The Impact of Eucalypts Plantation on Soil Moisture and Ground Vegetation Cover at St. Michaels in the Roma valley, Lesotho

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Abstract

The main aim of the present study was to assess the impact of *Eucalyptus rubida* plantation on soil moisture and ground vegetation cover in Lesotho. Since forestry is about the people as well as the environment, the methodology that was adopted in this study included questionnaire survey, soil moisture monitoring and vegetation survey. Local people between the ages of 40 to over 70 years were interviewed and the assumption was that people in these age category know better the impacts of the eucalypts in the area over the years. Three land-use types (eucalypts plantation, indigenous forest and grassland/rangeland) on the same topography, aspect and soil type were identified and studied and the results of soil moisture status after a rainfall event (over 5 days period) and ground vegetation cover were compared. The indigenous forest comprised of a mixture of tree species that include *Leucosidea sericea*, *Buddleja salviifolia, Rhus dentata*, *Rhus divaricata*, *Rhmnus prinoides*, *Euclea coriacea* and *Olea Africana* while the rangeland was mainly *eragrostis/aristida* grassland. The rate of soil moisture decrease between the three land-use types was significant and was in the following order: eucalypts plantation (3.37% per day) > indigenous forest (1.63% per day) > grassland/rangeland (1.56% per day). The high rate of soil moisture decrease of 3.37% per day could be attributed to high evapotranspiration rate of the eucalypts plantation. The frequency of ground flora of forbs, grasses and brush was found to be highest under the grassland followed by the indigenous forest and then eucalypts plantation. As pressure continues on the diversity of ground flora species as a result of anthropogenic influences and climate change it is imperative that robust inventory be done to document species and their pattern under different land-uses. Diversity of vegetative species provides livelihoods well-being and economic development and with the current level of research in Lesotho it is highly likely that ground flora vegetation will go extinct without anyone noticing. Policy implication of the findings of this study is that governments and other stakeholders will be informed when making-decisions, investing, budgeting and planning for *eucalyptus rubida*. The study will further help bring a shift in societal attitude towards both the indigenous forests and eucalypts.

Introduction

Lesotho did not have plantation forests prior to arrival of missionaries in 1833 (May, 1992). According to the 1992 Records of the Past Initiatives and Achievements by David May, missionaries exhausted trees of timber size during the establishment of their mission stations and it would seem that their tree planting endeavour was a means to counteract the effects of deforestation such as soil erosion and also help with firewood supply to the local inhabitants. It was during this time when land degradation was increasing that the government of Lesotho established the department of Agriculture in 1936 which was mandated to plant trees in an effort to control soil erosion (Sekaleli E.S). Foreign involvement in tree planting in Lesotho started in 1973 with the establishment of the Lesotho Woodlot Project (LWP) financed by the Anglo-American Cooperation, World Food Programme and the government of Lesotho.

Lesotho Woodlot Project began establishing eucalypts and pine plantations for local supply of poles and fuel wood and had by 1987 established about 7500 ha of eucalypts and pines plantations (Forest Division, 1991). LWP imported 46 species of eucalyptus from Australia between 1978 and 1979 (Richardson, 1985). *Eucalyptus rubida* has been widely planted and is recommended for planting in all agro-ecological zones of Lesotho with *E. stellulata* suitable for colder and wet areas while *E. macarthurii* and *E.nitens* are recommended for lower altitudes (Richardson, 1985). In 1993, the social forestry project was launched with the aim to encourage, assist, guide individuals, communities, schools and villages to plant and manage their own trees and forests. The Ministry of Forestry and Land Reclamation, which is responsible to showcase the contribution that forests can make to the alleviation of poverty, livelihood security and environmental protection in Lesotho (Lesotho Workcamps Association, 2009), has established forest plantations (including pine plantations) on large areas and this is continuing to increase in Lesotho. It must be noted, however, that Lesotho is still one of the least forested countries in Southern Africa as only 1.45% of the land area is estimated to be forested (Ministry of Forestry and Land Reclamation, 2008).

Greenpeace's co-founder, Dr Patrick Moore, believes that trees are the answer to many questions about the future of human civilisation and the preservation of the environment (Woodland Heritage, 2012). In the advent of climate change many scientists will concur with him. As an example, Sathaye and Ravindranath (1997) assert that managing forests to retain and increase their stored carbon will help reduce atmospheric carbon-dioxide and stabilize climate change. Furthermore, Macdicken (1997) states that carbon storage can be increased by expanding the area of tree plantations. However, there are claims that forest plantations in some areas have led to reductions in water yields from afforested catchments, as they use more water than the original grasslands or natural woodlands (Scott et al., 2000). One of the tree species reported to have negative effects on water yield is eucalypts (Pepper, 1896). A major argument against eucalypts plantations is that eucalypts remove excessive amounts of water from the soil, underground reserves and streams, and inhibit the growth of other vegetation under their canopy (Wise et al., 2011). The precise impacts of eucalypts plantations on water resources are diverse and not clear-cut and, therefore, subject to argument. Other authors including Wise et al., (2011) believe that eucalypts are efficient water users and should be planted in large numbers.

The study therefore investigated the impact of eucalypts plantations on soil moisture and ground vegetation cover at St. Michaels in the Roma valley, Lesotho with the following specific objectives:

1) Identify and document people's perceptions on the impacts of eucalyptus rubida on soil moisture and on ground vegetation cover in the Roma valley.

2) Determine soil moisture content levels under the two forest types (eucalypts and indigenous forests) and the adjacent non-forested land (grassland/rangeland) after a rainfall event at St.Michaels in the Roma valley.

3) Examine the herbaceous plants species and ground cover under the canopy of both forest types and compare with the adjacent non-forested land (grassland/rangeland).

4) Make policy recommendations based on the outcome of the study

Materials and Methods

Study area

The study was conducted at St.Michaels in the Roma valley located in the lowland agro-ecological zone of Lesotho in Maseru district (Fig.1). The site was chosen because of the arising concerns in the area that eucalypts plantations are diminishing the community's scarce water resources and that they should be cut and replaced with the indigenous forest. Furthermore, the site has also been chosen due to its close proximity to the National University of Lesotho Research Station to allow easy monitoring of soil moisture depletion after a rainfall event. The Roma valley is broad and fertile with its geological formation generally dominated by sedimentary rocks and surrounded by sandstone cliffs topped to the east by Basalt Mountains. The terrain is mostly hills and valleys dominated by undulating and rolling dissected plains. The elevation of the study area ranges from 1650m to 1787m.

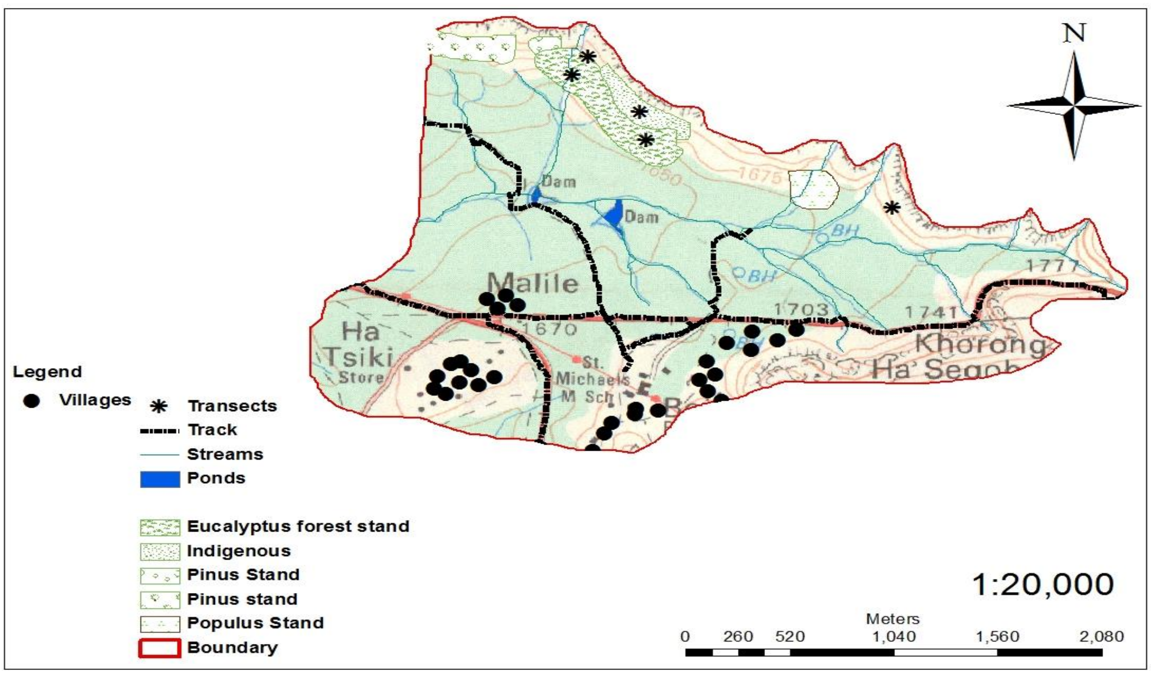

Fig. 1: Catchment area for the study area of St.Michaels in the Roma valley

Climate

In general, the climate of the area can be described as temperate, continental, sub-humid (Chakela, 1981) with mean annual rainfall ranging from 9mm in July and August to 75mm in November. Rainfall in this area is highest in the months of October to April during the rainy season and is drier between June and July (Fig.2).

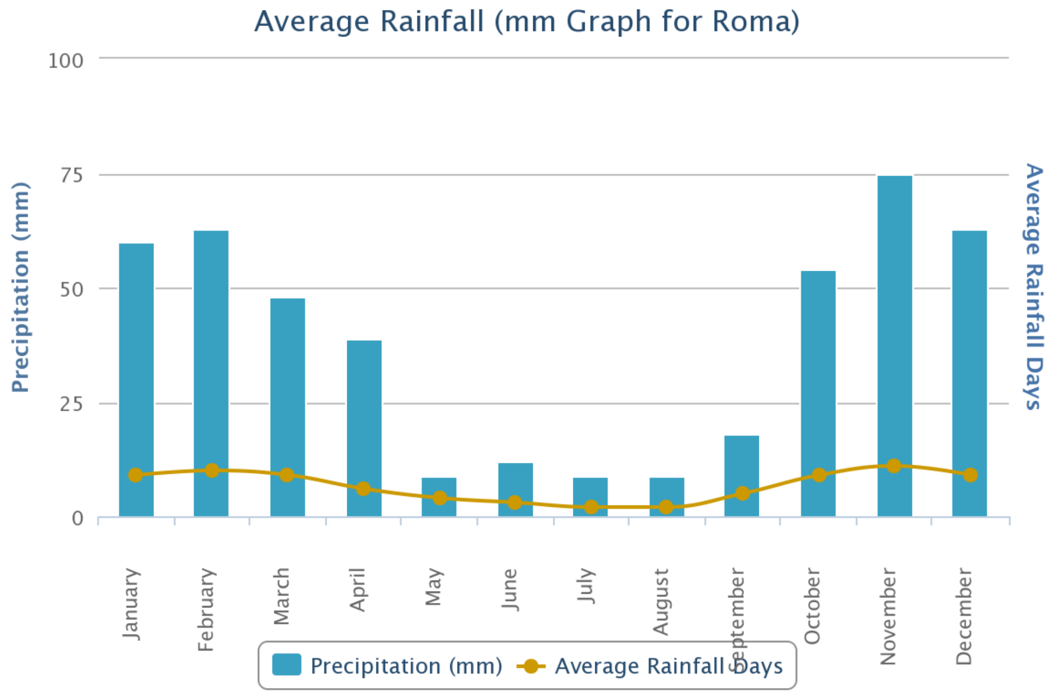

Fig. 2: Mean Annual Rainfall of the Roma valley

Source**:** http://www.worldweatheronline.com

Soil

Soils within the Roma valley and its adjacent catchment area of Maliele have been mapped by Carroll et al., (1976) and this is presented in Table 1. The thickness, drainage, texture and organic content of soils in this area seem to change downslope (Chakela, 1981). Soils in these areas are maily mollisols, alfisols and vertisols. Mollisols have a dark coloured surface layer and high organic matter and a base saturation of more than 50% while vertisols are clayey and have deep wide cracks and; alfisols have a light coloured surface layer with low organic matter and a clay enriched B-horizon, presence of aluminium and iron and a base saturation of more than 35% (United States Department of Agriculture, 1979).

Table 1: Soils of the Roma valley and adjacent Maliele catchment

Soil series	Family	Sub-group	Group	Sub-order	Order
Mats'aba	Fine-loamy, mixed, mesic	Typic-argiudolls	Argiudolls	Udolls	Mollisols
Ralebese	Fine-loamy, mixed, mesic	Lithic Hapludolls	Hapludolls	Udolls	Mollisols
Maliele	Fine-loamy, mixed, mesic	Cummulic Hapludolls	Hapludolls	Udolls	Mollisols
Leribe	Fine-loamy, mixed, mesic	Typic Hapludolls	Hapludolls	Udolls	Mollisols
Khabo, thin	Fine-loamy, mixed, mesic	Typic Argiudolls	Argiudolls	Udolls	Mollisols
Khabo	Fine-loamy, mixed, mesic	Typic Argiudolls	Argiudolls	Udolls	Mollisols
Maseru, dark	Fine-loamy, mixed, mesic	Cummulic Haplaquolls	Haplaquolls	Aquolls	Mollisols
Maseru	Fine, mixed, mesic	Typic Albaqualfs	Albaqualfs	Aqualfs	Alfisols
Tsiki	Fine-loamy, mixed, mesic	Typic Albaqualfs	Albaqualfs	Aqualfs	Alfisols
Phechela	Fine, montmorillonitic, mesic	Typic Pelluderts	Pelluderts	Uderts	Vertisols

Vegetation

The dominant forest tree species in the study area are exotics that include *eucalypts* and *pine plantations*. Gray poplar (*Populus canescens*) dominates in the gullies and *Salix babylonica* along the streams. Fruit trees (especially stone fruits such as peaches and apricots) are also grown around the homesteads. Vegetation is predominantly grasses of eragrostis. Indigenous trees include *Leucosidea sericea* (cheche), *Buddleia salviaefolia* (lelothoane), *Olea verucosa* (mohloare), *Rhamnus prinoides* (mofifi), *Euclea coriacea*/(ralikokotoane), and *Rhus pyroides* (kolit'sana). The area of *eucalypts* that is being investigated is approximately 11ha and the *eucalypts* are a coppice of a 30year old trees planted at a spacing of between 2.5m and 3m with no proper rows.

Methodology

1 Assessment of local people's perception on soil moisture and ground vegetation cover

Introduction

The study of the impacts of eucalypts and indigenous forests on soil moisture require long-term observation for confirmation, hence, the people who are 40 years old and above were selected for interview. The reason being that this group of people have lived long enough to know the history of these forests and the impact they have had over the years. The research question that is addressed through this survey is: What are the perceived impacts of eucalypts plantations on soil moisture and other water resources such as springs and streams as wells as ground vegetation cover by the people of St.Michaels in the Roma valley?

Methodology

Primary data was collected using structured questionnaire. The data was purely qualitative obtained through interviews using open-and-closed-ended questions. Recognising the importance of interviewing only individuals who are 40 years old and above called for a preliminary survey wherein the local authorities were conducted for the number of people who may be above the age of 40 in the study area. Based on this analogy, approximately 80 people were identified but only 60 were available for interview.

Ensuring data quality

In order to obtain the best possible data, the potentially sensitive nature of some of the topics needs to be appreciated. The research was conducted in a friendly, open and transparent manner in order to gain the trust of participants and ensure the greatest possible number of respondents, and truthful information. Before carrying out the survey, a brief explanation was made to each participant so that they know what is taking place and what their answers will be used for. They were given a chance to ask at any time questions that they had. It was emphasized to them that they are taking part voluntarily. Respondents were assured of their anonymity. Once methods were carried out, the answers or results were reviewed with the participant so they can check their answers and if they have been interpreted correctly.

2 Assessment of the impact of eucalypts on soil moisture

Introduction

The two forest-types (eucalypts plantation and indigenous forest) and the grassland were chosen with close geographic proximity in mind, to ensure similar climatic conditions such as irradiance, precipitation, wind effect as well as similar soils. The hypothesis to be tested is that eucalypts plantation enhances evapotranspiration (loss of soil moisture content), hence, contribute to reduction in water yield which consequently results in the drying and disappearing of springs and streams. On the contrary, indigenous forests and grasslands' contribution to the disappearance of springs and streams is either minimal or not there at all.

Methodology

Moisture content after a rainfall event was recorded in the selected forest types. A 200 m transect was demarcated on each of the forest types and grassland from which three mini-pits (toe slope, middle slope and upper slope) were dug at a spacing of 50 m. Soil horizons were demarcated in the soil profile and then soil samples collected from each horizon into air-tight plastic bags and taken to the Department of Soil Science laboratory of the National University of Lesotho for analysis of water content. Soil sampling was done immediately after a rainfall event to determine the water content at field capacity followed by sampling for four consecutive days to determine how fast the soil dries.

Soil moisture or soil water content was determined using gravemetric method as outlined by Black (1965). In the laboratory, 10 grams of wet soil was weighed into aluminium tins (of known weight) and the weight recorded as weight of tin (tare) + wet soil. The sample was placed into oven set at 105^0C for 24hours after which the sample was allowed to cool to room temperature and was weighed and recorded as weight of dry soil + tin

The following equation was used to calculate percentage of soil moisture:

soil moisture= {[(wt of wet soil + tare)-(wt of dry soil + tare)]/ [(wt of dry soil + tare)-(tare)]}*100

3 Assessment of the impact of eucalypts on ground vegetation cover

Introduction

The survey aimed at examining the herbaceous plant species and ground cover under the canopy of both forest types and compare with the adjacent non-forested land (grassland/rangeland) which forms the benchmark of the study area. It is hypothesised that as a result of reduced soil moisture, less number of herbaceous plants will grow under eucalypts than under either indigenous forest or grasslands.

Methodology

Vegetation was sampled in the three land-use types. Point intercept sampling method described by Evans and Love (1957) was employed to carry out the survey but those areas close to anthropogenic disturbances such as trail roads passing through the forest were avoided. Two 50 m transects were demarcated on each of the two forest-types and only one 50 m transect dermarcated on the benchmark area (rangeland/grassland) due to its homogeneity. On each transect a 50 m long measuring tape was stretched over the whole length of 50 metres. At 25 cm intervals (measurement points) along the measuring tape, a sampling rod was guided vertically to the ground. Herbacious plant species or ground cover classes that touched the rod were recorded as hits along the transect. All herbaceous plant species (grasses, brushes, and forbs) touched by the rod were identified and their names recorded as well as the ground cover classes (litter, rock, bare soil, base of vegetation). Generally, measurements were taken on a total of 200 sampling points. Percent cover was calculated by dividing the number of hits for each herbaceous plant species or ground cover class by the total number of points along a transect.

Data Analysis

The questionnaire as the tool to collect information on people's perceptions forms the basis of social study's data analysis. As a first step, resulting answers were coded and compiled and then served to create descriptive statistics. Also more important was the analysis of soil and vegetation survey which formed the core of the study. Data was subjected to the Statistical Package for Social Sciences (SPSS) as well as the excel spreadsheet. Presentations were done using descriptive statistical inferences to generate frequency tables, cross-tabulations and statistical graphs. Analysis of variance (ANOVA) was used to compare the differences in variance between the selected variables which include the eucalypt plantation, indigenous forest and the grassland/rangeland. The least significant difference (LSD) on the otherhand was used to determine the significance of the differences in means among the selected variables.

Results and discussion

There is a general conviction among the local people that *eucalyptus rubida* in the area has had negative impact in as far as soil moisture and water from springs and streams near and within the plantations is concerned (75% of the respondents). A number of authors including Woodcock, (2003), Lima (1984) and Sun et al., (2006) are of the same view that eucalypts plantations' contribution to the reduction of water table within the catchment and hence water yield in springs and streams is enormous. The basis for their conviction is on the lateral spreading of the roots of eucalypts trees which can range from 18-20 m in heavily compacted soils and 36 m in sandy soils, as well as their depth which can be well over 30 m. Moreover, the high evapotranspiration rates of eucalypts trees which range between 20 litres/tree/day to 40 litres/tree/day has also been a cause for concern (Lima, 1984). On the otherhand, Zegeye (2010) disagrees with the notion that eucalypts plantation's consumption of soil moisture is high relative to other vegetation types including agricultural crops and is supported by FAO (1988) that eucalypts are efficient at using water and converting it into biomass (in other words, they consume less water per unit of biomass produced) than most agricultural crops, conifers, acacias and broadleaved tree species. The argument of these authors is that eucalypts use only 510 litres of water/kg of biomass produced while conifers use 1000 litres of water/kg of biomass produced and agricultural crops such as potatoes, sunflower, field pea, horse bean and paddy rice use 600 litres of water/kg of biomass produced. It is important, under the circumstances, to note that the respondents also outlined long periods of drought, extremely high temperatures and scanty rainfall as some of the variables that cause soil moisture loss. The interview with the respondents ultimately revealed that the indigenous forests have had no negative effect on soil moisture and other water resources. Given their supposedly low water consumption (Everson et al., 2011) indigenous forests tend to be more favoured by the people of St.Michaels.

Long periods of drought, extremely high temperatures and scanty rainfall have been noticed by the respondents. 50% of the respondents complained that rainfall has become scanty in recent years compared to the past years when rainfall used to be for a long duration. At the same time, almost 40% and 10% of the respondents said that drought and extremely high temperatures, respectively, have caused a decline in soil moisture on both forest types and this has affected vegetation under the canopy of eucalypts plantation.

Perusal of the results on the effects of forests (*eucalyptus rubida* and indigenous forest) on ground vegetation cover as outlined by the respondents indicate that diversity of ground vegetation cover is more abundant under the indigenous forests (80% of respondents) than the eucalypts plantation (20% of respondents). The insight gained from the deliberation with the respondents is that eucalypts utilize high quantities of soil moisture which in the process makes it unavailable to the diverse plant species beneath the tree until ultimately some of the plants are out-competed. Supposedly, the high diversity of ground vegetation cover under indigenous forests is due to the fact that there is more moisture under indigenous forests compared to the eucalypts plantation. Other factors that have been reported to cause ground vegetation cover decrease under eucalypts plantations include competition for water (23% of respondents), shade from the eucalypts trees (15%), competition for nutrients (11%), overgrazing (10%), close spacing between eucalypts trees (7%), poisonous oils from trees (5%), trampling caused by movement of people in and out of the forest (3%) and unregulated digging of medicinal plants from the forest (3%).

The results of soil moisture losses between the eucalypts plantation, indigenous forest and the grassland as recorded for five consecutive days at St.Michaels in the Roma valley showed that the rate of soil moisture decrease was high under *eucalyptus rubida* compared to either the indigenous forest or the grassland. The order of soil moisture decrease was as follows: *eucalyptus rubida* (3.37% per day) > indigenous forest (1.63% per day) > grassland (1.56% per day). This is in conformity with the results of Lima et al., (2011) that the high growth rate of forest plantations relative to other vegetation results in high water consumption and, hence, reduced soil moisture

Table 2: Mean soil moisture for the two land-uses (forested and grassland/rangeland)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Soil moisture (%) **Day 1**	*Eucalyptus plantation*	9	21.86	8.28	2.76	15.49	28.23	13.90	40.06
	Indigenous forest	9	23.70	4.01	1.34	20.62	26.78	15.67	29.03
	Grassland/Rangeland	9	21.06	6.06	2.02	16.40	25.72	10.99	29.37
	Total	**27**	**22.21**	**6.22**	**1.20**	**19.75**	**24.67**	**10.99**	**40.06**
Soil moisture (%) **Day 2**	*Eucalyptus plantation*	9	16.92	4.53	1.51	13.44	20.40	9.77	25.16
	Indigenous forest	9	21.64	2.39	.80	19.80	23.47	18.20	25.00
	Grassland/Rangeland	9	20.39	5.35	1.78	16.27	24.50	11.79	27.63
	Total	**27**	**19.65**	**4.58**	**.88**	**17.83**	**21.46**	**9.77**	**27.63**
Soil moisture (%) **Day 3**	*Eucalyptus plantation*	9	11.86	2.63	.88	9.83	13.88	7.87	16.08
	Indigenous forest	9	20.44	1.88	.63	19.00	21.89	18.34	24.38
	Grassland/Rangeland	9	18.49	6.24	2.08	13.69	23.29	9.59	25.71
	Total	**27**	**16.93**	**5.41**	**1.04**	**14.79**	**19.07**	**7.87**	**25.71**
Soil moisture (%) **Day 4**	*Eucalyptus plantation*	9	11.08	4.19	1.40	7.86	14.30	5.71	18.69
	Indigenous forest	9	19.03	2.37	.79	17.20	20.85	15.34	21.29
	Grassland/Rangeland	9	16.86	5.63	1.90	12.53	21.19	9.29	23.76
	Total	**27**	**15.66**	**5.35**	**1.03**	**13.54**	**17.77**	**5.71**	**23.76**
Soil moisture (%) **Day 5**	*Eucalyptus plantation*	9	8.40	2.65	.88	6.36	10.44	4.60	13.12
	Indigenous forest	9	17.18	2.92	.97	14.94	19.42	12.36	21.95
	Grassland/Rangeland	9	14.84	5.22	1.74	10.82	18.85	6.78	22.93
	Total	**27**	**13.47**	**5.24**	**1.01**	**11.40**	**15.54**	**4.60**	**22.93**

Generally, the statistical analysis of soil moisture data revealed that on the first day, after a rainfall event, the eucalypts plantation recorded the highest soil moisture levels. This, however, was decreasing faster than on the other land-uses. The eminent reason for the high soil moisture under the eucalypts plantation after a rainfall event could be related to rainfall interception by their canopy. There were no significant differences in soil moisture between the grassland and the indigenous forest but was highly significant between the eucalypts plantation and the indigenous forest. These findings are supported by the results of Zhou et al., (2002) wherein they found that at catchment level over a period of 10 years the mean watertable level in the eucalypts forest was 80 cm lower than that on bare land while that under the mixed indigenous forest was 30 cm lower than the bare land or the control. This low water consumption by the indigenous forest compared to eucalypts plantation is in unison with Everson et al. (2011) that the indigenous forests use less water, have low water use efficiency and grow more slowly than the introduced eucalypts forests, hence, their low water-use has made them more favourable than the eucalypts plantation.

Table 4.11: Results of Analysis of Variance (ANOVA) for the five days

		Sum of Squares	Df	Mean Square	F	Sig.
Soil moisture (%) **Day 1**	Between Groups	33.025	2	16.512	.408	.670
	Within Groups	971.563	24	40.482		
	Total	1004.588	26			
Soil moisture (%) **Day 2**	Between Groups	107.675	2	53.838	2.946	.072
	Within Groups	438.619	24	18.276		
	Total	546.295	26			
Soil moisture (%) **Day 3**	Between Groups	364.869	2	182.434	11.064	.001
	Within Groups	395.748	24	16.490		
	Total	760.617	26			
Soil moisture (%) **Day 4**	Between Groups	303.805	2	151.903	8.296	.002
	Within Groups	439.445	24	18.310		
	Total	743.250	26			
Soil moisture (%) **Day 5**	Between Groups	371.836	2	185.918	13.046	.001
	Within Groups	342.015	24	14.251		
	Total	713.851	26			

Table 4.12: Results of the Least Significance Difference (LSD)

Dependent Variable	(I) Transect name	(J) Transect name	Mean Difference (I-J)	Std. Error	Sig.
Soil moisture (%) **Day 1**	Eucalyptus plantation	Indigenous forest	-1.83889	2.99933	.546
		Grassland/Rangeland	.80333	2.99933	.791
	Indigenous forest	Eucalyptus plantation	1.83889	2.99933	.546
		Grassland/Rangeland	2.64222	2.99933	.387
	Grassland/Rangeland	Eucalyptus plantation	-.80333	2.99933	.791
		Indigenous forest	-2.64222	2.99933	.387
Soil moisture (%) **Day 2**	Eucalyptus plantation	Indigenous forest	-4.72000*	2.01526	.028
		Grassland/Rangeland	-3.47222	2.01526	.098
	Indigenous forest	Eucalyptus plantation	4.72000*	2.01526	.028
		Grassland/Rangeland	1.24778	2.01526	.542
	Grassland/Rangeland	Eucalyptus plantation	3.47222	2.01526	.098
		Indigenous forest	-1.24778	2.01526	.542
Soil moisture (%) **Day 3**	Eucalyptus plantation	Indigenous forest	-8.58778*	1.91425	.000
		Grassland/Rangeland	-6.63889*	1.91425	.002
	Indigenous forest	Eucalyptus plantation	8.58778*	1.91425	.000
		Grassland/Rangeland	1.94889	1.91425	.319
	Grassland/Rangeland	Eucalyptus plantation	6.63889*	1.91425	.002
		Indigenous forest	-1.94889	1.91425	.319
Soil moisture (%) **Day 4**	Eucalyptus plantation	Indigenous forest	-7.94667*	2.01716	.001
		Grassland/Rangeland	-5.78222*	2.01716	.009
	Indigenous forest	Eucalyptus plantation	7.94667*	2.01716	.001
		Grassland/Rangeland	2.16444	2.01716	.294
	Grassland/Rangeland	Eucalyptus plantation	5.78222*	2.01716	.009
		Indigenous forest	-2.16444	2.01716	.294
Soil moisture (%) **Day 5**	Eucalyptus plantation	Indigenous forest	-8.77667*	1.77955	.000
		Grassland/Rangeland	-6.43778*	1.77955	.001
	Indigenous forest	Eucalyptus plantation	8.77667*	1.77955	.000
		Grassland/Rangeland	2.33889	1.77955	.201
	Grassland/Rangeland	Eucalyptus plantation	6.43778*	1.77955	.001
		Indigenous forest	-2.33889	1.77955	.201

*The mean difference is significant at the 0.05 level

The herbaceous plant species and ground cover in the study area was expected to vary between the *eucalyptus rubida*, the indigenous forest and the grassland. This hypothesis is based on the fact that the eucalypts plantation results in high soil moisture loss than either the grassland or the indigenous forest hence insufficient soil moisture for the underground flora in the eucalypts plantation. Svejcar et al., (1999) supports this hypothesis by stating that rainfall, which influences soil moisture, determines plant species diversity more than grazing pressure by livestock. When comparing the three land-use types in terms of the abundance of different plant species it was found that the grassland/rangeland had the highest frequency of grasses, forbs and brush than either the indigenous forest or the eucalypts plantation. The National Environment Secretariat (2000) confirms this by stating that 61% of the rangeland cover in Lesotho is dominated by grasses than any other type of vegetation. The reason for the low frequency of grasses, forbs and brush under the eucalypts plantation could be a result of the combined effect of shade and the release of chemical substances from the litter of eucalypt trees (Michelsen et al., 1996).

It should also be noted that the rockiness and bare ground under the *eucalyptus rubida* was high compared to the indigenous forest and the grassland. The high frequency of rocks could be a result of soil erosion in the eucalypts compared to the other land-uses or that the plantation may have been strategically planted on the rocky land. The following invader species, however, were recorded under the eucalypts plantation and are an indicator of degradation: *Athanasia thodei, Artemisia afra, Gnaphalium undulatum, Scobiosa columbaria, Aster fillifolias, Passerina Montana, Helichrysum trilleanatum, Erica maesta* and *Chrysocoma cilliata.* Only *Erica dominas* and *Scabiosa columbaria* were invaders species that were recorded under the indigenous forest while *Stoebe vulgari, Scobiasa columbaria* and *Erica dominas* were recorded under the grassland.

Table 3: Herbacious plant species and ground cover under eucalypts plantation

Eucalypts plantation					
Ground Cover	Frequency	Percentage	**Canopy cover**	Frequency	Percentage
Bare soil	45	42.5	Forb	8	8.5
Litter	34	32.1	Brush	6	6.4
Rock	20	9.4	Grass	80	85.1
Base of vegetation	17	16.0			

Table 4: Herbacious plant species and ground cover under the indigenous forest

Indigenous forest					
Ground Cover	Frequency	Percentage	**Canopy Cover**	Frequency	Percentage
Bare soil	32	32.0	Forb	9	9
Litter	29	29.0	Brush	8	8.0
Rock	3	3.0	Grass	83	83.0
Base of vegetation	36	36.0			

Table 5: Herbacious plant species and ground cover under the Rangeland/grassland

Benchmark area/Rangeland					
Ground Cover	Frequency	Percentage	**Canopy Cover**	Frequency	Percentage
Bare soil	31	31	Forb	4	4.0
Litter	7	7	Brush	13	13.0
Rock	5	5	Grass	83	83.0
Base of vegetation	57	57			

Conclusion and recommendations

Eucalypts are not altogether bad. An analysis of the opportunities available from *eucalyptus rubida* plantations as outlined by the respondents in the study area indicates that the eucalypt plantation can contribute to the sustainability of the well-being of the people of St.michaels. The eucalypts plantation has been found to be a source of energy (firewood), roofing and fencing poles, a harbour of indigenous medicine and a beautifier of the landscape of St.Michaels. These benefits could be harnessed and more opportunities opened for eucalypts related industries such as paper industries for the benefit of the residents of St.Michaels and the economy of Lesotho. As such, policy should be developed that will address the establishment of exotic plantation that include eucalypts in a way that is in harmony with the environment. Sound forest management and silvicultural practices such as spacing, thinning and debranching will help minimise the impacts that the eucalypts plantation might have on the environment and this calls for competent and well trained foresters. Local institutions such as universities, colleges and research department should also be strengthened so that they can develop more robust research on the impacts of eucalypts plantations on the four agro-ecological zones of Lesotho. This will help policy makers and policy implementers to make informed decisions with regard to eucalypts plantations. In addition, there is a need to consciously raise awareness to the local people on the outcome of studies such as this one because the people's attitude towards eucalypts has a strong influence on their decision making.

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