

**Spatio-temporal Characteristics of Roadside Landscape Components  
Along the Coastal Zone Between Amasra and Kurucaşile Cities of Bartın  
Province, Turkey**

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**Introduction**

Roads connect populations, societies, cultures and economies (Havlick, 2002; Delgado et al., 2007). They also serve astonishing landscapes for the travelers. Forested rural landscapes along the coastal zones display unique features which vary spatially and temporally (Marsh, 2010). Therefore, the coastal roadside landscape components involving particularly the sea, trees, shrubs, villages and agricultural areas supply recreation for the people who experience this trip. Roadside landscape and scenic quality not only satisfy visual perception of the travelers (Akbar et al. 2003) but also serve for the safe and comfortable travel (Mok et al., 2006; Öztürk and Gökyer, 2015).

Greenways are defined as the linkages of linear elements that are considered around the perspectives of ecological, recreational, cultural and aesthetic planning, design and management in order to ultimately lead towards sustainable land use (Ahern, 1995). Based on these perspectives and goal, the literatures (e.g. Ribeiro and Barão, 2006); that approach the roadside landscapes around the greenway concept have gained importance in relatively recent years. Hence, Fábos (1995) incorporated coastal areas into the frame of “ecologically significant corridors and natural systems” on behalf of sustainable biodiversity and wildlife mobility. Consequently, the comprehensive ecological analysis of the landscapes involving the coastal areas support the sustainable greenway and land use planning objectives (Hawkins and Selman, 2002; Ryan et al., 2006).

The geomorphology of Western Black Sea Region (Turkey) coastal zones is particularly mountainous and scarp; partly craggy in patches. Therefore, transportation is relatively difficult with narrow and meandering roads allowing limited, slow and slightly dangerous travel. Construction campaign of new roads introducing highways and tunnels to the region result in development and progress of transportation. Nevertheless, these transportation improvements lead to negative impacts and disturbances on the landscape ecology and environment generating fragments, discrete patches and habitats (Forman and Alexander, 1998; Forman and Deblinger, 2000). Amasra and Kurucaşile route is part of this road construction campaign which have been initiated since the beginning of this century and still continuing.

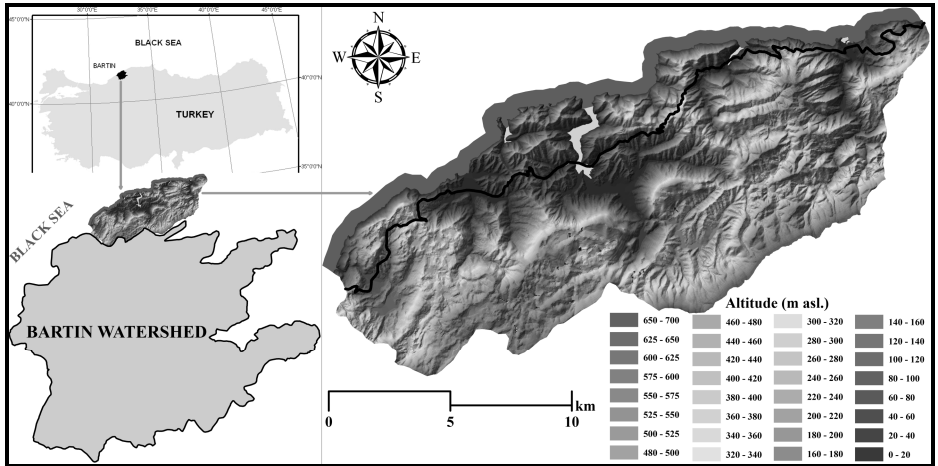
In order to evaluate the landscape ecological values, the spatial and seasonal variation of the landscape components along the roadside of Amasra and Kurucaşile route within part of the coastal zone in Bartın Province were investigated in this study. The roadside landscape components primarily involve forest stands, agricultural areas, reefs and settlements; particularly in the form of villages. Many literatures have applied NDVI technique of remote sensing to analyze the landscape ecology (e.g. Liu et al., 2012; Dahlin et al., 2014).

### **Materials and Methods**

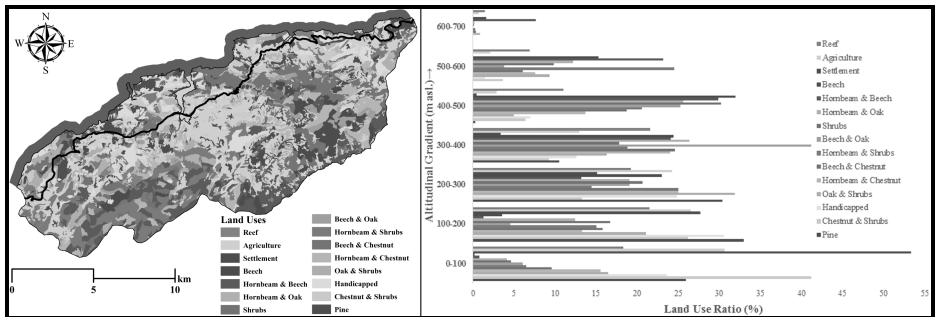
The study area is the coastal zone which extends about 36 km between Amasra and Kurucaşile cities excluding the city centers. The study area which covers 187 km<sup>2</sup>, is located in between 32°41' and 32°71' eastern longitudes, and between 41°71' and 41°84' northern latitudes (Figure 1). The altitude of the coastal zone ranges between the sea level and 700 m asl. The average altitude of the coastal zone is 274 m asl. The average slope of the coastal zone is 14.6° whereas the dominant aspects are towards the Black Sea (northwest, west and north respectively). The average annual total precipitation is 1046 mm. The total precipitations are 49 mm and 121 mm for the driest and wettest months; May and October-December respectively (TSMS, 2014). On the other hand, the average annual temperature is 12.6°C. The mean temperatures are 4.1°C and 22.3°C for the coldest and hottest months; January and July respectively (TSMS, 2014). Based on their durations, the western-northwestern and northern-northeastern winds are prevalent for the coastal zone (TSMS, 2014). The snowy days dominate the December and January with the snow cover depth of 15 cm in average (TSMS, 2014). Therefore, the coastal zone drops into the humid mesothermal climate regime (Atalay, 2011). The gray-brown podsollic, red-yellow podsollic and alluvial soils (TMFAL, 2005) have formed on limestones, sandstones, mudstones, conglomerates and vulcanite-sedimentary rocks (TGDMRE, 2007).

The forest and agricultural areas are the major land uses within the coastal zone (Figure 2). The reefs occur at almost 4% of the coastal zone. The settlements particularly in the form villages are generally located close to the road. These settlements cover about 3% of the coastal zone (Figure 2). Forest vegetation is composed of stands involving trees and shrubs whereas agricultural vegetation primarily comprise hazelnut (*Corylus avellana*), wheat (*Triticum spp.*) and maize (*Zea mays*). Black pine (*Pinus nigra*), maritime pine (*Pinus pinaster*), stone pine (*Pinus pinea* L.), Scots pine (*Pinus sylvestris*) and Turkish pine (*Pinus brutia*) are the major coniferous trees, while European hornbeam (*Carpinus betulus* L.), oriental beech (*Fagus orientalis* Lipsky),

sweet chestnut (*Castanea sativa*), pedunculate oak (*Quercus robur* L.), sessile oak (*Quercus petraea*) and Turkey oak (*Quercus cerris*) are the dominant deciduous ones (TGDF, 2011). Prickly juniper (*Juniperus oxycedrus*), oriental hornbeam (*Carpinus orientalis*), hop hornbeam (*Ostrya carpinifolia*), bay laurel (*Laurus nobilis*), common rhododendron (*Rhododendron ponticum*) and Spanish broom (*Spartium junceum*) are the prevalent shrubs (TGDF, 2011).



**Figure 1. Location of the study area (besides road line and coastal zone) within the Bartın Watershed and Turkey**



**Figure 2. Land use color pattern in May (left) with the distribution (%) of these land uses per altitudinal gradient (right) of the study area**

Using the “intersect” and “dissolve” modules of the “geoprocessing” tools in the Geographical Information Systems (GIS); ArcGIS 10, the land uses particularly the pure and mixed stands of the coniferous and deciduous forests in the coastal zone were determined and grouped. Moreover, the altitudinal gradients (100 m asl.) of the coastal zone were based on the digital contour maps. The 3D model of the coastal zone was delineated using “3D Analyst” module of the ArcGIS 10. Superimposing the digital land use map with the

altitude map, the distribution of these land uses per altitudinal gradient was identified. On the basis of the literature surveys, the temporal color patterns of the land uses; forest stands in particular were decided and consequently depicted on the digital maps. Furthermore, NDVI analysis were applied to the Landsat image of August, 2015 in order to quantify the distribution of the vegetation in the coastal zone. Thus, compatibility of the digital land use map with the NDVI data was tested.

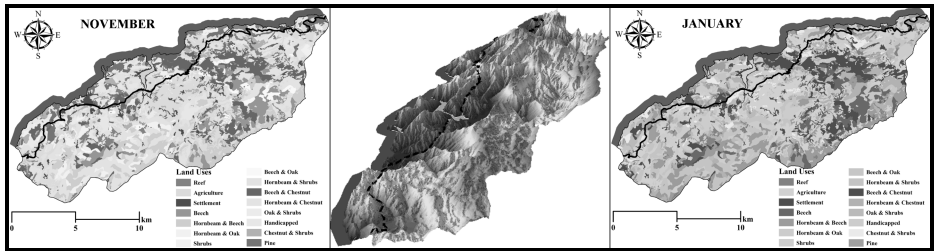
## **Results and Discussion**

Agricultural areas constitute the major land use covering about the 23% of the coastal zone. These agricultural areas are particularly (81% of the areas) located within the gradients of the first 300 m asl. (Figure 2). The villages which accompany these agricultural areas especially occur within the altitudinal gradients of the first 200 m asl. The villagers cultivate the agricultural vegetation and crops composed dominantly of hazelnut, wheat and maize. Since the hazelnut is even a deciduous shrub, its' leaves fade and turn into pale green and yellowish in the autumn until completely shedding in the winter. However, the residuals of wheat and maize are entirely removed from the area leaving the field as grassland in the autumn and winter. The livestock of the villagers graze on grasslands and pastures.

The vegetation period starts around late March and early April lasting about 6 to 7 months within the Bartın region (Öztürk, 2015; Öztürk and Gökyer, 2016). According to the meteorological data of the Bartın Station, the mean air temperature rises up to 11.1°C in April when the maximum and minimum temperatures are 17.6°C and 5.9°C respectively (TSMS, 2014). The soil temperature particularly at the depth of -50 cm has significant influences on the budburst and foliation of the trees (Öztürk et al., 2014; 2015). The mean soil temperature of -50 cm depth is 11.9°C in April when the average total precipitation is 56.3 mm (TSMS, 2014). The onset of foliation for the deciduous trees in the coastal zone; beech, chestnut, hornbeams and oaks is the early April. However, for the beech and oak, this date is delayed about 15 days at the Eastern Europe (Gaydarova, 2003), about one month at the Central Europe (Campioli et al., 2011) and Western Europe (Bequet et al., 2011).

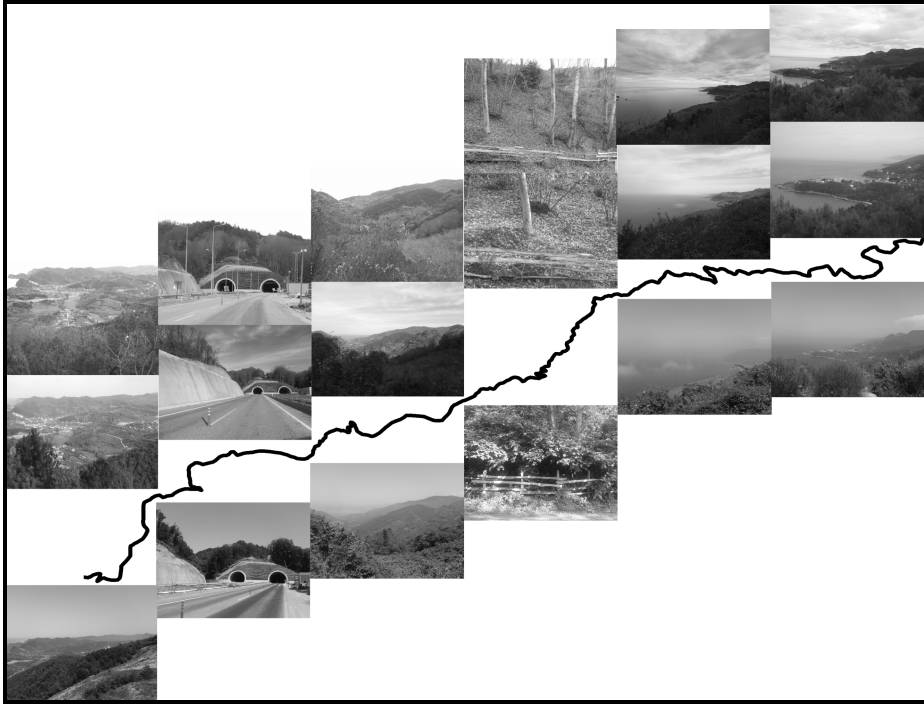
The deciduous mixed stands of oriental beeches with sweet chestnuts and European hornbeams form the second and third major land uses in the coastal zone with around 10% coverages (Figure 2). The mixed stands of oriental beeches with sweet chestnuts dominate the altitudinal gradients from 200 to 500 m asl. (68% of the stands) close to the Kurucaşile city in particular. The dark green leaves of the oriental beech fade into yellowish and reddish during their senescence and shedding in the autumn and winter respectively (Figures

3 and 4). Therefore, their dark and reddish brown bud and shoots together with grayish bark (Yaltırık, 1993) emerge in late winter (Figures 3 and 4). However, glossy green leaves of the sweet chestnut with pale green underside (Anşın and Özkan, 1997) fade into glorious and striking yellow in autumn before shedding in winter while their dusky buds and shoots together with the well-rounded trunk and deeply furrowed gray bark emerge (Figures 3 and 4). On the other hand, the mixed stands of oriental beeches with European hornbeams exist especially at the altitudinal gradients from 300 to 600 m asl. (77% of the stands). They are prevalent at the crests of the hills surrounding the landscape close to the southern boundary of the coastal zone. The green leaves of the European hornbeam fade into golden and orange yellow in autumn (Figures 3 and 4). After shedding their leaves, manifestation of the fluted trunk with the smooth greenish-gray bark and pale brown buds and shoots occurs in late winter (Figures 3 and 4).



**Figure 3. Three-dimensional view (middle) with the land use color patterns in November (left) and January (right) of the study area**

The deciduous mixed stands of European hornbeam with the shrubs particularly involving the oriental hornbeams and hop hornbeams cover almost 10% of the coastal zone (Figure 2). The hornbeams are the most prevalent trees in Bartın province and vicinity (Yılmaz, 2001). These mixed stands exist within the broad altitudinal range mostly between 100 m asl. and 600 m asl. The foliage and defoliation pattern of oriental hornbeams are similar with the European hornbeams whereas trunk of the former is not fluted. The hop hornbeam also displays the similar foliage and defoliation patterns like the European hornbeam and its' rough bark appears during the leafless period (Figures 3 and 4). The forests which have been handicapped for several reasons including the pure ecological conditions and abandonment of former agricultural lands spread relatively large areas (approximately 9%). These handicapped areas particularly extend from the sea level to the 300 m asl. and occur almost along the entire road landscape.



**Figure 4. Spring-summer (below the road line), autumn and winter (above the road line respectively) photographs of along the road of the study area**

The deciduous mixed stands of European hornbeams and sweet chestnuts also cover about 9% of the coastal zone (Figure 2). They also dominate broad altitudinal range from the sea level up to the 500 m asl. They can be encountered almost along the entire road landscape. In addition, the pure stands of oriental beeches appear approximately at the 6% of the coastal zone reaching from 200 m asl. up to 600 m asl. Nevertheless, the pure stands of pines which cover almost 5% of the coastal zone prevail along the first 300 m asl. altitudinal gradients (89% of the stands). Although the pines do shed their leaves in relatively few amounts, they exhibit the seasonal color pattern via navigating throughout the hues of green. Whereas the stone pines and maritime pines are identified with the sea level, the black pines, Scots pines and Turkish pines occur at relatively the higher altitudes. The reefs that yielded from limestones, sandstones and mudstones accompany these roadside vegetation within diverse altitudinal gradients. At almost the 4% of the coastal zone, those reefs have become integrated with the overall landscape especially contrasting with the vegetation during spring and summer, and harmonizing with that vegetation during autumn and winter (Figure 2).

The initial fading due to senescence of the leaves occurs in August and September within the Bartın region (Öztürk, 2015). The mean air temperature of 21.9°C in August drops to 17.7°C in September when the maximum and minimum air temperatures are 24.9°C and 12.1°C respectively. The mean soil temperature of -50 cm depth descends only about 2.5°C in September compared to the August. On the other hand, the average total precipitation increase to 96.7 mm (TSMS, 2014). In the mid-November, the leaves of the deciduous trees which reflect the hues of yellow fall in half (Figures 3 and 4) (Öztürk, 2015). The maximum and minimum air temperatures are respectively 15.3°C and 4.2°C in November when the mean air and soil temperatures (-50 cm) are only 8.8°C and 12.5°C respectively. However, the average total precipitation ascends to 116.1 mm (TSMS, 2014). According to studies on alders in Northern Europe (Eschenbach ve Kappen, 1996), and on birches and beeches in Japan (Nasahara et al., 2008; Muraoka et al., 2010; Nagai et al., 2011), these deciduous trees became almost entirely leafless at the end of November. The precipitation rarely occurs in the form of snow in November (TSMS, 2014). Furthermore, the deciduous trees completely shed their leaves in January when the snow dominates approximately 8 days. The mean depth of the snow cover reaches almost 12 cm in January when the mean air and soil temperatures (-50 cm) are 4.1°C and 6.7°C respectively (TSMS, 2014). The maximum and minimum air temperatures are 9.1°C and 0.4°C respectively in January when the average total precipitation is 105.6 mm (TSMS, 2014).

The deciduous mixed stands of European hornbeams and oaks exist at only about 3% of the coastal zone (Figure 2). These mixed stands occur particularly between the altitudinal gradients of 200 and 500 m asl. (71% of the stands). They especially occur close to the Amasra city. Three species of oaks appear in the coastal zone; pedunculate, sessile and Turkey oaks. The dark green leaves of the pedunculate oak with a large crown fade into reddish brown in autumn. The magnificent leafless crown of the pedunculate oak makes their twisted trunk with gray-brown fissured bark, and dark brown buds and shoots apparent in late winter (Figures 3 and 4). The trunks and barks of the latter species are similar with the pedunculate oak. However, the dark green leaves of the sessile oak with a broad crown turn into orange brown in autumn (Figures 3 and 4). The pale brown buds and shoots of sessile oak become obvious in late winter (Yaltırık, 1993). On the other hand, the dark and glossy green leaves of the Turkey oak fade into yellow to gold in autumn (Figures 3 and 4). The buds of the Turkey oak are lighter in color (reddish brown) compared to the other two oak species. The deciduous mixed stands of chestnut and shrubs occur at only about 3% of the coastal zone ranging within the first 200 m asl. in particular (Figure 2). They extend throughout and close to the roadside. However, the deciduous mixed stands of beeches with the oaks that cover only about 2% of

the coastal zone (Figure 2). They particularly dominate the altitudinal gradients between 200 and 500 m asl. (86% of the stands). In contrast, the mixed stands of oaks with the shrubs that cover only 2% of the coastal zone, are prevalent within the first 200 m asl. (86% of stands). The remaining 1.5% of the coastal zone is covered by the shrubs consisting of the prickly junipers, bay laurels, common rhododendrons and Spanish brooms in particular. They extend from the altitudinal gradient of 100 m asl. up to the 600 m asl.

According to the NDVI analysis, 79% of the coastal zone is covered with forest whereas 15% of the coastal zone is covered with agricultural areas. On the other hand, settlements together with the reefs occur at the 6% of the coastal zone. These NDVI results indicate, to some extent the compatibility of the remote sensing data with the digitized actual land use data.

### **Conclusion**

The spatial and seasonal pattern of the roadside landscape components were analyzed for the Amasra-Kurucaşile coastal zone in this study. The characteristics of those landscape components particularly the roadside vegetation were comprehensively evaluated in terms of their phenological traits. The results of this study not only contribute to the physical determination of the roadside landscape characteristics but also promote conceiving of the roadside vegetation from the aesthetic frame. Therefore, the discussion intensively concentrated on the spatial and temporal color patterns of the roadside vegetation. Hence the spatial and temporal color patterns of vegetation is relatively one of the less referred topics of landscape architecture.

Since the road construction campaign along the coastal zone is still in operation, the ecological sensitivity of the corridors should delicately be detected in order to prevent the pristine coastal zone from disturbances and mitigate the possible impacts. Furthermore, integrated roadside and coastal zone planning around the concept of greenway and land use planning will be essential not only for recreational and aesthetic objectives the but also for the biodiversity and habitat sustainability.

Environmental consequences of the road construction also involve dealing with the possible climate warming impacts. Associated with the global warming, the possible climate warming that would originate from the road materials and vehicles threaten the natural environment by putting pressure on flora and fauna in the coastal zone. Consequently, sustainable landscape planning that consider and base on ecological and phenological aspects of the natural environment is certainly requisite for the roadside and the coastal zone.



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