs was established in related to stand area is higher than 50 ha. The shape of sample plots was square with 25x25 m size. After cutting of the leafy shoots they were weighted. Total fresh leafy shoot yield per hectare of bay laurel was calculated by multiplying with the density of bay laurel in the related stand and coefficient of conversion to hectares (GDF, 2013). In each harvesting plan, due to the area was divided three blocks, each year only one block can be harvested. Also, production can be made in the same block in three years.

When the accounting records were examined, it was seen that the average annual production amount was 200 tons and 650 tons for the related planning periods 1994-2003 and 2013-2017 respectively. These records showed that while harvested amount is much higher than the planned amount (about 16 tons) in the harvesting plan for 1994-2003, it is considerably below of planned amount (about 6,100 tons) in the harvesting plan for (2013-2026) (Anonymous, 2018).

Since the potential bay laurel areas were assumed to be only degraded areas and bay laurel yield was estimated based on a traditional equation, the total productivity was predicted very low in the first period. However, used intensive sampling for bay laurel grown naturally under vegetation as well as degraded areas for detecting spatial distribution of bay laurel areas and more realistic calculating method of the productivity provided positive contribution on bay laurel yield in the last period. Taking sample from each stand with bay laurel allowed different variations to be taken into consideration.

In order to identify the spatial distribution of bay laurel areas, the calculated fresh leafy shoot yield per hectare for each stand and harvesting block were integrated into GIS database for each planning period separately. The maps indicating spatial distribution and productivity for different planning periods as 1974, 1994 and 2013 were

prepared using ArcInfo 10™. Accordingly, about 25 tons, 16 tons and 6,100 tons of fresh leafy shoot yield of bay laurel for each block in the first (1974-1993), second (1994-2003) and last (2013-2026) harvesting plans were determined, respectfully, to harvest (Figure 2). The results showed that the productivity of bay laurel have increased for 40 years and more products were sent to the markets. The international trade statistics showed that the exported amount of bay laurel leaf from Turkey and the income generated from this trade have importantly increased since 2001 (TUIK, 2018).

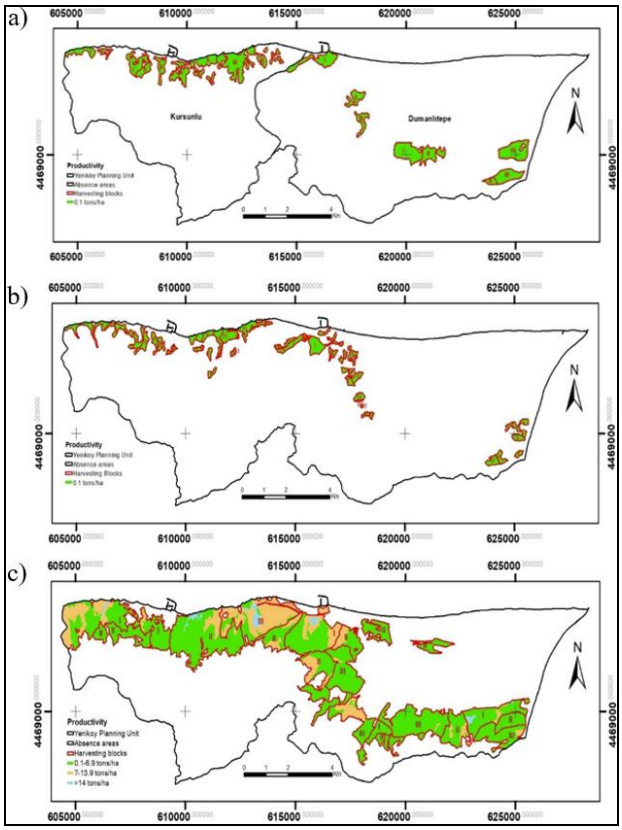

Figure 2. Spatial distribution and productivity of bay laurel for 1974 (a), 1994 (b) and 2013 (c)

3.2 Temporal Changes in Land Use/Land Cover Classes

According to harvest plans of bay laurel between 1974 and 2013, while bay laurel areas between 1974 and 1994 decreased, bay laurel areas greatly increased between 1994 and 2013. Total areas of bay laurel are 741 ha, 527.62 ha and 3,448.34 ha in 1974, 1994 and 2013, respectively. In addition, bay laurel productivity showed a small decrease of 29% between 1974 and 1994, and a remarkable increase of 36,050% was seen between 1994 and 2013.

Table 2. Bay laurel productivity and size based on land use/land cover classes.

Land Cover Classes	Years						Difference between 1974-2013(+/-)
	1974		1994		2013		
	Area (ha)	Yield (tons)	Area (ha)	Yield (tons)	Area (ha)	Yield (tons)	Area (ha)
Degraded	485.10	48.51	527.62	52.76	499.15	2,884.98	14.05
Softwood-hardwood	-	-	-	-	13.47	55.55	13.47
Mixed hardwood	136.87	13.68	-	-	2,934.51	15,584.91	2,797.65
Pure hardwood	-	-	-	-	1.20	3.52	1.19
Mixed with bay laurel	119.05	11.90	-	-	-	-	-119.04
Total	**741.00**	**74.10**	**527.62**	**52.76**	**3,448.34**	**18,798.96**	

In the first period bay laurel extends on degraded stands (485.10 ha), under mixed hardwood stands (136.87 ha) and some stands where bay laurel has mixture as a tree type with about 119 ha. However, bay laurel is located

just in the degraded stands in 1994. It is confirmed that bay laurel can grow in degraded areas, under mixed or pure hardwood and softwood-hardwood mix stands in 2013 (Table 2). The remarkable changes in spatial distribution and productivity of bay laurel between 1974 and 2013 can be seen in Figure 1. As an overall change, there was a net increase of 365 % in total bay laurel areas and 25,27 % in total productivity from 1974 to 2013 (Table 2). In order to analyze the change of land use/land cover classes and bay laurel composition between 1974 and 2013 in Yeniköy planning unit, forest cover types were categorized as degraded, soft hardwood, mixed hardwood, pure hardwood and mixed with bay laurel areas. While bay laurel areas in degraded stands increased about 8.8% and 2.9%, the productivity in these areas increased about 8.8% and 5,8% in 1994 and 2013, respectively. The most remarkable changes were occurred in mixed hardwood stands with 2,0 % increase. Also, bay laurel stands which existed in 1974 disappeared in 1994 and 2013 (Table 2).

All transitions between two periods (from 1974 to 2013) based on land use classes are shown in Table 3. The results show that there are not any bay laurel stands in 2013. Of bay laurel stands, 11.3% and 35.3% turned into softwood-hardwood and mixed hardwood stands, respectively, that include bay laurel. However, 53.4% of bay laurel stands does not include bay laurel in 2013. In addition, of bay laurel areas under degraded stands, 186.70 ha (38.5%), 201.45 ha (41.5%) and 96.96 ha (20%) turned into degraded, mixed hardwood stands and stands, respectively, where bay laurel doesn't grow any more. Similarly, bay laurel areas under mixed hardwood stands turned into the areas under degraded (55.7%), mixed hardwood (33.8%) and no bay laurel areas (10.5%). However, of the areas don't include bay laurel in 1974, 236.24 ha and 2,644.82 ha include bay laurel under degraded and mixed hardwood areas respectively in 2013 (Table 3).

Table 3. Transitions between land use classes (based on forest management plans between 1974 and 2013).

Years	2013					1974
Land Use Classes	**Degraded**	**Softwood-hardwood**	**Mixed hardwood**	**Pure hardwood**	**Null**	**Total (ha)**
Degraded	186.70	-	201.45	-	96.96	**485.10**
Mixed hardwood	76.22	-	46.28	-	14.37	**136.87**
Bay laurel	-	13.45	41.97	-	63.63	**119.05**
Null	236.24	0.02	2,644.82	1.20	7,527.20	**10,409.47**
Total (ha)	**499.15**	**13.47**	**2,934.51**	**1.20**	**7,702.15**	**11,150.49**

*Null means the areas where bay laurel is not available

3.3. Temporal Changes in Canopy Cover

In order to analyze any structural changes in bay laurel areas, temporal changes based on crown closure in bay laurel areas were examined. Between the years 1974 and 2013, while the size of low coverage and full coverage stands including bay laurel increased by around 30% and 1,170%, respectively, the size of degraded forest areas (< 10%) where bay laurel grow are almost the same. However, the productivity of bay laurel increased by around 10,300%, 67,100% and 5,850% in the low coverage, full coverage stands and degraded forest areas including bay laurel (Table 4). In addition, the size and the productivity of bay laurel in the areas where bay laurel was not observed with medium coverage, changed to 380.01 ha and 2,109.24 tons in 2013. In general, when two period compared for distribution of bay laurel areas in terms of canopy cover although the differences between bay laurel areas are not very much, the productivity importantly increased in low coverage and degraded forest areas. This result demonstrated that the visual quality of bay laurel areas has been improved.

Table 4. Changes in areas and productivity of bay laurel based on forest canopy cover between 1974-2013.

Canopy cover (Criteria % cover)	Years						Difference between 1974-2013(+ -)
	1974		1994		2013		
	Area (ha)	Yield (tons)	Area (ha)	Yield (tons)	Area (ha)	Yield (tons)	Area (ha)
1 (low coverage, 11%-40%)	59.76	5.97	-	-	77.44	619.68	17.68
2 (medium coverage, 41%-70%)	-	-	-	-	380.01	2,109.24	380.01
3 (full coverage, >71%)	196.15	19.61	-	-	2,491.73	13,185.04	2,295.58
Degraded forest (0-10%)	485.10	48.51	527.62	52.76	499.15	2,884.98	14.05
Total	**741.00**	**74.10**	**527.62**	**52.76**	**3,448.34**	**18,798.96**	

All transitions for canopy cover classes between 1974 and 2013 are shown in Table 5. While of bay laurel stands in canopy cover-1, 7.2% and 46.5% changed to the bay laurel areas in canopy cover-2 and canopy cover-3 respectively, of bay laurel stands in canopy cover-3, 8.4% and 27.1% changed to the bay laurel areas in canopy cover-2 and canopy cover-3 respectively. Similarly, degraded areas include bay laurel in the first period changed to mostly canopy cover-2, canopy cover 3 and degraded areas where bay laurel grow in the last period by around 8.0%, 33.5% and 38.5% respectively. However, in general about 175 ha areas (24%) does not include bay laurel in the last period any more even though it contains bay laurel in the first period. In addition, 2,882.26 ha areas do not include bay laurel in the first period changed in the last period to canopy cover-1, canopy cover-2, canopy cover-3 and degraded areas where bay laurel grows by around 2.7%, 11.1%, 78.0% and 8.2% respectively (Table 5).

Table 5. Transitions in forest canopy cover areas according to forest cover type maps between 1974-2013 where bay laurel distributed.

Years / Canopy Cover	2013					1974
	1	**2**	**3**	**Degraded**	**Null**	**Total(ha)**
1	-	4.27	27.78	-	27.70	**59.76**
3	-	16.42	53.22	76.21	50.29	**196.15**
Degraded	0.08	38.96	162.40	186.69	96.96	**485.10**
Null	77.36	320.34	2,248.32	236.24	7,527.19	**10,409.47**
Total (ha)	**77.44**	**380.01**	**2,491.73**	**499.15**	**7,702.15**	**11,150.49**

*Null means the areas where bay laurel is not available

3.4. Temporal Changes in Development Stage

In the first period the forest areas including bay laurel were concentrated within the development stage "b" (young). Although there were no areas of regenerated and mature-over-mature stands in 1974, remarkable change was seen in 2013 correspond to 217.25 ha and 2,600.40 ha respectively. In the last period bay laurel productivity in mostly mature or mature/over-mature stages of the forest was 14,676.68 tons corresponding about 78.1% of total productivity (Table 6).

Table 6. Changes in areas and productivity of bay laurel based on forest development stages between 1974-2013.

Years	1974		1994		2013		Difference between 1974-2013(+ -)
Development Stages* (criteria average dbh)	**Area (ha)**	**Yield (tons)**	**Area (ha)**	**Yield (tons)**	**Area (ha)**	**Yield (tons)**	**Area (ha)**
a- ab	-	-	-	-	217.25	793.38	217.25
b	255.91	25.58	-	-	-	-	-255.91
bc	-	-	-	-	131.52	443.89	131.52
c-cd	-	-	-	-	2,600.40	14,676.68	2,600.40
Degraded forest	485.10	48.51	527.62	52.76	499.15	2,884.98	14.05
Total (ha)	**741.0**	**74.1**	**527.62**	**52.76**	**3,448.34**	**18,798.96**	

*: a means regenerated areas (average dbh <8 cm), b means young areas (average dbh 8-19.9 cm), c means mature areas (average dbh 20-35.9 cm) and d means over-mature areas (average dbh> 36 cm).

Areas of young development stage "b" including bay laurel in 1974 (approximately 255.91 ha) had grown naturally into young/mature (development stage bc) and mature/over-mature (development stage c-cd) by around 10% and 30% respectively. Moreover around 30 ha and 171 ha of degraded areas had transitioned into young and mature/over-mature development stages respectively. It is a possible evidence of the increased quality of forest. In addition, about 187 ha of young stage, 106 ha young/mature stage and 2,352 ha mature/over-mature stages were converted from the areas did not have any bay laurel to bay laurel areas in the last period (Table 7).

Table 7. Transitions in forest canopy cover according to forest cover type maps between 1974-2013 where bay laurel distributed.

Development Stages	**2013**					
1974	**a-ab**	**bc**	**c-cd**	**Degraded**	**Null**	**Total**
b	-	25.08	76.61	76.21	78.00	255.91
Degraded	30.02	-	171.41	186.69	96.95	485.05
Null	187.22	106.43	2,352.36	236.24	7,527.19	10,409.47
Total	**217.25**	**131.52**	**2,600.40**	**499.15**	**7,702.17**	**11,150.49**

4. Conclusions

There are not any bay laurel stands in 2013 although there was 119 ha in 1974. This would not be surprising as wood production was the only focus of forest management planning approach in the past and applied silvicultural treatments were not about to protect bay laurel.

When three periods are compared for productivity, noticeable changes were seen. Total production of bay laurel for 1974-1993, 1994-2003 and 2013-2026 was 74.1, 52.7 and 18,798.96 tons, respectively. Especially in the last period, there was remarkable changes for spatial distribution and productivity of bay laurel. The area of bay laurel was only 741.00 ha in 1974 whereas 3,448.34 ha in 2013. One of the reasons of these changes could be the differences in inventory methods determining spatial distribution of bay laurel areas. In the first years although it is known that bay laurel also can grow under vegetation, just degraded areas and the stands with bay laurel as a tree type were assumed to contain bay laurel product. Reasons such as heterogeneous distribution of bay laurel in different form like tree or shrub caused not to use modern inventory methods to determine spatial distribution areas. Besides, while any inventory technique and sampling design could not be used for determining fresh leafy shoot yield of bay laurel, a constant of 0.1 ton per hectare was used to estimate the productivity. The lack of use of any sampling technique and design without considering variations in different areas caused underestimated, unrealistic and uniform results in predicting the productivity. However, in the last period the use of intensive sampling techniques and GIS provides more realistic and accurate estimation of the productivity.

The results clearly indicated that the NWFPs were ignored in the past due to the complexity of the sampling process. The evaluation of management planning approach in Turkey made a great contribution to the management of NWFP due to their increased ecological and economic importance in the world. For some products detailed sampling methods are used and more accurate harvesting plans are prepared. However, because execution time of harvesting plan and management plan in the study area does not overlap when the implementation period of forest management plan is over, the harvesting plan is not used anymore. Thus, the integration of these products into forest management plans is very important.

The main reason for the serious increase in bay laurel productivity although increasing rate of degraded areas between two periods is not much is the forestry policy changes in the study area. Some arrangements for the use of degraded forest areas were practiced by Bursa Regional Directorate of Forestry. Accordingly, tenancy of these areas was offered to forest villagers provided that they made produce bay laurel in these degraded areas. After these villagers carried out some activities on the area such as field clearing and soil-processing with their own possibility, they raised bay laurel as orchard. Although the tenancy of degraded forest areas seen to be a positive contribution to the productivity in a short term, it can cause serious problems as long as there are not enough and sufficient controls in the long term.

When harvested amount of bay laurel based on accounting records were compered for the last two periods, remarkable differences were seen. Annual 600 tons of bay laurel was produced on average in the last period while annual 200 tons of bay laurel was produced on average between 1994-2003 years. The main reason of this serious difference between the production foreseen by the harvesting plan and the legal production amounts related to the permits for nineties is due to the inadequacy of the plans. Although a considerable increase in bay laurel production was seen lately due to bay laurel cooperative (Kurşunlu cooperative), it couldn't be reached optimum production of bay laurel in the last period. Especially, infrastructure deficiencies and technical incompetence such as insufficient road network, lack of labor and landform can be shown as the main reasons for the under harvesting in the last period.

As a result, to ensure economic, ecologic and social sustainability of NWFP and increase the productivity of these products following points should be considered:

- Sustainable production of NWFP should be possible with the integration of these products into forest management plans instead of harvest plans.
- Modern sampling methods for spatial distribution and productivity of NWFP should be tried to estimate more accurate results.
- In addition, different methods that require less time, labor and money should be tried to estimate occurrence of these products. In this way, it is easier to integrate them into forest management plans.
- An important detail that to estimate spatial distribution and productivity of NWFP the empirical models including some risk factors such as forest fire, insect damages and climatic change instead of traditional equations are critical for integration of NWFP into forest management plans.
- Because some activities on forest areas such as field clearing and soil-processing as well as pruning and thinning have a positive contribution on the productivity, silvicultural interventions should not be ignored to increase the NWFP productivity.
- Besides, some forestry policies about NWFP like tenure system should be determined by government to promote rural development and sustainable harvest.

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