A Quantitative Analysis of the Woody Vegetation in Ajloun Forest Reserve-Jordan

Anas E. Abu Yahya* and Sameh Khatatbeh

Royal Society for the Conservation of Nature, P.O. Box 1215, Amman, 11941, Jordan

Received: December 7, 2020; Revised: February 6, 2021; Accepted: February 19, 2021

Abstract: Ajloun Forest Reserve was established to conserve the evergreen oak (*Quercus coccifera* L.), which is one of the only four forest types that have been recorded in Jordan. There are many forces which cause degradation for such ecosystems, including natural (low rainfall, drought) and human (overgrazing, firing, woodcutting) factors. The objective of this study is to assess the status of vegetation structure in terms of the existing woody species using vegetation attributes. This will provide scientific-based tools for the management to identify the trend of the forest. The survey was carried out in October 2016 using 102 macro-plots with a micro-plot located in the center. The woody plants were classified into three basic classes: trees, shrubs, and climbers; also their regeneration and their vegetation attributes (density, frequency, abundance, and their relatives) were calculated. The results revealed that the estimated woody area is 54% and the ground cover is 46% of the reserve. As for the tree layer, *Quercus coccifera* L. exhibited the highest values and *Phillyrea latifolia* L. showed the lowest values. Trees' regeneration showed the same trend. As for eclimbers' layer, *Smilex aspera* L. showed the highest values, while *Ephedra aphylla* Forssk. has the lowest values. The same results apply to the climbers' regeneration. As for the shrubs' layer, *Cistus creticus* L. recorded the highest values and *Ruta chalepensis* L. recorded the lowest values. As for their regenerations, *Cistus creticus* L. recorded the highest values while some species recorded a zero value. The structure of the Ajloun Forest Reserve is composed mostly of *Quercus coccifera* L. with high values of density parameter. The regeneration is concentrated in the east, north, west, and center of the reserve, while the south and south-west areas displayed the least values of regeneration which may be attributed to the existence of little canopy cover, grazing and the fact that it is more exposed to sunlight (south facing). *Rhamnus palaestinus* Boiss. and *Cistus creticus* L. have high values, which were reported as indicator species for Mediterranean non-Forest vegetation. To ensure the sustainability of forest ecosystems, monitoring programs of woody species and their regeneration, as well as the indicator species of ecosystem degradation should be taken into consideration while making the reserve management plans.

Keywords: Evergreen Oak, Vegetation attributes, Ajloun Forest Reserve.

*Corresponding author:
anas.sabbarenie@rscn.org.jo

Introduction

Jordan's forest communities are limited in extent in the northern parts of the country in addition to scattered regions in the south comprising less than 1% of the country's total area (DeMeo *et al*., 2010). Al-Esawi (1996) classified forests in Jordan into four types: Pine Forests (*Pinus halepensis* Mill.), Evergreen Oak Forests (*Quercus coccifera* L.), Deciduous Oak Forests (*Quercus ithaburensis* Decne.), and Juniper Forests (*Juniperus phoenicea* L.). The forest ecosystem plays a very important ecological and environmental role, and provides many services for human beings including provisioning (medicinal plants), regulating (soil erosion), in addition to some cultural (recreational), and supporting (nutrient cycling) services (Reid *et al.,* 2005). However,

there are different factors and driving forces that lead to the deterioration of such natural heritage, including natural factors (drought) and human activities (overgrazing, wood cutting, fires and agricultural expansion). The fragility of such an ecosystem in Jordan needs comprehensive monitoring programs for a better understanding of the forest dynamics. This knowledge will direct the mitigation and management policies at the conservation and sustainability of the ecological values of the forest despite all the threats.

The Ajloun Forest Reserve has an area of about 12km² totally fenced. It was established in 1987 to protect the stand of *Quercus coccifera* L. and other associated bio-species of flora and fauna. The altitude ranges from 900 to1050m with typical Mediterranean conditions, i.e., a cool rainy and snowy winter (average temperature 10°C), and a hot dry summer (average temperature 30°C). The annual rainfall is around 500mm. The soil is of the red Terra-Rosa type, which gives this Mediterranean region the best biodiversity status in the country (Al-Eisawi, 1996).

However, activities of overgrazing, woodcutting, intensive collecting of medicinal plants, invasion of alien species, climate change, tourism, and the refugee issue are responsible for the acceleration of the deterioration of this forest ecosystem (MoEnv, 2015). These accelerating challenges have led to a sharp deterioration in this ecosystem and to the loss of its biodiversity components and therefore its proper functioning and the services it provides. Indeed, woody plant regeneration in the forest is a natural process that expresses the dynamics of forest reproduction (Wang *et. al.*, 2008) and it is essential for the conservation of biodiversity in the ecosystem (Rahman *et al*., 2011).

Understanding the regeneration status and dynamics is crucial for planning management activities (Puhlick *et. al.,* 2012). This survey is aimed at assessing the status of vegetation structure in terms of the woody plant species (trees, shrubs, and climbers) using vegetation attributes including density, relative density, frequency, relative frequency, and abundance.

Materials and Methods

The survey was carried out over the period 15-30 October 2016 using the quadrate method. A total of 102 quadrates (macro-plot) of 250m X 250m were selected and a micro-plot of 10x10m located in the center of each macro-plot was implemented.Indeed, this restricted number of quadrates is taken out of the 157 quadrate that cover the whole reserve due to the rugged topography, tangled vegetation, and private lands (Figure 1).On the other hand, the Society of American Foresters classified plants according to growth habits into: trees (woody perennial plants that attain a height of at least 4-5m), shrubs ("a perennial woody plant smaller than a tree, usually with several perennial stems branched from the base"), and climbers (or vines) (a "woody or herbaceous plant with the stems not erect but depending on other plants or objects for support") (Clepper, 1944).

Furthermore, natural regeneration (non-reproductive individuals) of all recorded species was included in the listed records. The following attributes or parameters were calculated using the formulas as described by Krebs (1956) including density, relative density, frequency, relative frequency, and abundance as follow:

Density = (Total Number of individuals of a specie in all plots / Total number of plots studied)

Relative Density = [Total number of each species in all transect (plots) / Total number of plots studied] X 100

Frequency = [Total Number of plots in which the species occurs / Total number of plots studied] X 100

Relative Frequency = [Number of occurrences of a species in study area / Number of occurrences of all species in the same area] X 100

Abundance = (Total Number of individuals of species in all plots / Total number of plots in which the species occurs)

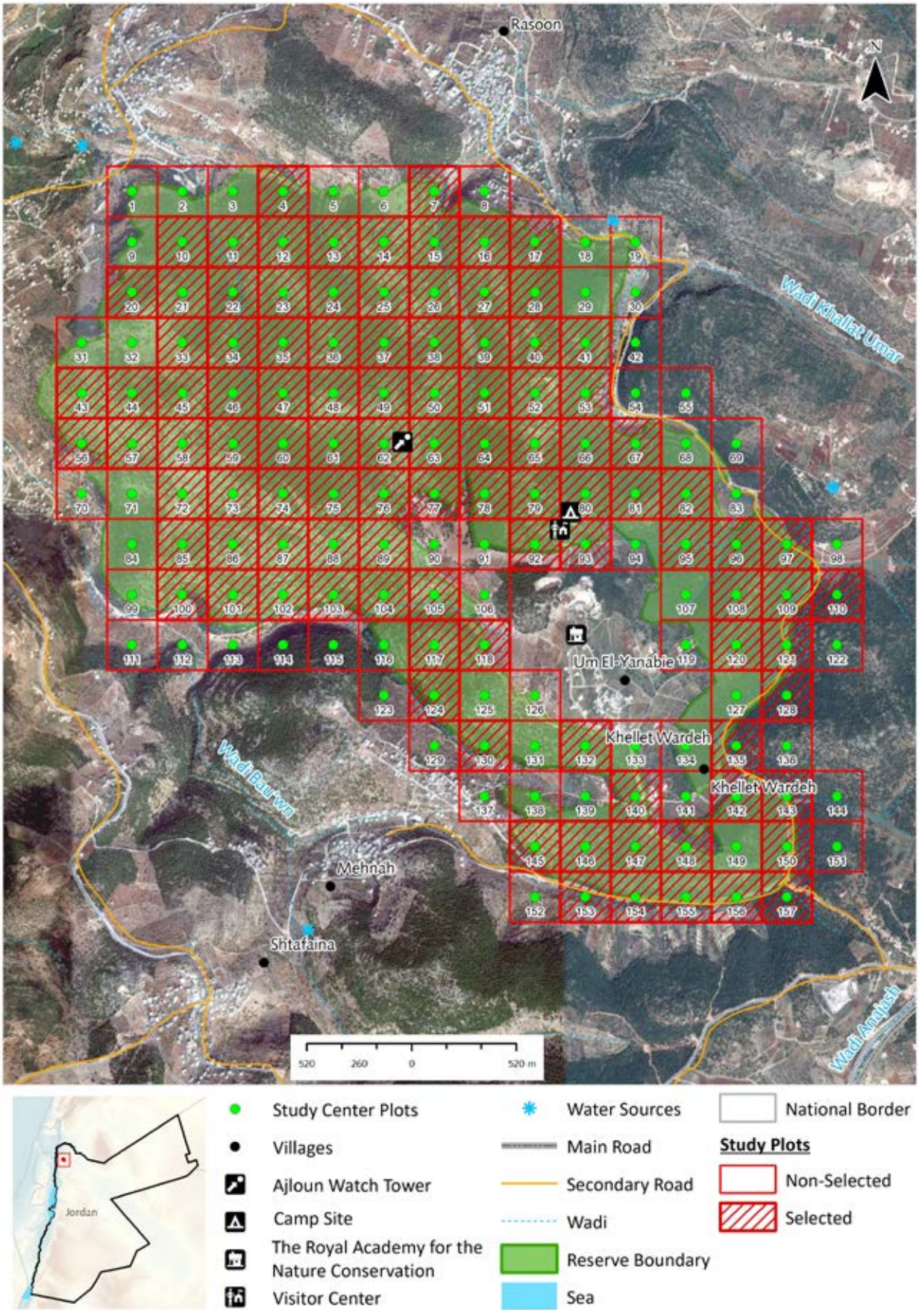

Figure 1. Map of surveyed quadrates (selected) at Ajloun Forest Reserve

However, abundance does not a full picture of the species numerical strength (Al-Eisawi and Oran, 2015), and relative abundance depends on the determination of the canopy cover of all species, which should not be considered for precision purposes. Thus, relative abundance will not be calculated in this study.

Results

Ground and Woody Cover

The results revealed that the area of the woody vegetation cover in the Ajloun Forest Reserve was estimated at 54% of the total area; of which the ground cover area constituted 46% and included small gravels, soil, rocks, and leaves.

Trees

Attributes of the Trees' Layer

During the survey, ten tree species have been recorded, of which *Quercus coccifera* L. showed the highest values of all attributes, whereas *Phillyrea latifolia* L. exhibited the lowest values of attributes in general with the exception of abundance, which has been recorded for *Crataegus aronia* (L.) Bosc ex DC. (Table 1).

Attributes of Trees Regenerations

Quercus coccifera L. regeneration has the highest value of all attributes (Table 2). *Phillyrea latifolia* L. and *Rhamnus palaestinus* Boiss recorded the lowest values of density and abundance respectively. Whereas *Phillyrea latifolia* L. recorded the lowest percentages of frequency, relative frequency, and relative density.

Climbers

Attributes of Climbers' Layer

Among the five climber's species that have been recorded in the reserve, the *Smilex aspera* L. showed the highest values of density, relative density, frequency, relative frequency, and abundance as shown in table 3. While *Ephedra aphylla* Forssk showed the lowest values of attributes with the exception of abundance, which was recorded for *Lonicera etrusca* Santi

Attributes of Climbers' Regenerations

Ephedra aphylla Forssk showed the highest abundance value followed by *Smilax aspera* L., whereas there was no record of the other climber species' regenerations within the quadrate (Table 4). At the same time, *Smilex aspera* L. recorded the highest percentages of frequency, relative density, and relative abundance followed by *Ephedra aphylla* Forssk. Zero values of regeneration for other climber species were recorded.

Shrubs

Attributes' Results of the Shrubs' Layer

Among the six shrub species that have been recorded in the survey, *Cistus creticus* L. recorded the highest values of all attributes excluding abundance, whereas the highest value was recorded by *Osyris alba* L. (Table 5). Furthermore, *Ruta chalepensis* L. recorded the lowest values of attributes excluding abundance which was recorded for *Prasium majus* L.

Attributes' Results of Shrubs' Regeneration

Cistus creticus L. recorded the highest density value followed by *Osyris alba* L. and *Phlomis viscosa* Poir, whereas other species recorded zero density values (Table 6). The ranking of species abundance values was *Osyris alba* L., *Cistus criticus* L., and *Phlomis viscosa* Poir with no records for other species. The highest percentages of frequency, relative density, and relative abundance for this species was recorded for *Cistus criticus* L. followed by *Phlomis viscosa* Poir. and *Osyris alba* L. Again, zero values of these attributes for the other shrub species within the quadrate were recorded.

Table 1. Values of all calculated attributes of recorded trees in 2016

Scientific Name	Density	Frequency%	Abundance	Relative Density%	Relative Frequency%
Arbutus andrachne L.	0.65	24.51	2.64	6.99	12.25
Cercis siliquastrum L.	0.08	2.94	2.67	0.85	1.47
Crataegus aronia (L.) Bosc ex DC.	0.16	13.73	1.14	1.69	6.86
Phillyrea latifolia L.	0.03	0.98	3.00	0.32	0.49
Pistacia palaestina Boiss.	0.58	43.14	1.34	6.25	21.57
Pyrus syriaca Boiss.	0.03	2.94	1.00	0.32	1.47
Quercus coccifera L.	7.36	93.14	7.91	79.56	46.57
Quercus infectoria G.Olivier	0.28	11.76	2.42	3.07	5.88
Rhamnus palaestinus Boiss.	0.06	4.90	1.20	0.64	2.45
Styrax officinalis L.	0.03	1.96	1.50	0.32	0.98

Table 2. Values of all calculated attributes of trees' regeneration in 2016.

Scientific Name	Density	Frequency%	Abundance	Relative Density%	Relative Frequency%
Arbutus andrachne L.	0.23	8.82	2.56	1.00	4.19
Cercis siliquastrum L.	0.14	2.94	4.67	0.61	1.40
Crataegus aronia (L.) Bosc ex DC.	0.32	16.67	1.94	1.44	7.91
Phillyrea latifolia L.	0.05	1.96	2.50	0.22	0.93
Pistacia palaestina Boiss.	1.16	52.94	2.19	5.14	25.12
Pyrus syriaca Boiss.	0.60	3.92	15.25	2.66	1.86
Quercus coccifera L.	18.10	91.18	19.85	80.44	43.26
Quercus infectoria G.Olivier	1.67	15.69	10.63	7.41	7.44
Rhamnus palaestinus Boiss.	0.15	12.75	1.15	0.65	6.05
Styrax officinalis L.	0.10	3.92	2.50	0.44	1.86

Table 3. Values of all calculated attributes of recorded climbers in 2016.

Scientific Name	Density	Frequency%	Abundance	Relative Density%	Relative Frequency%
Clematis cirrhosa L.	0.41	12.75	3.23	10.80	12.38
Ephedra aphylla Forssk.	0.21	7.84	2.63	5.40	7.62
Lonicera etrusca Santi	0.29	15.69	1.88	7.71	15.24
Rubia tenuifolia d'Urv.	0.59	20.59	2.86	15.42	20.00
Smilax aspera L.	2.31	46.08	5.02	60.67	44.76

Table 4. Values of all calculated attributes of climbers' regeneration in 2016.

Scientific Name	Density	Frequency%	Abundance	Relative Density%	Relative Frequency%
Clematis cirrhosa L.	0.00	0.00	0.00	0.00	0.00
Ephedra aphylla Forssk.	0.39	0.98	40.00	48.78	10.00
Lonicera etrusca Santi	0.00	0.00	0.00	0.00	0.00
Rubia tenuifolia d'Urv.	0.00	0.00	0.00	0.00	0.00
Smilex aspera L.	0.41	8.82	4.67	51.22	90.00

Table 5. Values of all calculated attributes of recorded shrubs in 2016.

Scientific Name	Density	Frequency%	Abundance	Relative Density%	Relative Frequency%
Asparagus aphyllus L.	0.36	20.59	1.76	6.73	19.09
Cistus criticus L.	2.65	39.22	6.75	49.09	36.36
Osyris alba L.	0.79	7.84	10.13	14.73	7.27
Phlomis viscosa Poir.	1.50	34.31	4.37	27.82	31.82
Prasium majus L.	0.06	4.90	1.20	1.09	4.55
Ruta chalepensis L.	0.03	0.98	3.00	0.55	0.91

Table 6. Values of all calculated attributes of shrubs' regeneration in 2016.

Scientific Name	Density	Frequency%	Abundance	Relative Density%	Relative Frequency%
Asparagus aphyllus L.	0.00	0.00	0.00	0.00	0.00
Cistus creticus L.	0.23	6.86	3.29	52.27	46.67
Osyris alba L.	0.12	1.96	6.00	27.27	13.33
Phlomis viscosa Poir.	0.09	5.88	1.50	20.45	40.00
Prasium majus L.	0.00	0.00	0.00	0.00	0.00
Ruta chalepensis L.	0.00	0.00	0.00	0.00	0.00

Discussion

The vegetation cover of the woody species in the Ajloun Forest Reserve constitutes around 55% of 12km² which comprises the reserve's total area. This is an indication that it is one of the highest vegetation density and diversity in the country; the forest ecosystem is described as having the highest richness and diversity of all the vegetation cover in Jordan. Al-Eisawi and Oran (2015) reported that the best vegetation covers in the north of the country ranges from 40 to 100%.

The survey confirmed the significant dominance of *Quercus coccifera* L. over other plant species in terms of both composition and regeneration. On the other hand, the current survey revealed that the Ajloun Forest Reserve is characterized by the highest number of tree density compared to other places in the country with about 925.5 trees per hectare. Specifically, the density values of *Quercus coccifera* L., *Arbutus andrachne* L., *Pistacia palaestina* Boiss., and *Quercus infectoria* L. were 736 plant/ha, 65 plant/ha, 58 plant/ha, and 28 plant/ha, respectively.

Tadros and Ananbeh (2018) reported that the density values of the leading woody species in the Ajloun Forest Reserve were as follows: *Quercus coccifera* L. (412.4 plant/ha), *Arbutus andrachne* L. (165 plant/ha), *Pistacia palaestina* Boiss (144.3 plant/ha), and *Quercus infectoria* L. (82.5 plant/ha). All previous results are in agreement with the management objective of the reserve to conserve a healthy, dominant, and representative vegetation of *Quercus coccifera* L. in the northern parts of the country (RSCN, 2016).

The survey results showed high values of the density parameter, in parallel with good regeneration levels for these plant species. The new seedlings of *Quercus coccifera* L. is concentrated in the dense areas in the east, north, west, and center of the reserve, while the south and south-west areas of the reserve showed the least regeneration value, which may be attributed to having less canopy cover, grazing, and more exposure to sun light (south facing).

All of the aforementioned indicators confirm that *Quercus coccifera* L. and its regeneration appear to be viable within the reserve, which agreed with the results of DeMeo *et al*. (2010) and Tadros and Ananbeh (2018). The current survey covers the whole area of the reserve in comparison to others. The regeneration of the tree species provides a good indicator of the ecological status. The dominance of *Quercus coccifera* L. has been recognized

and confirmed clearly, but other species need to be investigated, such as *Arbutus andrachne* L. and *Pistacia palaestina* Boiss. Proper planning is an essential requirement to ensure a successful forest management (Davis *et al*., 2001) and this includes the ability to predict future forest structure and composition (Taylor *et al*., 2008).

Correspondingly, *Cistus creticus* L. showed dominance over other species and *Rhamnus palaestinus* Boiss. showed good values in terms of vegetation attributes. *Rhamnus palaestinus* Boiss. and *Cistus creticus* L. were reported by Al-Eisawi (1996) as indicator species for the Mediterranean non-forest Vegetation and are treated as degraded forests. Recording such plants with high values of vegetation attributes should be taken into account in the making of the reserve management plans.

Most of the phytogeographical region in Jordan is under anthropogenic and natural threats that are changing the structure and composition of woody vegetation (Al-Eisawi and Oran, 2015). Subsequently, more efforts are needed toto face the ever-increasing threats through *in situ* conservation of such critical ecosystems, since the protected areas would be the cornerstone of biodiversity conservation (Gaston *et al*., 2008). Forests and the regeneration of woody species are an essential indicator the conservation of biodiversity (Hossain *et al*., 2004), which supports the developing of management activities and helps determine priorities to ensure the sustainability of these ecosystems (Haider *et al*., 2017).

Acknowledgement

The authors are grateful to the RSCN management for their support throughout this work namely Mr. Yehya Khaled- the general director and Dr. Nashat Hamidan- director of Conservation Monitoring Centre (CMC). Thanks are extended to colleagues in CMC, especially the GIS unit who prepared the required maps for this survey, and to all other colleagues who have provided support during all phases of this survey.

References

Al Eisawi D. 1996. **Vegetation of Jordan**. Regional Office for Science and Technology for the Arab States, UNESCO, Cairo.

Al-Eisawi, D and Oran, S. 2015. Assessment of the vegetation cover of northern high mountains in Jordan. *Journal of Biodiversity and Environmental Sciences*, **6 (5):** 93-106.

Clepper, H. 1944. Editorial: Forestry Terminology. *Journal of Forestry*, **42(2):** 79–80

Davis LS, Johnson KN, Bettinger PS and Howard TE. 2001. **Forest management: To Sustain Ecological, Economic and Social Values**, 4th ed. McGraw-Hill, New York.

DeMeo, D, Triepke, J, Smadi, M, Ananbeh, Y and Duran, F. 2010. Forest inventory and monitoring of Ajloun Reserve-Jordan. *Natural Areas Journal*, **30 (3):** 271-278.

Gaston, KJ, Jacksonm SF, Cantú-Salazar, L and Cruz-Piñón, G. 2008. The ecological performance of protected areas. *Annual Review of Ecology, Evolution, and Systematics*, **39 (1):** 93-113.

Haider, MR, Alam, S and Mohiuddin, M. 2017. Regeneration potentials of native tree species in three natural forests of Sylhet, Bangladesh. *Journal of Biodiversity Conservation and Bioresource Management***, 3(2):** 1–10.

Hossain, MK, Rahman, ML, Hoque, ATMR and Alam, MK. 2004. Comparative regeneration status in a natural forest and enrichment plantations of Chittagong (south) forest division. *Bangladesh Journal of Forestry Research***, 15 (4):** 255–260.

Krebs CJ. 1956. **Ecological Methodology**, Harper and Collins, New York.

Ministry of Environment (MoEnv). 2015. The National Biodiversity Strategy and Action Plan (NBSAP). Amman.

Puhlick, JJ, Laughlin, DC and Moore, MM. 2012. Factors influencing ponderosa pine regeneration in the

southwestern USA. *Forest Ecology and Management*, **264:** 10–19.

Rahman, MH, Khan, MASA, Roy, B and Fardusi, MJ. 2011. Assessment of natural regeneration status and diversity of tree species in the biodiversity conservation areas of Northeastern Bangladesh. *Journal of Forestry Research*, **22 (4):** 551.

Reid W, Mooney H, Cropper A, Capistrano D, Carpenter S and Chopra K. 2005. **Millennium Ecosystem Assessment. Ecosystems and Human Well-Being: Synthesis**. Island Press: Washington, DC, USA.

Royal Society for the Conservation of Nature (RSCN). 2016. Ajloun Forest Reserve Management Plan. Amman. (unpublished report).

Tadros, M and Ananbeh, Y. 2018. Vegetation Composition and Structure of Woody Plant Communities in Ajloun Forest Reserve. *Jordan Journal of Agricultural Sciences*, **14 (2):** 223-230.

Taylor, AR, Chen, HYH and Van Damme, L. 2008. A Review of Forest Succession Models and Their Suitability for Forest Management Planning. *Forest Science*, **55 (1):** 23-36.

Wang, H, Li, G, Yu, D and Chen, Y. 2008. Barrier effect of litter layer on natural regeneration of forests: a review. *Chinese Journal of Ecology*, **27:** 83–88.