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Estimation of biomass and carbon stock of *Quercus incana* and their effect on insect population in Barawal valley of district upper Dir

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Abstract
The present study carried out in the Barawal valley of District upper Dir. In this study the growing stock (m^3ha^{-1}), biomass (t ha^{-1}) and carbon stock (t ha^{-1}) of the study area were estimated through field inventory. For the determination of biomass volume of the tree were calculated and for the estimation of volume (m^2ha^{-1}) tree height (m) and diameter (cm) were estimated. After that stem biomass (t ha^{-1}) total biomass (t ha^{-1}) and carbon stock (t ha^{-1}) were calculated. Diameter class (cm) in the study area range from 6 to 74 cm, and density (tree ha^{-1}) range from 1 to 38 trees ha^{-1}. Average tree height (m), basal area (m^2ha^{-1}) and volume (m^2ha^{-1}) were 5.7, 15 and 54 respectively. The total estimated stem biomass (t ha^{-1}) of the study area was 38 (m^2ha^{-1}) and tree biomass was 59 (t ha^{-1}). The estimated carbon stock (t ha^{-1}) in the study area ranged from 4 to76 t ha^{-1} and its average was 29 t ha^{-1}.

Keywords: *Quercus incana,* Barawal valley, biomass volume, global carbon storage

Introduction
Global climate change had dramatically increased the attention of scientific and political communities to study the global carbon storage and the carbon balance [1]. The concentration of atmospheric CO_2 has increased from 315 ppm (in 1958) to 387.35 ppm in 2009 [2]. Trees store up to 82 percent of the global plant biomass and are therefore it is considered an important variable in the global carbon cycle. This global importance of forest ecosystems emphasizes the need to accurately determine the amount of carbon stored in different forest ecosystems. Carbon circulates among the oceans, terrestrial biosphere and atmosphere. In addition to it, human activities, such as fuel combustion and deforestation, affect the carbon dioxide (CO_2) concentration of the atmosphere [3, 4]. The estimation of biomass is a vital aspect of studies of carbon storage and carbon balance. Forest ecosystems are renowned as important elements of the global carbon cycle, as well as the cycle of various other greenhouse gases (GHG) that are believed to considerably affect climate [5]. Between 1980 and 1995, the earth's biosphere actively removed due to approximately 30 % of the new carbon added to the atmosphere by human activities [6, 7].
The data regarding Pakistan in GFRA 2005 presents the total carbon stocks (M t) for the entire country. However, no scientific work was done on actual measurements regarding biomass and carbon stocks estimation in any forest type of Pakistan and the GFRA (2005) estimates are based on remote sensing and may be error prone. So it is necessary to have accurate and reliable estimates regarding biomass and carbon stock for proper forest management.
The present study was carried out on *Q. Incana* (broad leaved tree) forest of Barawal Dir upper which is a dry temperate ecological zone. The forest of study area was differentiated into mixed fir *(Abies pindrow*) and spruce (P*icea smithiana*) forest, mixed fir, spruce, kail (*Pinus willichiana*), deodar (*Cedrus deodara*) and broad leaved forest. Research work was aimed to find out amount of biomass and carbon stocks in *Q. Incana* in Barawal valley, which helped in finding out future growing stocks estimates regarding biomass and carbon stocks, related research studies, also prove useful for international projects for REDD and REDD+ which are combating climate change. The specific objectives of the study were;
a) To calculate growing stock of *Q. Incana* forest in Barawal valley.
b) To estimate the biomass for *Q. Incana* in Barawal valley.
c) To determine the amount of carbon stock stored in *Q. Incana* in Barawal valley.

2. Materials and Methods

2.1 Study area

Barawal valley lies at the extreme end of the District Dir Upper, Khyber Pakhtunkhwa Fig.1 The geographic location of the study area is 35° 5' 11" N latitude and 71° 45' 38" E longitude, with elevation of 5000-9000 ft.. The annual temperature ranges from -2 ^{0}C in December to 32 ^{0}C in July. The mean annual precipitation is 750 mm.

The research was carried out in Barawal Planning Unit. That is composed of total 210 numbers of compartments divided into different blocks.

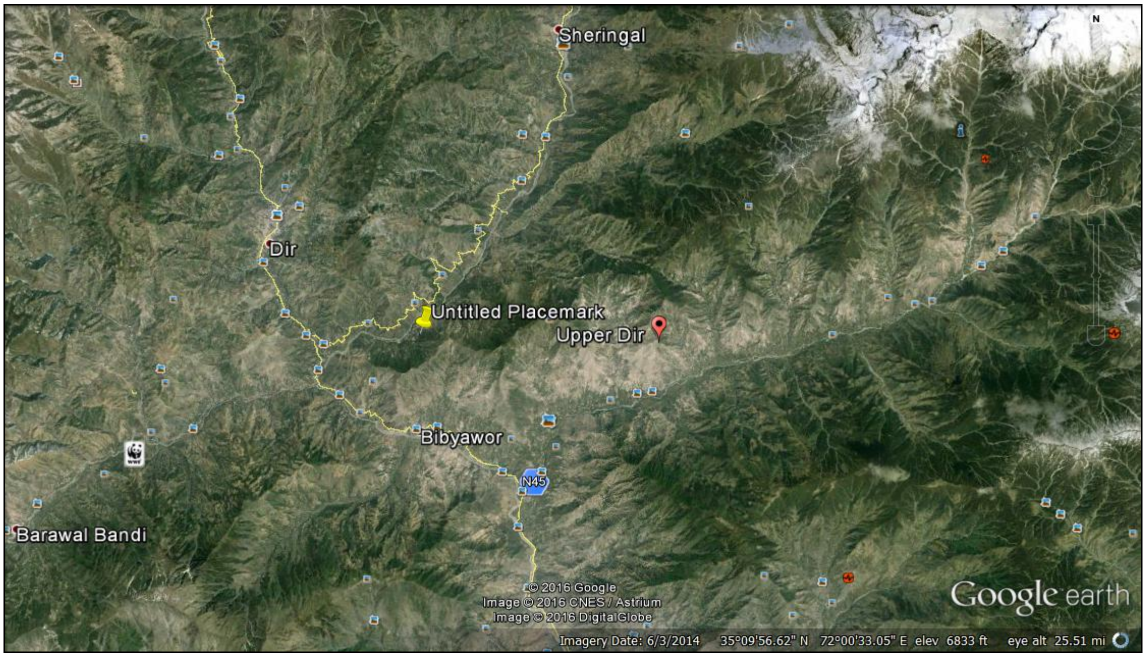

Fig 1: Satellite image of District Upper Dir taken from Google earth

2.2 Plot selection

The *Q. Incana* forest of Barawal valley forest was divided into three strata on the basis of cover percentage.
1) Dense 75 % 2) Medium 50% 3) Sparse 25%.
From each stratum, further three sample plots were taken and hence 9 sample plots were considered in every forest type. So in this way total 36 sample plots were selected for data collection. The size of each sample plot was 0.1 ha.

2.3 Analysis of Data

For the determination of biomass tree volume (m^3ha^{-1}) and wood density (kg m^3) was calculated and then from the biomass of tree their carbon stock was calculated [10].

2.4 Determining tree diameter and Height

The diameter (cm) of each tree was determined at breast height with the help of the caliper. The tree below diameter of 6 cm was not enumerated. Tree height (m) of each tree was determined by using Abneys level.

2.5 Determination of volume of tree

Tree Volume (m^3 ha^{-1}) was determined from diameter, height, and form factor**.** The following formula was used for tree volume estimation

$$V = \pi/4 \times d^2 \times h \times f$$ [8] ….equation 1

Where h = tree height, f= form factor, d= diameter at breast height point.

2.6 Biomass calculation

Stem biomass was calculated from the relation of stem volume and basic wood density. Stem volume was calculated from tree height and tree cross sectional area. The value of wood density was sourced from available literature [9]. The following formula was used to calculate stem biomass.
Stem biomass = Volume × Wood density …equation 2
Total tree biomass was calculated from stem biomass and biomass expansion factor (BEF). Stem biomass was multiplied with BEF and total tree biomass was found out. The following formula was used for total tree biomass estimation.
Total Tree Biomass= Stem Biomass × BEF…equation 3
In present study BEF value of 1.55 was used [10]

2.7 Measurement of carbon stock

The carbon stock in the present study was estimated from the value of calculated total tree biomass and conversion factor. Total tree biomass was multiplied with conversion factor which is 0.50. This value of conversion factor has been used globally [10]. The following relation was used to determined total carbon stock.
Total Carbon Stock= Total tree Biomass × 0.5...equation 4

2.8 Statistical analysis

For the statistical analysis of the data sigma plot version 10 was used. Standard deviation (SD), Means and Co-efficient of variance (%CV) was determined at plot level for biomass and carbon stock. Regression model was developed to study the relation of stem diameter (cm) and stem density (ha^{-1}), basal area (m^2 ha^{-1}) and stem volume (m^3 ha^{-1}), basal area (m^2 ha^{-1}) and stem biomass (t ha^{-1}).

3. Results and Discussion

Based on the research objectives of the carbon stock assessment of *Q. Incana* in Barawal mean results were summarized as following

3.1 Density
The average trees density of *Q. Incana* in Barawal was estimated that as 295 trees ha^{-1}. In the present study the density starts from 1 tree ha^{-1} to a high value of 38 tress ha^{-1}. The average density for four sites ranges from 207 to 388 trees ha^{-1}.
It was found in the present study from the inventory that the density was increased as the diameter class increased but after 12(cm) diameter class the density of the trees started decrease with increase in diameter class (cm) gradually, and hence the graph shows declining Fig.2. The decrease in density with increase in diameter is due to the competition of the Oak trees in the study area. The natural growth in the lower diameter classes was satisfactory as it was conserved by local community. Details of stem density are given in. The relation between tree diameter (cm) and density (trees ha^{-1}) is plotted in Fig.2. The data was statistically analyzed to develop regression model. It can be seen from the Fig.2 that there was a significant correlation between tree diameter and tree density. The value of R^2 =.86 showed positive relationship.
Similar study was conducted by Khan [10], and found that the Stem density of the Sheringal Dir Kohistan ranges from 80 ± 8 to 510 ± 42 trees ha^{-1}. The mean stem density of the site was 226 ± 7 trees ha^{-1}. The value of R^2 was .78 in his study.

3.2 Tree Height
The present study results showed that average tree height in all four sites was 96 m ha^{-1}. Tree height ranges from 3.0 to 9.5 m for diameter class 6 to 74 cm respectively and mean tree height was 5.7 m with a mean diameter of 40 cm. The study showed that the tree height depends upon the diameter. In order to study the relation of diameter with height we developed a regression model Fig.3. The graph produced so was straight inclined. The relation between diameter and height was polynomial cubic with R^2 = .97. A slight increase in height with increase in diameter was recorded throughout the present study and shows a strong relationship between tree height and its diameter. The present study results are also supported that tree height dependent upon diameter. [11]. in their study it was found that the height of the tree increases with increase in stem diameter.

3.3 Tree volume
The minimum tree volume was recorded for diameter class 6 (cm) which was 0.03 m^3 ha^{-1} and the maximum tree volume was recorded for diameter class 70 cm 3.9 m^3 ha^{-1}. The mean volume in present study was 1.662046 m^3 ha^{-1}. Tree volume is the function of tree diameter. With increase in tree diameter the volume of tree increases. The relation of tree volume and tree diameter is best described in Fig.4.
The results coincide with the study conducted by Khan [10]. The mean stem volume of the Oak Scrub forest was 46.37 ± 0.85 m^3 ha^{-}1.The minimum volume was found in the diameter classes range from 8 to 20 cm and the maximum volume was found in the diameter class of 49 cm and above.

3.4 Tree Basal Area
The results demonstrated that the minimum basal area was 0.014144 m^2 and the maximum basal area was 1.026818 m^2 $ha^{-1}$and mean basal area was 0.468792 m^2 ha^{-1}. It was concluded that tree volume correlate on basal area Fig.5. With increase in basal area the volume of a tree also increased. To describe the relationship between tree basal area and tree volume a regression model was developed. It was found that there was a significant relationship between the basal area and volume, and R^2= 0.7839 which shows a strong relationship. Similar results were mentioned by Moinuddin [12]. His study reported that a basal area of 1.47, 16 and 25 $m^2 \cdot ha^{-1}$ from Hindu Kush and Himalayan ranges of Pakistan.

3.5 Stem Biomass
The results found that with the increase of basal area the stem tree biomass also increases. The basal area ranges from 0.014144 to 1.026818 $m^{2,}$ and the TSBM was estimated ranges from 0.022162 to 3.450109 t.ha^{-1} Fig.6. The total basal area and TSBM was 16.40772 m^2, 40.72013t.ha-1calculated respectively. The relationship between basal area and STBM was statistically analyzed by polynomial regression R^2= .78, and found that there is a significant relation between the two variables.
Our results were nearly similar to the results reported by Tiwari [13], that the value of mean biomass 258.98 t ha-^{1} of the region is within the range of 121.33-247.21 t ha-^{1}.

3.6 Relation between basal area and total biomass of *Quercus incana*
The biomass of the trees calculated in the present study showed that the forest close to the community has more biomass as that away from near to the community and away from community, but in the forest far away from community the biomass value again became decreased. The average biomass for the study area was 59 t ha^{-1} Fig.7.
The relation between Basal area and total biomass was calculated and found that total basal area ranged from 0.021922 m^2 to 1.591568 m^2 for the diameter range 6 - 74 cm. The basal area was found maximum with the increase in diameter classes. Similarly the total biomass also increases with the increase in basal area. Hence the total biomass depends upon the value of basal area. The relation between the basal area and total biomass was statistically analyzed by polynomial regression R^2= .78 and found significant relation between the two variables. The current study results also coincide with the results of Paladinić [14].

3.7 Relation between basal area and carbon stock of *Quercus incana*
The present study determined the carbon stock of the *Q. Incana* in Barawal at four sites. The smallest value of carbon stock was 4 t ha^{-1} in the forest area close to community. The amount of carbon stock increased in the area near to the community (8 t ha^{-1}) and away from the community (76 t ha^{-1}). But when the carbon stock was estimated in the forest area far away from the community the amount of carbon stock again decreased. The average carbon stock for all the four sites was 29 t ha^{-1}.
The results of the study found that there was a strong relationship between the basal area and total carbon stock of *Q. Incana*. There is direct relation between basal area and carbon stock. The relation between the basal area and carbon stock was statically analyzed by polynomial regression R^2= .78 Fig.8. that the positive correlation between the two variables i.e. basal area and carbon stock. There is direct proportion between the two variables.
The results were supported by Sharma [15], he reported that calculated total carbon of the entire region ranged between 111.68 (fir and spruce forest) to 142.40 (mixed coniferous forest) t ha^{-1} with a mean value of 129.29 t $ha^{-1.}$

3.8 Insect population
The present study at four sites revealed that the forest area having more density had high biodiversity of insects. The natality rate decreased as we go from the area having more density to that of less dense forest.

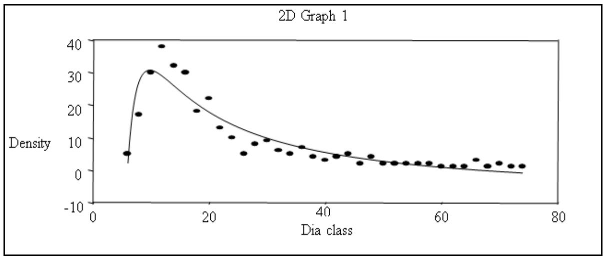

Fig 2: Relation between tree Diameter and Density of *Q. Incana* in Barawal during the year 2013-15.

Equation: Polynomial, Inverse Third Order
f=y0+(a/x)+(b/x^2)+(c/x^3)
R R^2 Adj R^2 Standard Error of Estimate
0.9323 0.8692 0.8566 3.8573

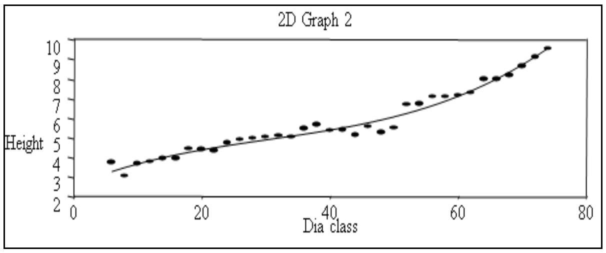

Fig 3: Relationship between Diameter class and Height of Q. Incana Diameter and Height

Equation: Polynomial, Cubic
f=y0+a*x+b*x^2+c*x^3
R R^2 Adj R^2 Standard Error of Estimate
0.9864 0.9729 0.9703 0.2909

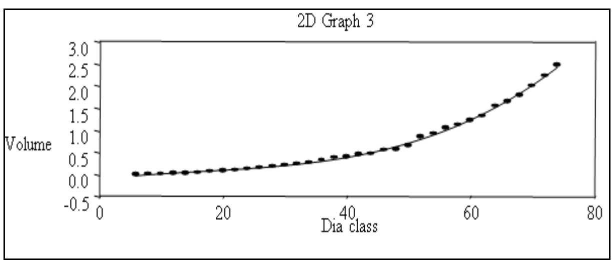

Fig 4: Relationship of diameter class and volume of *Q. Incana*

Equation: Polynomial, Cubic
f=y0+a*x+b*x^2+c*x^3
R R^2 Adj R^2 Standard Error of Estimate
0.9990 0.9980 0.9979 0.0325

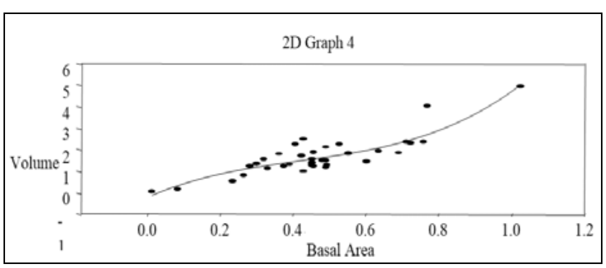

Fig 5: Relationship between Basal area and average volume of *Q. Incana*

Equation: Polynomial, Cubic
f=y0+a*x+b*x^2+c*x^3
R R^2 Adj R^2 Standard Error of Estimate
0.8854 0.7839 0.7630 0.4455

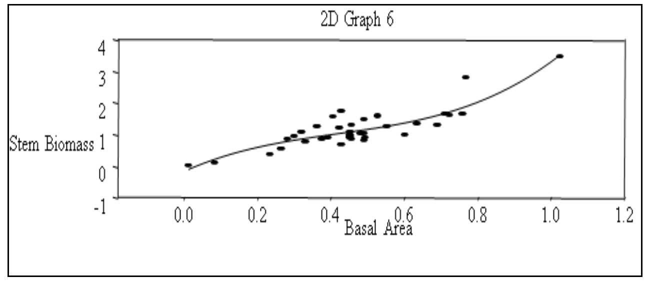

Fig 6: Relationship between Basal area and Tree stem biomass of *Q. Incana* in Barawal during the year 2013-15

Equation: Polynomial, Cubic
f=y0+a*x+b*x^2+c*x^3
R R^2 Adj R^2 Standard Error of Estimate
0.8854 0.7839 0.7630 0.3119

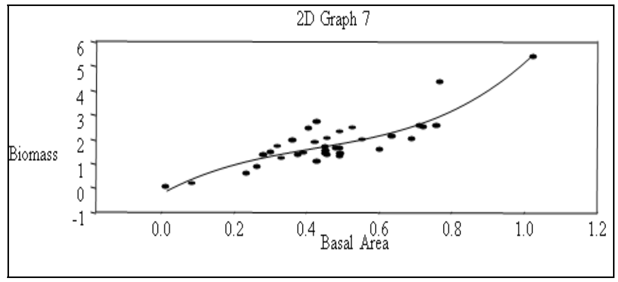

Fig 7: Relationship between Basal area and total tree Biomass of *Q. Incana* in Barawal during the year 2013-15

Equation: Polynomial, Cubic
f=y0+a*x+b*x^2+c*x^3
R R^2 Adj R^2 Standard Error of Estimate
0.8854 0.7839 0.7630 0.4834

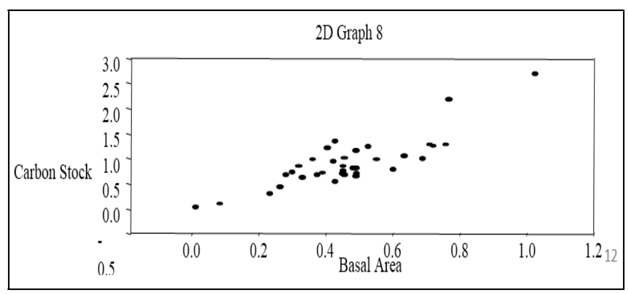

Fig 8: Relationship between Basal area and Carbon stock of *Q. Incana* in Barawal during the year 2013-15

Equation: Polynomial, Cubic
f=y0+a*x+b*x^2+c*x^3
R R^2 Adj R^2 Standard Error of Estimate
0.8854 0.7839 0.7630 0.2417

4. Conclusion

It was concluded from the present study that as we go away from the forest area close to community the value of volume, biomass and carbon stock decreases, which is due to the reason that the local people are conserving the forest near to them. The forest area far away from the community has more threats and hence the tree density was low and ultimately the volume, biomass and carbon stock was also low. It was further concluded that the insects population also dependent upon the trees density. The natality rate at the area far away from community was high from that of the area closed to community.

5. Recommendations

On the basis of the results of present study the following general suggestions were put forwarded.

1. Biomass acts as carbon sinks, source of energy and as a mitigater of the greenhouse gas, so it is necessary to plant more trees.
2. Biomass is more cost effective in combating climate change than the benefits of other ecosystem services, so the increase in biomass is quite important.
3. To improve the study of biomass and carbon stock it will prove useful results for international projects REDD and REDD+ which are combating climate change.
4. Reforestation practices are need on current basis to improve the covers in the blank areas.
5. The re enforcement of the forest policy are needed to monitor forest degradation and shifting cultivation the study area.
6. Introduction of the fast growing species to be carried out to reduce pressure on the forest resources for fuel wood demand of the local people.
7. To increase the diversity and natality rateof insects it is necessary to increase the biomass.

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