PHYSICAL PROGRESS REPORT
OF SCHEME

ESTIMATION OF ECONOMIC LOSSES IN REAL TERM PER HECTARE BASIS DUE TO FOREST FIRE IN UTTARAKHAND AND MADHYA PRADESH

(1/04/2021-30/09/2021)

Submitted by
Indian Council of Forestry Research and Education, Dehradun.

(Progress Report of the scheme "Estimation of economic losses in real term per hectare basis due to Forest Fire in Uttarakhand and Madhya Pradesh" funded by National Authority CAMPA)

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1. Introduction:

Based on the recommendations of the Parliamentary Standing Committee on Science & Technology, Environment & Forests to Uttarakhand (June 2016) Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India (GoI) vide letter no. F.No.7-2/2016-FPD dated 11th March, 2017 requested Indian Council of Forestry Research and Education (ICFRE), Dehradun to submit a proposal for undertaking the study on Estimation of economic losses in real term per hectare basis due to forest fire. Accordingly, ICFRE proposed a pilot study entitled "Estimation of economic losses in real term per hectare basis due to Forest Fire in Uttarakhand and Madhya Pradesh" for funding from National Authority CAMPA towards addressing the requirements **of estimation of total economic loss in real terms of monetary value on per hectare basis for the study states of Uttarakhand and Madhya Pradesh.** Through the study a framework / approach /methods /tools and techniques will be provided to estimate tangible and intangible losses due to forest fire on per hectare basis which may be used in other similar situations. **The pilot study being multidisciplinary in nature will be conducted by ICFRE through its institutes at Dehradun (Forest Research Institute) and Jabalpur (Tropical Forest Research Institute) in association with partner institutions mentioned below**:-

i. Forest Survey of India (FSI),Dehradun
ii. Wild life Institute (WII) ,Dehradun
iii. National Institute of Hydrology (NIH)
iv. G.B Pant National Institute of Himalayan Environment & Sustainable Development, Kosi-Katarmal, Almora, Uttarakhand (GBPIHESD)

The total outlay of scheme is Rs 378.840 lakhs. The scheme was sanctioned through Order No. 13-35/2019-CAMPA, dated 28th January, 2020 of National Authority Campa, MoEF& CC, New Delhi for recurring expenditure and vide Order No. 13-35/2019-CAMPA, dated 28th January, 2020 of National Authority Campa, MoEF&CC, New Delhi for Non-Recurring expenditure. As per approved scheme 50% of the funds were received on 26th February 2020. The scheme is for 24 months. As per the proposal, the date of initiation of the Project will be from the date of finalization of polygons for the study by FSI. The funds lying balance on 01.04.2020 were revalidated for 2020-21 through letter dated 26th August, 2020 vide File No. 13-35,2019-NA.

2. Objectives of the Scheme are as under:

a) To quantify the forest loss in terms of total economic value i.e., monetary value on per hectare basis for the forest types in the States of Uttarakhand and Madhya Pradesh.

b) Burnt area assessment and severity classification due to forest fire for the respective states.

c) Economic loss assessment of terrestrial flora due to forest fire on per hectare basis for the respective states

d) Economic loss assessment of faunal diversity due to forest fire on per hectare basis for the respective states

e) Economic loss assessment of hydrological changes due to forest fire on per hectare basis for the respective states

f) Economic loss assessment of provisioning services and cultural value of forest produce loss due to forest fire on per hectare basis for specific forest types and extrapolated for the respective states.

3. Physical Progress of Scheme

3a: <u>Coordination review meeting for execution of the project</u>

i. Inception meeting of all the project partners (Forest Survey of India-Dehradun, Wild Life Institute-Dehradun, National Institute of Hydrology-Roorkee, GBPNIHESD Almora, ICFRE Dehradun, Forest Research Institute Dehradun and Tropical Forest Research Institute- Jabalpur) and Nodal Officers of State Forest Departments (Uttarakhand & Madhya Pradesh) was organised at ICFRE, Head Quarter, Dehradun on January 22, 2020 to discuss in detail the methodology and structure of the project for the smooth execution of it. It was discussed at length and all project partners agreed to conduct the study on the burnt polygons of forest areas burnt during fire season 2019 in different forest types as per the parameters identified in the approved project. Recruitment of staff was initiated by partners. Literature survey was under taken and consultation with experts was held in social distancing mode to decide methodology. Tender process for purchases was initiated by all the project partners in their respective institutes as per the project schedule.

ii. The 2nd Coordination meeting was held on 12th May 2020 after unlock 1.0 of COVID- 19 to expedite the process of finalization of site of burnt area for the study. As discussed in 1st and 2nd coordination meeting, FSI submitted the Interim Report on findings of Burnt Scar Assessment of Uttarakhand on 9 June 2020. The minimum mappable unit for the study was 3 hectares. The burnt scars were classified into Severely Burnt, Moderately Burnt and Low Burnt severity classes based on the reflectance of a pixel of the satellite data. Based on the analysis of satellite data, a total of 4,897 fire polygons of different sizes with minimum area of 3 ha were identified in Uttarakhand. The 3rd coordination meeting was held on 29 June 2020. The received report on burnt scar polygons as shape files for fire season 2019 and also protocols to open the shape files was circulated amongst the partners of the project. The burnt scar polygon having minimum area of 3 hectare with following attributes have been provided in shape file, Format (.shp).

   a) Polygon ID (ID. No)
   b) Severity classes burnt-severe, moderate and low.
   c) Burnt scar in hectares
   d) Forest range information-boundaries of 18 relevant forest ranges in Uttarakhand
   e) Forest cover/density classes from dense, moderately dense, open, scrub
   f) Forest type group-1-total 9 forest types groups in Uttarakhand
   g) Altitude zones ranging from 0-900 meters to above 3600 metres
   h) Slope classes ranging from 0-3° to above 36°, Aspect classes-North, South, East, West

iii. In fourth coordination meeting held through video-conferencing (VC) on 24 September 2020, for reviewing progress and to discuss amongst project partners to decide a coherent methodology to work on the selected Burnt and Unburnt Polygons of Uttarakahnd and Madhya Pradesh required to conduct further studies as per the requirement of the approved project it was found that that based on the forest fire year 2019, details of 4897 polygons of Uttarakhand was received from Forest Survey of India, Dehradun. Out of these 4897 polygons identified, tentatively 164 selected Burnt Scar Polygons with minimum area of 3 ha belonging to different forest types, slope, aspect, severity of burnt areas etc were

short listed. However FSI Dehradun requested SFD Uttarakhand to validate 4897 polygons along with 164 shortlisted polygons. Uttarakahnd State Forest Department and FSI validated 289 polygons of Uttarakhand. The statistical expert from ICFRE identified 42 forest fire polygons (moderately burnt =32, low burnt =10) for the study in Uttarakhand which stands communicated to all the project partners. Also the permission received from PCCF & HoFF Uttarakhand has also been communicated to all the PIs of the Project.

iv. FSI submitted information regarding Burnt Scar Polygons' for State of Madhya Pradesh to ICFRE. Total 17288 fire polygons of different sizes with minimum area of 3 ha have been listed in Madhya Pradesh. The burnt scar polygons belong to Severely Burnt, Moderately Burnt and Low Burnt classes. Out of 17288 fire polygons 178 polygons were finalized as per statistical requirements and keeping in view different parameters like forest types, slope, aspect etc. Madhya Pradesh State Forest Department and FSI validated 228 polygons. The statistical expert from ICFRE identified total 49 fire affected polygons (severe burnt = 5, moderately burnt =24, low burnt =20) for M.P. These details of polygons have been communicated to all the partners. Also, the permission received from PCCF & HoFF during 2nd week of December, 2020, has been forward to all the PIs of the project.

v. In fifth coordination meeting held through video conferencing (VC) on 21 May 2021, to review the progress so far made by all the Partner Institutes for last financial year ending 31st March, 2021 and submission of Utilization Certificates and cumulative physical progress reports (along with photographs and data) by all the Partner Institutes for last financial year i.e., 01st April, 2020 to 31st March, 2021. All project partners presented their work. The progress made by all the partners for duration 1/04/2020 to 31/03.2021 has been submitted to MoEF&CC. The progress made by all project partners for duration 01/04/2021 to 30/09/2021 is detailed below:

3b. Progress made by Partner institutes:

❖ G.B. Pant National Institute of Himalayan Environment Institute (GBPNIHEI)

Objective: Economic loss assessment of provisioning services and cultural value of forest produce loss due to forest fire on per hectare basis for specific forest types and extrapolated for the respective states.

This report is a follow-up to the quarterly report i.e., March-June, 2021 of this project. Altogether, during the six months (April-September, 2021) period a total of 23 and 22 polygons were surveyed in burnt and un-burnt forests in the identified polygons of forest fire of 2019 in Uttarakhand and Madhya Pradesh, respectively. Field survey teams are still in the field and taking data of remaining polygons. Summary of major parameters of data collected during April-September, 2021 forest fire affected forests of Uttarakhand and Madhya Pradesh are as follows-

1. Among the herb layer biomass of 54 species in Uttarakhand and 49 species in Madhya Pradesh was measured found in the studied polygons. Similarly, for shrubs, biomass was estimated for 28 species in Uttarakhand and 22 species in Madhya Pradesh.
2. Among the tree layer fruit yield of NTFPs, 23 and 12 species in Uttarakhand and Madhya Pradesh, respectively was estimated (data under compilation).
3. In the MAPs species, 58 species in Uttarakhand and 41 species of MAPs were recorded and biomass of tradable part of these species were separately estimated (data under compilation).
4. Identification of the plant species collected during the reporting period in Uttarakhand and Madhya Pradesh with the help of experts of TFRI, Jabalpur (Dr. Jyoti Desai & Dr. Sanjay Kumar) and Dr. Ravi Upadhyay, SBS Degree College, Pipariya (M.P.).
5. During the reporting period (post-monsoon), we have recorded 11 (herb and shrub) and 13 (herb and shrub) new species (other than species recorded in pre-monsoon survey) in Uttarakhand and Madhya Pradesh, respectively.
6. Fuelwood estimation was done (and continued) in the 45 surveyed polygons for measuring dead standing trees/stumps both in Uttarakhand and Madhya Pradesh.
7. Review of literature on phytosociology, taxonomical parameters and economic valuation of NTFPs, MAPs etc. for both the Uttarakhand and Madhya Pradesh was carried out (and continued).

8. Visit to different agencies such as; Bhesaj Sangh, Dehradun Uttarakhand Van Vikas Nigam, Dehradun (Uttarakhand Forest Development Cooperation), Uttarakhand Forest Department, Dehradun, Forest Research Institute, Dehradun, and Wildlife Institute of India, Dehradun were made for collecting market rate list of various economic/ important NTFPs species.
9. During the reporting period a total of 690 and 660 quadrats for herb, 460 and 440 for shrubs, were laid in Uttarakhand and Madhya Pradesh, respectively.
10. Stakeholder's consultations / meetings were held with the local people and other stakeholders to estimate the monetary loss due to forest fire of fodder, fuel wood, NTFPs and MAPs etc. was carried during the reporting period.

Parameter wise progress of the work during the reporting period:

1. Biomass estimation of the useful/tradable part of the species-

A reconnaissance survey of the polygons was carried out before actual field work during late to post-monsoon season in 2021. Based on the survey, on the MAPs and wild edible/fruit yielding plants across the polygons thirty quadrats of 1x1m (for herbs), twenty quadrats of 5x5 m (for shrubs) and ten quadrats of 10x10 m (for trees) were laid down randomly to evaluate biomass (useful/ tradable part) and plant density per hectare basis. The categorization of bushes of NTFP value into small, medium and large was based on the average number of shoots per plant. For each species, mean fruit yield per plant was determined from 10 randomly selected bushes and trees of different size. In the case of herb species, we dig out 10 randomly selected individuals of different size of only those species which are used for their belowground parts and fresh weight measured at the field and dry weight at the lab after oven dry (70^{o}C for 24 hrs). So far, we have collected 54 species of herbs (Annexure – I) and 28 shrubs (Annexure II) for estimation of total biomass (out of which 53 species were having MAPs properties and 29 wild edibles) in Uttarakhand.

Fig. 1 Step-wise method for biomass estimation of the useful/tradable part of the species (A) categorization of bushes of different size; (B) measurement of fresh weight of the useful/tradable part at the field; (C) preparing species for oven dry (D) oven dry of species at lab

Similarly, in M.P. we estimated total biomass of 49 herbs and 22 shrubs species (in which 53 species are of MAPs properties and 18 wild edible). However, our filed work and literature survey is still continuing to estimate the biomass/ density/ yield for those species which are not yet matured or not in fruiting stage so far.

Fig. 2 Some plants of economic values (A) Flower of *Desmodium trifolium* (B) Leaves of *Bergenia ciliata* (C) Fruit of *Cassia fistula* (D) Cone of *Pinus roxburghii* (E) Fruits of *Bahunia variegata* (E) Fruits of *Pyracantha crenulata* (F) Fruits of *Rubus ellipticus* (G) Fruits of *Ficus roxburghii*

2. Identification of unidentified plant species of M.P. polygons-

In the present field work (late monsoon to post-monsoon period) across the 22 polygons studied till now in Madhya Pradesh, a total of 62 plant species were recorded. However, 17 plant species are yet to be identified with the help of experts in M.P. We are sharing plant specimens to these experts along with their photos taken in the field and maintaining the herbarium sheet. During the reporting period 17 new species have been identified by the taxonomists which are different from the species recorded in pre-monsoon survey in 2020-21. The exact numbers of species will be provided in the FTR after conducting complete field work/ identification.

3. Estimation of volume of the dead standing tree/stumps-

For estimation of standing dead wood volume within the burnt polygon ten quadrats of 10m x 10m size were randomly laid in the polygon so that it represents the entire vegetation type. Standing dead wood were measured for diameter and height/length in the corresponding quadrat. Diameter was measured at three points across the stump (diameter at base; diameter at breast height, diameter at top) and the dead standing tree charred due to forest fire. Later, based on fire damage percentage and 3rd and 4th grades of the dead standing wood was classified into fuelwood/timber use.

Fig. 3 Estimation of volume of the dead standing tree/stumps: (A) Measuring of dead standing stump; (B) Pine tree affected by fire; (C) Burnt stump of pine.

4. Field workshop to standardize the methods and techniques of loss estimation with forest officials-

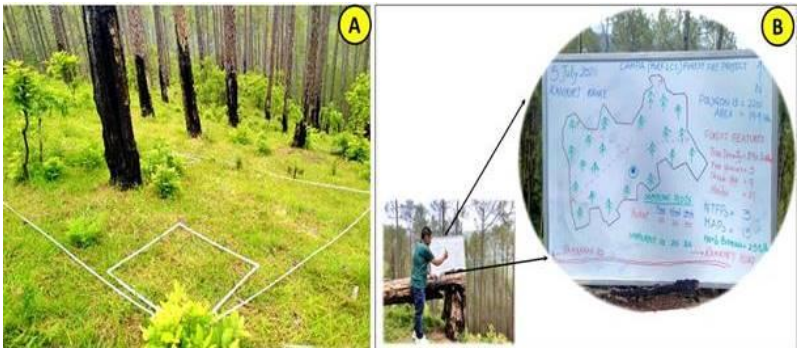


Fig. 4 Field workshop/ demonstration (A) Quadrat; (B) Dr. GCS Negi, PI of the project, demonstrating methods for field work and comparing pre- and post-monsoon data of the polygon 2201, Ganiadeoli beat, Ranikhet range

A two-days field workshop conducted under the supervision of Dr. GCS Negi, PI of the project at polygon ID 2201, Ganiadeoli Beat, Ranikhet Range with all the project staff to discuss various issues those are encountered during the field work. The main aim of the workshop was to demonstrate the methods for post monsoon data collection, and to compare pre-and-post monsoon data of polygon. After the completion of field workshop, a stakeholder's consultation meeting was carried out at Forest Research Centre, Ranikhet to assess the economic values of the forest products i.e., MAPs, wild edibles, fodder, and other NTFPs. The meeting started with a short presentation of the project objective and methodology by the PI of the project

and project RA. In the following discussion all the officials and staff of the Forest Research Centre participated.

5. Estimation of the herbaceous biomass-

Herbs biomass was estimated using total harvest method by randomly placing 30 quadrats (1m x 1m) distributed across the ten quadrats of 10x10 m each representing the entire vegetation of both burnt polygons and adjacent unburnt forest. Before placing the quadrate the entire polygons were trekked to identify the suitable locations for intensive study. Herb biomass was harvested using a scissor, weighed in an electronic balance and brought to laboratory for dry weight estimation.

Fig. 5 Stepwise methodology for estimation of the herbaceous biomass: (A), (B) randomly laid quadrat; (C) harvesting vegetation; (D) harvested quadrat; (E) weighing the herbaceous biomass (fresh weight)

6. Future plan of action-

The field survey is already in progress in burnt and un-burnt forests in Uttarakhand and Madhya Pradesh. The details of the work elements are as follows:

1. Detailed survey in the field will focus on the individual biomass of MAPs species
2. Biomass estimation (fresh weight at field) of plant parts/ whole plant of economic value of MAPs species reported in 2020-21 and additional species
3. Estimation of yield of wild edible individual plant species
4. Biomass of individual herb biomass
5. Biomass of individual shrub biomass
6. Volume of dead standing trees/ stumps
7. Transect walk in the polygon and listing/inventory of species, and
8. Stakeholder's consultations / meetings with the local people nearby the polygon

9. Literature survey and consultations with experts / stakeholders for estimation of loss due to forest fire.

❖ National Institute of Hydrology (NIH), Roorkee

Objective: Economic loss assessment of hydrological changes due to forest fire on per hectare basis for the respective states

Study Area

The study was proposed to be carried out in plots of 1 ha size in the states of Uttarakhand and Madhya Pradesh. Two neighbouring plots (one burnt and another un-burnt) of 1 ha size would be selected; one of these two plots in each of the finally selected burnt forest polygons i.e. 42 Nos. in Uttarakhand and 49 Nos. in Madhya Pradesh and one nearby unburnt plot in the similar forest type in the vicinity. The location and details of these sites have been given in Tables 1 and 2.

Table 1: Finally selected 42 Burnt plots in the forest areas of Uttarakhand

		Burnt Polygons		
SN	**Forest type**	**Severe**	**Moderate**	**Low**
1.	Group 3- Tropical Moist Deciduous Forests	Nil	4	2
2.	Group 5- Tropical Dry Deciduous Forests	Nil	Nil	2
3.	Group 9 -Subtropical Pine Forests	Nil	18	2
4.	Group 12- Himalayan Moist Temperate Forests	Nil	9	2
5.	Group- TOF/Plantation	Nil	1	2
	Total	**Nil**	**32**	**10**

Table 2: Finally selected 49 Burnt plots in the forest areas of Madhya Pradesh

SN	**Forest type**	**Burnt Polygons**		
		Severe	**Moderate**	**Low**
1.	Group 3- Tropical Moist Deciduous Forests	2	4	8
2.	Group 5- Tropical Dry Deciduous Forests	3	20	12
3.	Group 9 -Subtropical Pine Forests	Nil	Nil	Nil
4.	Group 12- Himalayan Moist TemperateForests	Nil	Nil	Nil
5.	Group- TOF/Plantation	Nil	Nil	Nil
	Total	**5**	**24**	**20**

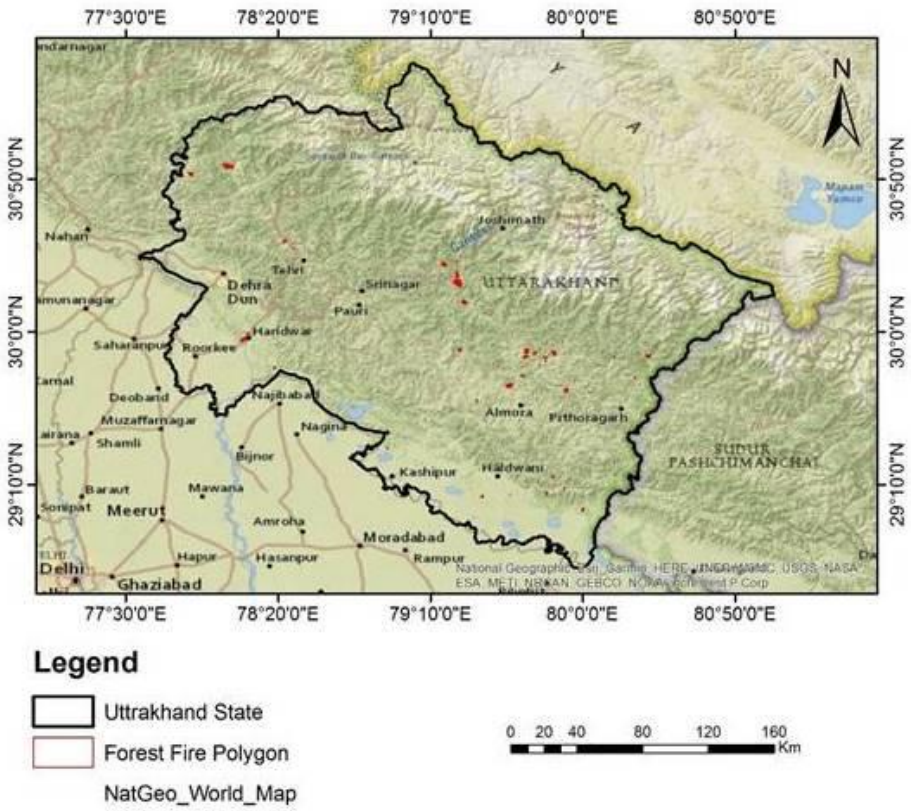


Fig. 6 Finally selected 42 Burnt plots in the forest areas of Uttarakhand

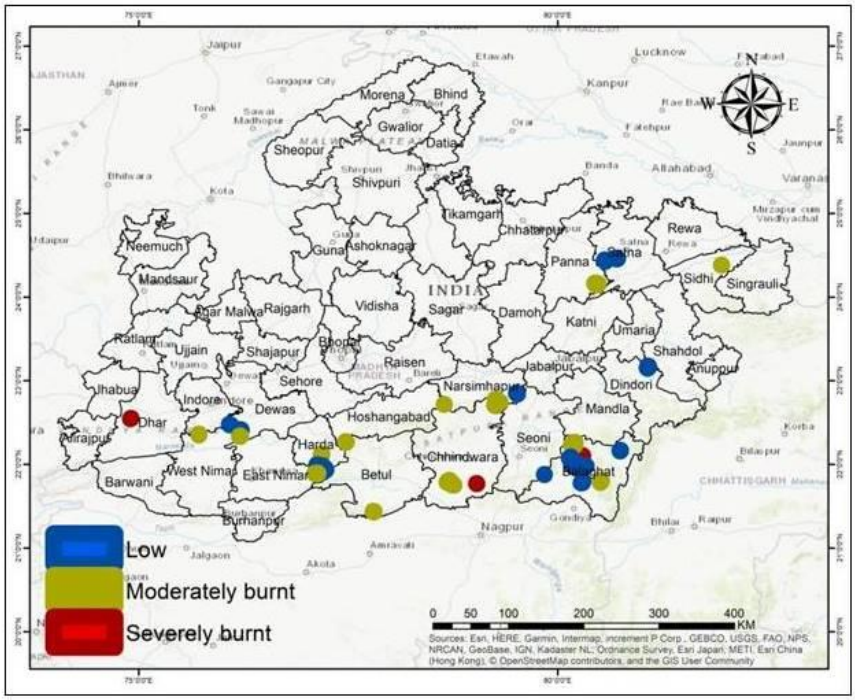


Fig. 7 Finally selected 49 Burnt plots in the forest areas of Madhya Pradesh

Methodology

Part A. Estimation of changes in hydrological response due to forest fire

A paired-plot approach would be adopted in the study that involves use of two neighbouring plots (one burnt and another un-burnt) where precipitation inputs, pre-burnt vegetation characteristics, soil and geological conditions, and other variables are similar/ identical.

Field and Laboratory Investigations:

The burnt and un-burnt plots shall serve as treated and control plots for estimating the changes in hydrological variables. Extensive field and laboratory investigations would be carried out in experimental and control plots in all the forest types and in both the states. Double Ring Infiltrometer Tests and Guelph Permeameter Tests will be conducted to determine the infiltration capacity and hydraulic conductivity of the burnt and unburnt plots. The soil sampleswill be collected from the burnt and unburnt plots and analyzed in the laboratory for determination of soil texture, soil organic matter, soil porosity, soil-water retention characteristics, soil permeability etc. The field investigations would also be carried out for determination of vegetation cover characteristics and hydrologic condition of the cover.

Fig. 8 Field investigations at Rajaji National Park

Assessment of Hydrological Response:

The gridded historical precipitation data, AET data and soil maps will be obtained from various sources. Direct runoff from the experimental plots will be estimated by SCS Curve Number (SCS-CN) Method.

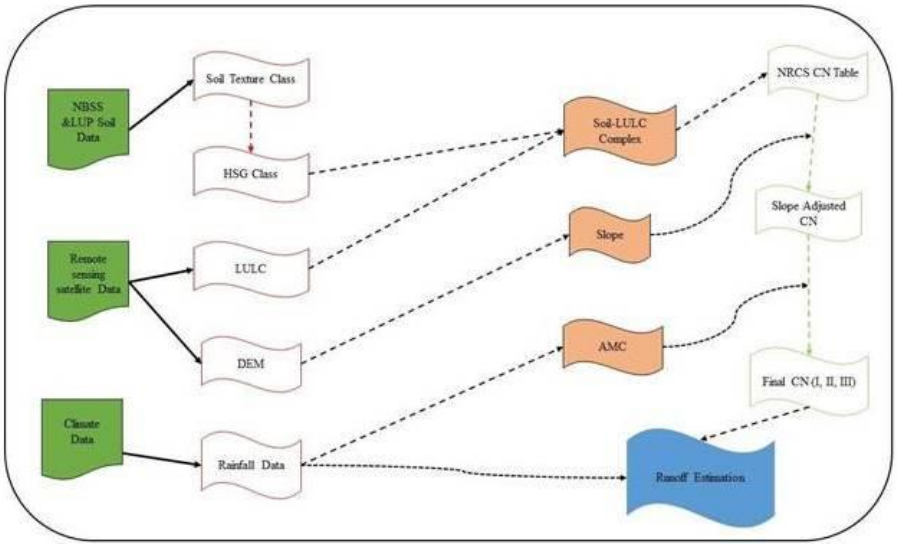


Fig. 9 Flowchart of runoff estimation procedure using SCS-CN method

The curve numbers for AMC-II condition are derived from NEH-4 tables and these curve numbersare used for estimation of runoff using the following equations:

$$Q = \frac{(P - 0.05S)^2}{P + 0.95S} \qquad S = \frac{25400}{CN} - 254$$

Further, these curve numbers are converted for AMC-I or AMC-III using the following equations:

Model	AMCI	AMC III
Sobhani (1975)	$CN_I = \frac{CN_{II}}{2.334 - 0.01334CN_{II}}$	$CN_{III} = \frac{CN_{II}}{0.4036 + 0.005964CN_{II}}$
Hawkins et al. (1985)	$CN_I = \frac{CN_{II}}{2.281 - 0.01281CN_{II}}$	$CN_{III} = \frac{CN_{II}}{0.427 + 0.00573CN_{II}}$
Chow et al. (1988)	$CN_I = \frac{4.2CN_{II}}{10 - 0.058CN_{II}}$	$CN_{III} = \frac{23CN_{II}}{10 + 0.13CN_{II}}$
Neitsch et al. (2002)	$CN_I = CN_{II} - \frac{20(100 - CN_{II})}{\{100 - CN_{II} + \exp[2.533 - 0.0636(100 - CN_{II})]\}}$	$CN_{III} = CN_{II}\exp\{0.00673(100 - CN_{II})\}$
Mishra et al. (2008)	$CN_I = CN_{II} - \frac{20(100 - CN_{II})}{2.274 - 0.012754CN_{II}}$	$CN_{III} = \frac{CN_{II}}{0.430 + 0.0057CN_{II}}$

Further, for assessing the hydrological response, Thornthwaite Water Balance Method

will be used incorporating the precipitation data, AET data, SCS-CN estimated runoff and the hydrological parameters derived from the field and lab investigations. The difference in hydrological response of the two plots would be ascribed to the changes due to fire.

Assessment of Soil Erosion Patterns:

Modified Universal Soil Loss Equation (MUSLE) will be employed to assess the sediment yield patterns as follows:

$S = 11.8 (Q^* qp)^{0.56} K^* LS^* C^* P$

where, S is the single storm sediment yield (tons), Q is the runoff volume (m^3), qp isthe peak discharge. The peak discharge may be estimated using the following equation:

$q_p = 0.278^* A^* d / Tp$

where, A is area (km^2); d is runoff depth (mm); Tp is the rise time of the hydrograph (h) (time from the beginning of runoff to the time of peak runoff.

$$t_{lag} = \frac{2.587 * L^{0.8}\left(\frac{1000}{CN} - 9\right)^{0.7}}{1900 * H^{0.5}} \quad [11.7]$$

where,

t_{lag} = Lag time [hr].

L = Hydraulic watershed length [m].

CN = Hydrologic area-weighted curve number.

H = Average watershed land slope [%].

The hydraulic watershed length L can be approximated for small watersheds (<2000 ha) by the formula 11.8.

$$L = 110\ A^{0.6} \quad [11.8]$$

where,

A = watershed area [ha].

$t_{lag} = 0.6\ t_c$

where,

t_c = Time of concentration [hr].

The main difference compared to the USLE is the replacement of the rainfall factor with a direct estimate of surface runoff and peak runoff rate. This method requires rainfall data, soil parameters, slope, vegetation cover, and land management practices. Due to forest fire, there will be change in soil erodibility and vegetation cover which will be reflected in the soil erosion patterns.

Part B. Estimation of Economic Losses due to change in hydrological response induced by forest fires

The study will evaluate economic loss based on the effect of forest fire on the hydrological behaviour of experimental plots through conducting primary surveys of selected sites under burnt and un-burnt categories specific to the study area. Capture the socio-economic and environmental loss due to change in hydrological behaviour caused by forest fire. The broad regulating and supporting ecosystem services of forest like water cycle and its related biophysical attributes like interception, infiltration, water holding, surface runoff, soil erosion, sedimentation, river flow, downstream water quality and impact on aquatic lives will be focused and their impacts on ground and surface water causing loss or gain will be analyzed and estimated. The loss or gain will be analyzed in terms of use (direct and indirect) and non-use values using the methodology of TEEB India Initiative including the socio-economic and environmental losses/gains due to hydrological change.

Multi-stage random sampling technique will be adopted. The sample households will be chosen in the various selected distance ranges (to be specified depending on the experimental area of the forest). The semi-structured questionnaire will be used to collect the primary data. A survey will be conducted to test the questionnaire. Focused group discussions (FGDs) will also be conducted to get the qualitative data from the stakeholders. The questionnaire will cover broad aspects of socio-economic and demographic characteristics of the households and their access to environmental goods to investigate the various impacts and effects of wildfire on their lives, livelihood, occupation, assets, health, and different natural sources like water, food, soil/ agricultural land, homestead trees. To understand the differences in socioeconomic characteristics of stakeholders, several variables will be considered such as family-size and its composition; level of education; occupation; landholding pattern; livestock-ownership pattern; ownership of agricultural machinery and implements; exposure to watershed and wild fire and distance; access to infrastructure and natural resources; etc. In addition to use of statistical toolsand techniques, different GIS techniques shall be used. The analysis will be made by focusing on its impact on different systems and subsystems like land/soil/agriculture, forest, water, and their services. Different market and non-market valuation techniques will be applied to assess themonetary value of economic losses.

Current Progress Status of The Project

The field investigations (including double ring infiltrometer tests and Guelph Permeameter Tests and soil sample collection for texture, soil moisture retention, organic matter content etc.) at the burnt and unburnt plots are going on. Till now, we have completed the field investigations at 14 burnt polygons in Uttarakhand and 24 burnt polygons in Madhya Pradesh along with equal number of neighbouring unburnt plots. The laboratory investigations for the analysis of collected soil samples are also going on in parallel.

The required gridded precipitation data, Actual Evapotranspiration (AET) data, National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) soil maps and Leaf Area Index for both theburnt and unburnt plots in both the states have been obtained.

The development of various maps required for the assessment of change in hydrologic responseas well as for assessment of soil erosion patterns is in progress.

One component of the study titled "Estimation of economic loss due to change in hydrologic variables caused by forest fires in Uttarakhand and Madhya Pradesh" has been awarded to the Department of Humanities and Social Sciences, IIT Roorkee. Their assessment of economic loss will be based on surveys and the inputs on hydrologic response provided by NIH. They have finalized the questionnaire for the survey and started the field surveys.

Field Investigations in Madhya Pradesh

The 49 burnt sites in forests of Madhya Pradesh comprise of 20 low burnt, 24 moderately burnt and 5 severely burnt sites. The burnt sites are distributed in the various regions of Madhya Pradesh and field experiments along with soil sampling cannot be performed at one go for all the49 sites. Therefore, the experiments have been planned in four phases to cover these 49 test sites spread all over Madhya Pradesh. 24 burnt sites were selected to be covered in the first andsecond phase of the field visits to cover the burnt sites located in the districts of Hoshangabad, Narsinghpur, Katni, Satna, Sidhi, Dindori, and Balaghat. The experiments have been performed at these 24 burnt sites and the adjoining 24 unburnt/control sites so that the changes that might have resulted due to forest fires can be evaluated.

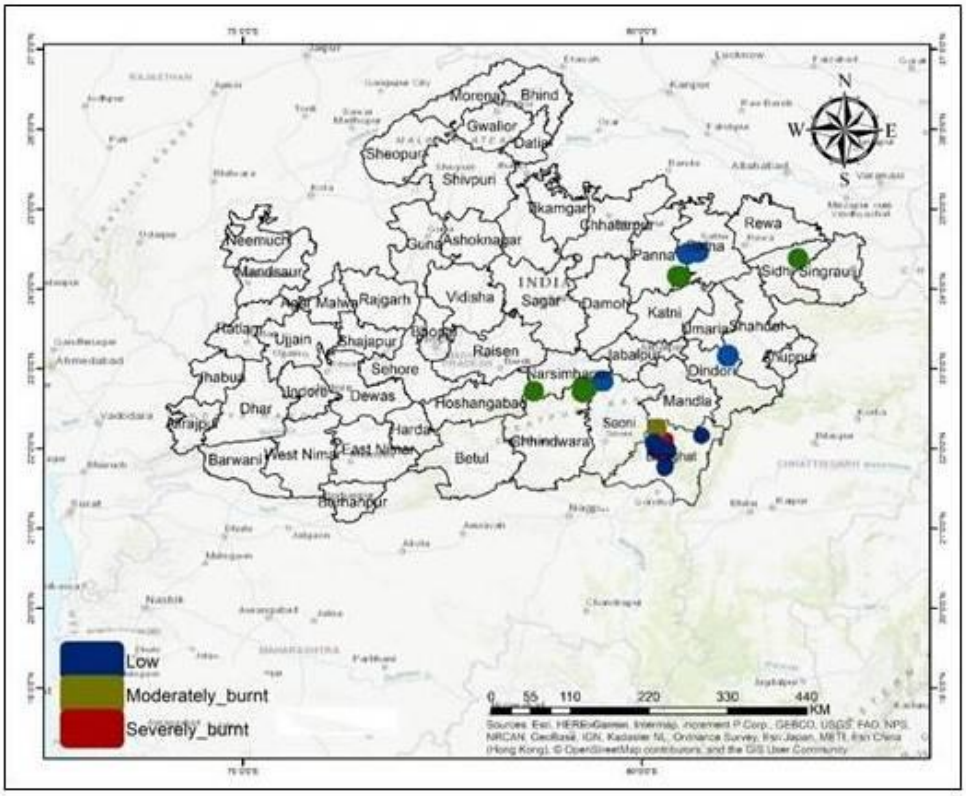


Fig. 10 Completed 24 burnt and unburnt (control) sites in forests of Madhya Pradesh

Field experiments were carried out to determine the saturated hydraulic conductivity and infiltration capacity at the selected 24 burnt forest sites and adjoining unburnt (control) sites. The cumulative infiltration that took place during the test duration of 5 hours and 50 minutes was also computed from the analysis. The results of the infiltration tests and Guelph Permeameter tests for the burnt and unburnt forest sites are summarized in Table 3 whereas Table 4 shows the test results at the adjoining unburnt (control) test sites. At few sites, the infiltration tests could not be conducted due to topographical constraints and trekking time limitations within the forests to reach some of the test sites.

Table 3: Saturated hydraulic conductivity, Infiltration capacity and Cumulative infiltrationat burnt forest sites

SN	Forest Division	Forest Range	Burnt forestsites (Beat)	Comp .No.	Fire Severity	Saturated hydraulic conductivity(cm/sec)	Infiltration rate (cm/hr)
1	Hoshangabad	Bankhedi	Dolni	321	Moderate	2.952	3.8
2	Narsinghpur	Narsinghpur	Usri	136	Moderate	1.008	1.1
3	Narsinghpur	Narsinghp	Jatlapur	150	Moderat	5.436	5.1

		ur			e		
4	Narsinghpur	Narsinghpur	Kislai	155	Moderate	5.868	-
5	Narsinghpur	Gotegaon	Dungariya	39	Low	2.952	2.9
6	South Panna	Kalda	Kutmi khurd	851	Moderate	0.900	1.9
7	Satna	Nagod	Surdaha	321	Low	0.468	1
8	Satna	Nagod	Jhingodar	330	Low	1.332	-
9	Satna	Nogod	Shyam Nagar	294	Low	2.340	-
10	Sidhi	Sidhi	Sidhi	1007	Moderate	1.944	1.8
11	Dindori	Shahpur	Surkhi	120	Low	2.916	-
12	Dindori	Shahpur	Surkhi	120	Moderate	3.384	-
13	Satna	Nagod	Khagaha	293	Low	2.340	-
14	South Panna	Kalda	Jursinha	817	Moderate	-	-
15	South Balaghat	Balaghat	Bori	667	Low	0.049	1.6
16	South Balaghat	Loungur	Varudgota	5	Severe	1.065	4
17	North Balaghat	South Lamta	Dongarbodi North	1373	Severe	0.324	0.9
18	North Balaghat	South Lamta	Manpur	1356	Low	0.294	5.2
19	North Balaghat	South Lamta	Mohgaon	1314	Low	0.292	3.3
20	North Balaghat	North Lamta	Basegaon	1195	Moderate	0.006	3.9
21	North Balaghat	North Lamta	Kumjhar	1211	Moderate	0.607	4.4
22	North Balaghat	North Lamta	Basegaon	1210	Low	0.457	4.8
23	South Balaghat	Lougur	Khursudh	56	Low	0.144	2.7
24	Kanha NationalPark (Core)	Mukki	Samnapur	195	Low	0.342	1

Table 4: Saturated hydraulic conductivity, Infiltration capacity and Cumulative infiltrationat Unburnt (control) sites

SN	**Forest Division**	**Forest Range**	**Burnt forestsites (Beat)**	**Comp .No.**	**Fire Severity**	**Saturated hydraulic conductivity(cm/sec)**	**Infiltrationrate (cm/hr)**
1	Hoshangabad	Bankhedi	Dolni	321	Moderate	3.636	4.7
2	Narsinghpur	Narsinghpur	Usri	136	Moderate	2.052	1.7
3	Narsinghpur	Narsinghpur	Jatlapur	150	Moderate	11.052	6.9
4	Narsinghpur	Narsinghpur	Kislai	155	Moderate	7.956	-
5	Narsinghpur	Gotegaon	Dungariya	39	Low	3.132	3.2
6	South Panna	Kalda	Kutmi khurd	851	Moderate	2.088	2.8
7	Satna	Nagod	Surdaha	321	Low	1.764	1.2
8	Satna	Nagod	Jhingodar	330	Low	5.796	-
9	Satna	Nogod	Shyam Nagar	294	Low	2.952	-
10	Sidhi	Sidhi	Sidhi	1007	Moderate	2.700	2.4

11	Dindori	Shahpur	Surkhi	120	Low	6.264	-
12	Dindori	Shahpur	Surkhi	120	Moderate	6.264	-
13	Satna	Nagod	Khagaha	293	Low	3.240	-
14	South Panna	Kalda	Jursinha	817	Moderate	-	-
15	South Balaghat	Balaghat	Bori	667	Low	0.370	4
16	South Balaghat	Loungur	Varudgota	5	Severe	0.454	5.4
17	North Balaghat	South Lamta	Dongarbodi North	1373	Severe	0.068	3.7
18	North Balaghat	South Lamta	Manpur	1356	Low	0.008	5.8
19	North Balaghat	South Lamta	Mohgaon	1314	Low	0.144	5.8
20	North Balaghat	North Lamta	Basegaon	1195	Moderate	0.538	5.6
21	North Balaghat	North Lamta	Kumjhar	1211	Moderate	0.023	5.6
22	North Balaghat	North Lamta	Basegaon	1210	Low	0.363	5.7
23	South Balaghat	Lougur	Khursudh	56	Low	0.063	4.2
24	Kanha National Park (Core)	Mukki	Samnapur	195	Low	0.098	5.7

Field Investigations in Uttarakhand

The 42 burnt sites in the forest areas of Uttarakhand comprise of 10 low burnt, 32 moderately burnt sites distributed across five forest types. The burnt sites are distributed in the various regions of Uttarakhand, therefore, the experiments have been planned to cover the sitesaccording to the forest divisions. The field investigations were started during last week of January. Considering the harsh winter climate at the hilly sites, it was planned to carry out the field investigations starting from the plain areas of Uttarakhand and further approaching towards the hilly sites. The experiments have been performed at the 14 burnt sites and the adjoining 14 unburnt/control sites so that the changes that might have resulted due to forest fires can be evaluated.

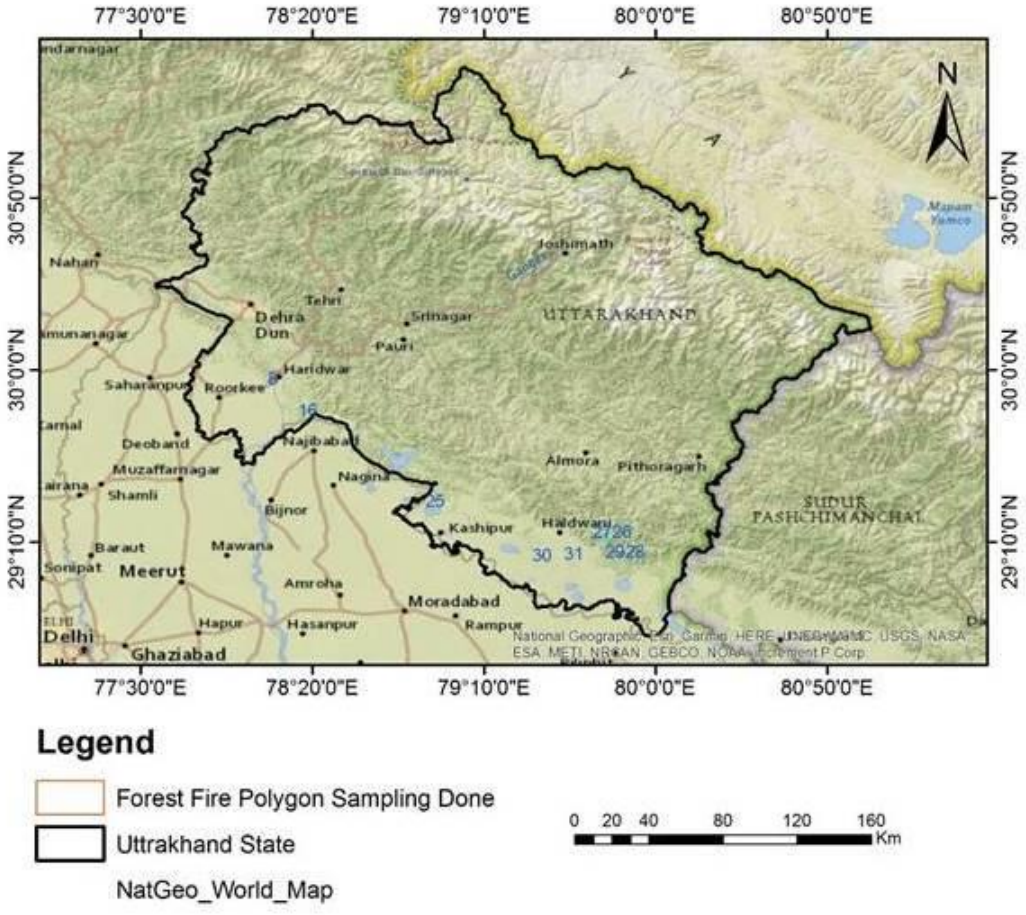


Fig. 11 Completed 14 burnt and unburnt (control) sites in forests of Uttarakhand

Field experiments were carried out to determine the saturated hydraulic conductivity and infiltration capacity at the selected 14 burnt forest sites and at equal number of adjoining unburnt(control) sites. The results of the infiltration tests and Guelph Permeameter tests for the burnt and unburnt forest sites are summarized in Table 5 whereas Table 6 shows the test results at the adjoining unburnt (control) sites.

Table 5: Saturated hydraulic conductivity, Infiltration capacity and Cumulative infiltrationat burnt forest sites

SN	Division	Range	Beat	Comp. No.	Hydraulic Conductivity (Kfs) (cm/hr)	Infiltratio nRate (cm/hr)
1	Raja Ji National Park	Haridwar	Ranipur East	0	0.997	9.546
2	Raja Ji National Park	Haridwar	Kharkhari North	0	2.303	1.069
3	Haridwar	Chiriyapur	Kotawali	10	0.250	0.7
4	Terai East	Kilpura	West Kilpura - 1	51	0.979	1.82
5	Terai East	Kishanpur	Kishanpur South	8	0.409	2.959
6	Tarai Central	Haldwani	Tanda Center	109	0.064	1.018
7	Tarai West	South Jaspur	Tumaria	39	1.754	2.036
8	Haldwani	Danda	North Lowaranala	0	-	19.855

9	Haldwani	Danda	Durgapipal	4	0.054	2.291
10	Haldwani	Jaulasal	Hatgarh	9	-	6.491
11	Haldwani	Nandhaur	Ratarao	5	-	26.727

Table 6: Saturated hydraulic conductivity, Infiltration capacity and Cumulative infiltrationat Unburnt (control) sites

SN	Division	Range	Beat	Comp. No.	Hydraulic Conductivity (Kfs) (cm/hr)	Infiltration Rate (cm/hr)
1	Raja Ji National Park	Haridwar	Ranipur East	0	1.965	29.591
2	Raja Ji National Park	Haridwar	Kharkhari North	0	1.479	7.255
3	Haridwar	Chiriyapur	Kotawali	10	0.827	0.682
4	Terai East	Kilpura	West Kilpura - 1	51	3.354	2.036
5	Terai East	Kishanpur	Kishanpur South	8	0.013	5.727
6	Tarai Central	Haldwani	Tanda Center	109	0.556	0.509
7	Tarai West	South Jaspur	Tumaria	39	3.529	2.291
8	Haldwani	Danda	North Lowaranala	0	0.076	91.636
9	Haldwani	Danda	Durgapipal	4	-	14.891
10	Haldwani	Jaulasal	Hatgarh	8	-	-
11	Haldwani	Nandhaur	Ratarao	4	-	26.727

Inferences Drawn from the Field Investigations

For most of the sites, the infiltration capacity and saturated hydraulic conductivity at unburnt (control) sites have been found to be more than that at the burnt forest sites. The reasonfor the same may be attributed to the repulsive behaviour due to the ashes of the burnt trees getting accumulated over the soil surface and soil pores. The deposition of the ash as well as its downward movement in the subsequent monsoon season causes coagulation and formation of soil aggregates that generally acts as an impervious medium like a cement layer and thereby reducing the infiltration rate and movement of water within the soil matrix. The Figures showing the infiltration capacity and cumulative infiltration for burnt and adjoining unburnt (control) sites in forests of Madhya Pradesh and Uttarakhand are given in (Annexure III).

❖ Wild life Institute (WII), Dehradun

Objective: Economic loss assessment of faunal diversity due to forest fire on per hectare basis for the respective states.

The encounter rates in the post-fire season and relative abundance index has been analysed. By comparing the encounter rates of mammal species, it was found that the encounter rates of Himalayan Goral (1.25 to 1.55 sign per km) and Indian Leopard (1.25 to 1.39 per km) has

increased, while the encounter rates of other species Indian Crested porcupine (0.85 to 0.55 sign per km), Wild pig (0.60 to 0.26 sign per km), Barking deer (0.88 to 0.24 sign per km) and Sambar (0.17 to 0.06 sign per km) reduced, while encounter rates were same for Golden Jackal (0.08 sign per km).

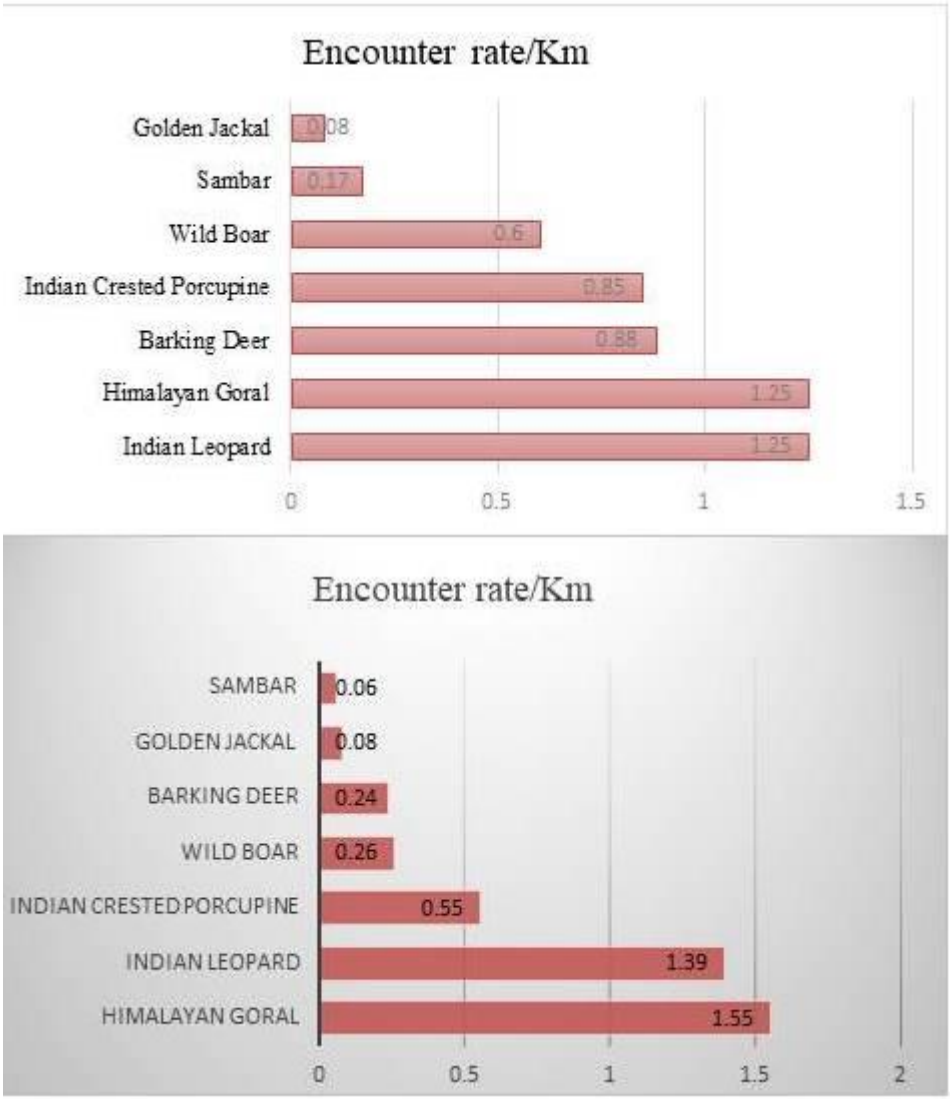


Fig. 12 Bar graph showing encounter rates of indirect signs of mammal's in Pre-fire season (above) and in post fire season (bottom)

Relative Abundance Index: In the study area, a total 18 camera traps were installed and for the analysis of relative abundance index, only the photographs of wild animals were used. The trend of relative abundance index of mammals was in the following order in pre-fire season:

Barking Deer > Himalayan Goral > Indian Crested Porcupine > Masked Palm Civet > Indian Leopard > Wild pig > Sambar > Red Fox > Grey Langur

The trend of relative abundance index of mammals in post-fire season is in the following order:

Barking Deer > Indian Crested Porcupine > Indian Leopard > Wild pig > Himalayan Goral > Red Fox > Masked Palm Civet > Leopard cat > Grey Langur > Rhesus macaque

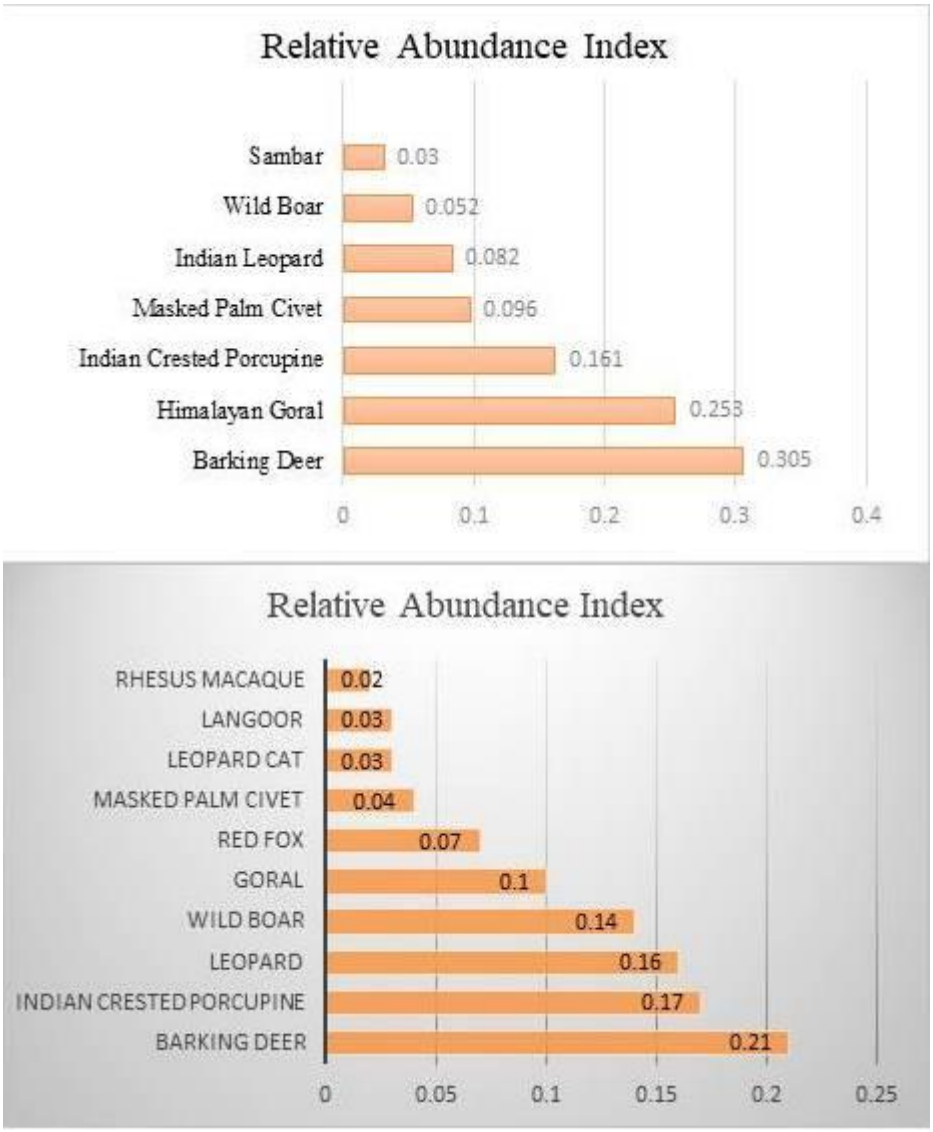


Fig. 13 Bar graph showing Relative Abundance Index (RAI) of mammal's in Pre-fire season (above) and in post fire season (bottom)

The other parameters related to mammals, birds and reptiles are being analysed and listing is in progress. The parameters with respect to spatial effect of fire and monetary impact of it is being developed.

❖ Forest Research Institute (FRI), Dehradun

Objective: Economic loss assessment of terrestrial flora due to forest fire on per hectare basis for the respective states

Keeping in view different variable (Forest Type, Forest Density Class, Altitude and Slope), 42 forest fire polygon were selected (32 Moderately Burned Polygon and 10 Low burnt Polygon) for study.

For phytosociological survey laid out plots size 10M × 10M, 5M × 5 M and 1M × 1M for Trees, Shrubs and herbs layers respectively. Collected dead twigs, litter, and diameter for Tree Carbon pool while entire plant for shrubs and Herbs have been harvested. Collected soils samples from different burnt and unburnt polygons areas for bulk density and carbon pool.

Field survey have been conducted to collect vegetation and carbon pool data from all burnt and unburnt polygons (ID 1552, ID 4007, ID 386, ID 4002, ID 336, ID 397, ID 548, ID 367, ID 1783, ID 2201, ID 4603, ID 1238, ID 2179, ID 2045, ID 2041, ID 2374, ID2655, ID1008, ID 1020, in different Forest Types of Uttarakhand viz. Himalayan Moist Temperate Forests and Subtropical Pine Forests, Tropical Moist Deciduous Forest, Tropical Dry Deciduous Forest, at Haridwar Forest Division, Rajaji National Park, Binsar Wildlife Sanctuary, Almora Forest Division, Civil Soyam Almora, Nainital Forest Division, Tarai West Forest Division, Haldwani Forest Division, Tons Forest Division, Chakrata forest Division, Tehri Forest Division, Bageshwar Forest Division, Badrinath Forest Division, Kedarnath Wildlife Sanctuary (Annexure III).

Poly 2045- Unburnt (Sub Tropical Pine Forests): MB
Binsar Wildlife Sanctuary Division: Dhaulchina Beat (Binsar North)

Fig. 14 Pre-monsoon

Fig. 15 Post-monsoon

Poly 2045-Burnt (Sub Tropical Pine Forests): MB
Binsar Wildlife Sanctuary Division: Dhaulchina Beat (Binsar North)

Fig. 16 Pre-monsoon

Fig. 17 Post-monsoon

- The all 42 polygon covered for study. Out of which pre and post mansoon data have been collected for 35 polygon only 7 polygon left for premansoon data.
- The Phytosociological data have been collected from different burnt areas and adjoining unburnt areas. The data analysis of different diversity indices (Importance Value Index (IVI), Shannon-Wiener index (H‟) and Buza and Gibso's evenness index) are in under progress.
- Rare, endangered and threatened category species (RET) have also been identified referring to the Red Data Book of Botanical Survey of India, IUCN Red data list as well other published records.
- The preparation of listing of Cryptogamic flora (Bryophytes and Lichens are also under preparation for all sites.
- The list of invasive species (if any) are also r prepared for all sites.
- Lab analysis: For 5 Carbon pool dead twigs, litter were collected, and diameter for Tree were measured while for shrub and herb entire plant have been harvested. Collected soils samples from different burnt and unburnt polygons areas for bulk density and organic carbon.

Fig. 18 Bryophyte Diversity in different sites

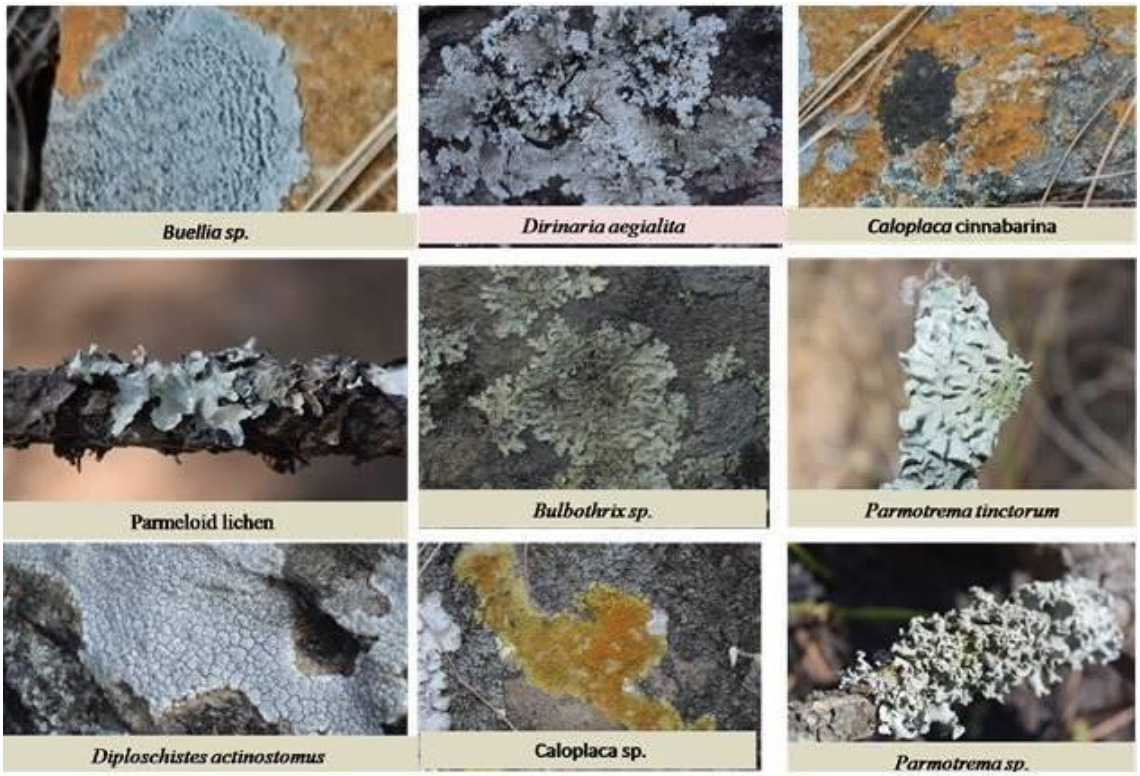


Fig. 19 Lichen Diversity in different sites

❖ Tropical Forest Research Institute (TFRI), Jabalpur

Objective : Economic loss assessment of terrestrial flora due to forest fire on per hectare basis for the respective states

Status of Survey Sites:

Primary baseline data on Terrestrial floral diversity was collected through extensive field surveys in the study area during pre-monsoon and post-monsoon season using stratified sampling with GPS locations. The quadrate nested method was used for vegetation sampling for trees, shrubs, and Herbs. The phytosociological data for trees and shrubs were collected from random quadrates of 10 m ×10 m and 5 m × 5 m size. Random quadrats of 1 m × 1 m size were laid for the study of herbaceous flora. Status of the field survey for identification of flora and sample collection for carbon stock assessment in 5 carbon pools as stated below Table 1.

Table 1: Status of survey sites

Season	Completed sites	Yet be completed sites	Total sites
Pre-Monsoon	33	16	49
Post-Monsoon	16	33	49
Total	49	49	98

16 in-completed sites of pre-monsoon season could not be covered due to prevailing lockdown of COVID-19.

Fig. 20 Field survey in the study area during pre-monsoon and post-monsoon season

A. Sample Collection (Litter, Deadwood, Herb, and Shrub):

Samples of Litter, Dead Wood, Herb, and Shrub were collected in the pre-monsoon season for all visited sites and further processed under the laboratory for moisture content analysis. Each site consists of two areas such as fire and control for which we have collected minimum 5 random samples from each area. Batch-wise, litter, dead wood, herb, and shrub samples were kept in an oven and after every three days weighing have been done until constant weight is attained. The register is maintained to record the fresh weight of all samples and their consequent dry weights. Status of samples collection and analysis of collected samples have been shown in the table no. 2 and 3 respectively.

Table 2: Status of Sample Collection

Season (Pre-Monsoon)	Samples collected	Samples to be collected	Total
Litter	33	16	49
Dead Wood	33	16	49
Herb	33	16	49
Shrub	33	16	49

Table 3: Status of sample analysis

Season (Pre-Monsoon)	Samples analysed (till sept. end)	Samples to be analysed	Total
Litter	22	11	33
Dead Wood	15	18	33
Herb	21	12	33
Shrub	16	17	33

B. Soil samples analysis (Bulk Density & % Organic Carbon):

Soil samples collected from both control and fire sites were brought to the TFRI laboratory for further analysis. These samples were first dried by keeping in an oven until dry and constant weight achieved and calculated bulk density, second, the sample is put through a sieve to obtain well uniform particle size later on organic carbon was determined using the Walkley-Black method. As of now, total 76 (38 sites × 2 classes (fire and non-fire/control) samples have been collected (Table-4). However, 71 soil samples have been analysed for the bulk density and % organic carbon while the remaining samples are in under process. The result of the analysed samples showed in table (Annexure- IV). Based on the result, it was observed that most of the samples show high carbon content as per the standard rating chart. Percent organic carbon of samples observed within the range of 0.08%-2.92%.

Table 4: Status of soil samples collected for Bulk Density and % Organic Carbon

Sampling Season	Completed	To be completed	Total
Pre-Monsoon	38	11	49

C. Identification of plants:

During the field survey, the number of plants of different species in each quadrate was identified and counted while unidentified plants were collected and brought to TFRI. Identification and nomenclature of plants have been done by using regional and state floras and also some of the plants identified by using online websites such as *Flowers of India*, *India Biodiversity Portal*, *Kew Herbarium*. For accepted names, *the plant list* website is checked regularly.

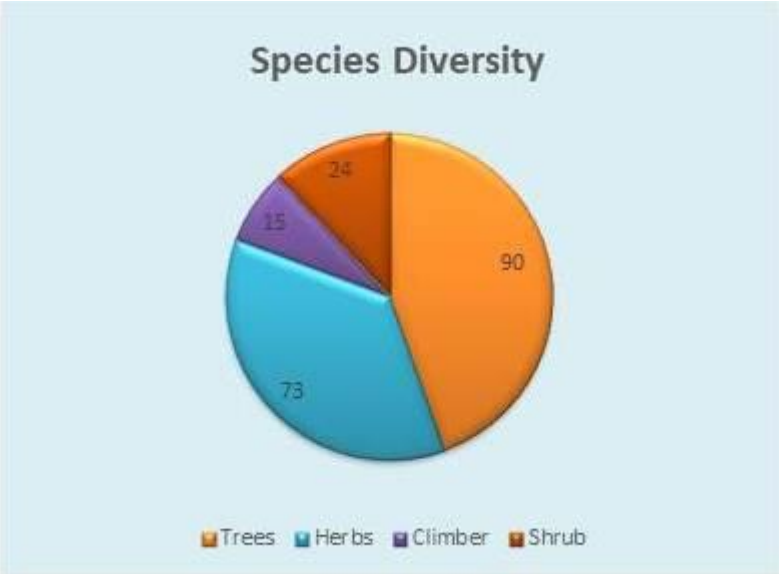


Fig. 21 Habit-wise Species Diversity

After correct identification, plant data is entered into an excel sheet and unique species are extracted. As far now a total of 202 unique plant species are observed, out of which 90, 15, 24, and 73 are Trees, Climbers, Shrubs, and Herbs respectively (Annexure- V).

Fig. 22 Flora observed during the site visit a: *Strobilanthes callosa, b: Bidens biternata, c: Desmodium heterocarpon, d: Oldenlandia ovatifolia*

Constraints:

Since the field work for collection of data of pre-monsoon period couldn't be undertaken by some institutes due to Covid restrictions and in some cases the pre-monsoon data shall be collected during Jan-Feb, 2022, to complete the study, the extension of the project would be required to complete the field activities followed by analysis of data and preparation of composite report for submission to the MoEF&CC.

Annexure-I

List of herb species recorded in Uttarakhand

S. No.	Species	Family
1.	*Aerisema serratum* (Thunberg) Schott *	Araceae
2.	*Ageratum conyzoides* L. *	Asteraceae
3.	*Agrimonia japonica* (Miq.) Koidz. *	Rosaceae
4.	*Ajuga bracteosa* (DC.) *	Geraniaceae
5.	*Anaphalis adnata* Wall. ex DC. *	Asteraceae
6.	*Anaphalis aristata* (DC.) *	Asteraceae
7.	*Anaphalis contorta* (D. Don) Hook. f.	Asteraceae
8.	*Apluda mutica* L.	Poaceae
9.	*Arundinella nepalensis* Trin.	Poaceae
10.	*Arundinella prunella*	Poaceae
11.	*Arundinella pumila* Hochst.ex A.Rich.	Poaceae
12.	*Bergenia ciliata* Sternb. *	Saxifragaceae
13.	*Bidens pilosa* L. *	Asteraceae
14.	*Cassia mimosoides* DC. *	Fabaceae
15.	*Cirsium arvense* (L.) Scop.	Asteraceae
16.	*Conyza sumatrensis* (Retz.) E. Walker*	Asteraceae
17.	*Cynodon dactylon* Linn. *	Poaceae
18.	*Cynoglossum furcatum* Wall. *	Boraginaceae
19.	*Cyperus rotundus* L.	Cyperaceae
20.	*Desmodium microphyllum* (Thunb.) DC. *	Fabaceae
21.	*Desmodium trifolium* (Labill.) G. Don*	Fabaceae
22.	*Dioscorea deltoidea* Wall. ex Griseb.	Dioscoreaceae
23.	*Erigeron canadensis* L.	Asteraceae
24.	*Erigeron sumatrensis* Retz.	Asteraceae
25.	*Euphorbia hirta* L. *	Euphorbiaceae
26.	*Euphorbia prolifera* Buch. Ham. ex D. Don*	Euphorbiaceae
27.	*Gallium aprine* L. *	Rubiaceae
28.	*Gallium rotundifolium**	Rubiaceae
29.	*Geranium wallichianum* D. Don ex Sweet*	Geraniaceae
30.	*Gomphrena celosioides* Mart. *	Amaranthaceae
31.	*Gonostegia hirta* (Blume) Miq. *	Urticaceae
32.	*Hedychium spicatum* Buch.-Ham. ex Sm. *	Zingiberaceae
33.	*Isodon japonicus* (Burm. f.) H. Hara	Lamiaceae
34.	*Justicia procumbens* L.	Acanthaceae
35.	*Lactuca serriola**	
36.	*Lespedeza cuneata* (Dum. Cours.) G. Don	Fabaceae
37.	*Leucas lanata* Baker*	Lamiaceae
38.	*Micromeria biflora* (Buch.-Ham. ex D. Don) Benth. *	Lamiaceae
39.	*Miscanthus nepalensis* (Trin.) Hack.	Poaceae

40.	*Ocimum tenuiflorum* Burm. f.	Lamiaceae
41.	*Osbeckia stellata* Wall. ex C.B. Clarke*	Melastomataceae
42.	*Oxalis corniculata* R. Knuth*	Oxalidaceae
43.	*Panicum verticillatum* L.	Poaceae
44.	*Persicaria capitata* (Buch.-Ham. ex D. Don) H. Gross*	Polygonaceae
45.	*Polygala elongata* Klein ex Willd.	Polygalaceae
46.	*Praxelis clematidea* R.M. King & H. Rob.	Asteraceae
47.	*Setaria parviflora* (Poir.) Kerguelen	Poaceae
48.	*Siegesbeckia orientalis* L. *	Asteraceae
49.	*Thymus serpyllum**	Lamiaceae
50.	Trichodesma indicum *(L.) Lehm.* *	Boraginaceae
51.	*Urginia indica**	Liliaceae
52.	*Valeriana wallichii* DC.	Caprifoliaceae
53.	*Viola* spp Wall. ex Ging.	Violaceae
54.	*Vitis vinifera* L.	Vitaceae

*MAPs those are used for plant parts and have economic values.

Annexure-II

List of Shrub species recorded in Uttarakhand

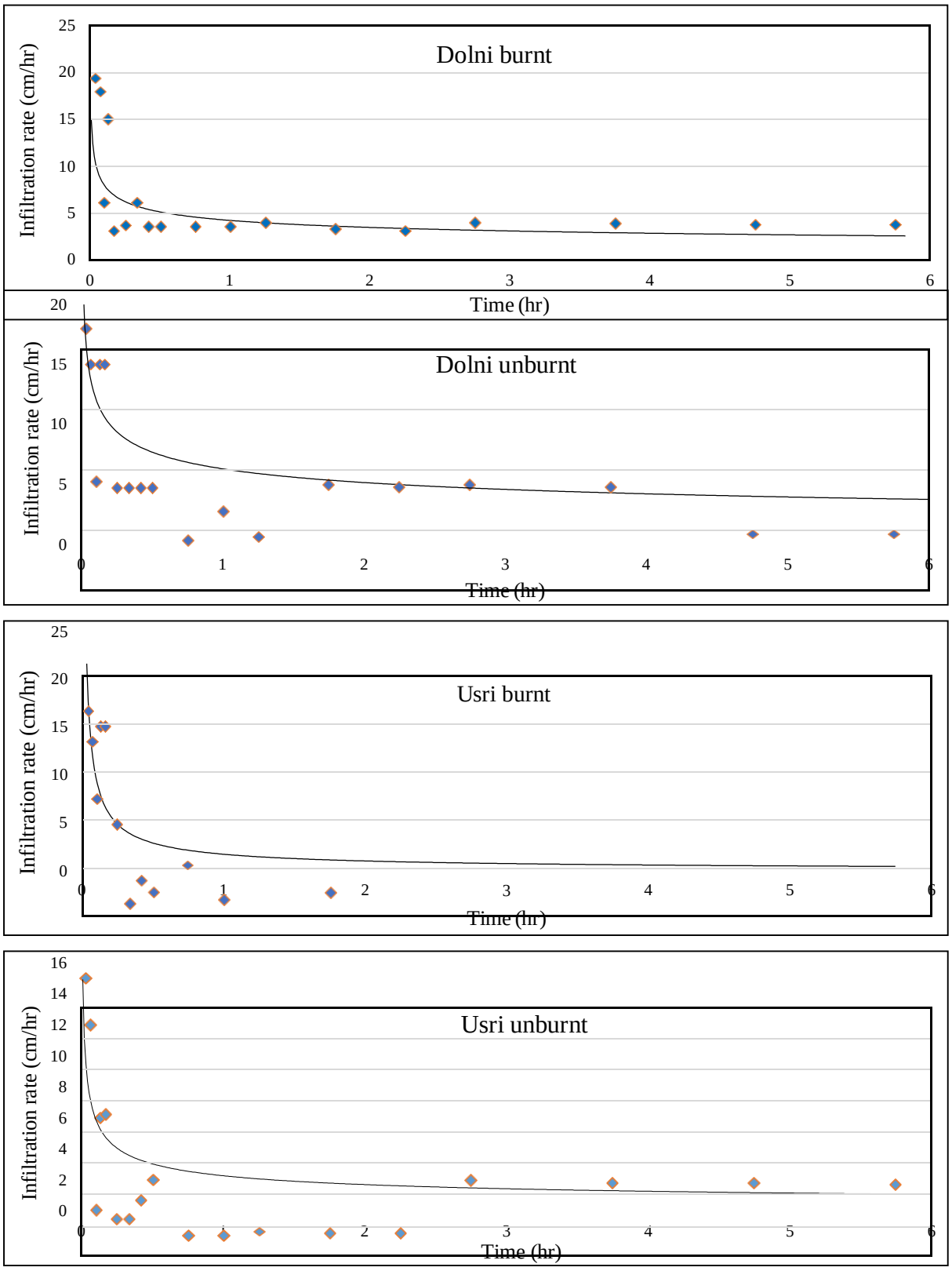
S.No.	Species Name	Family
1.	*Aechmanthera gossypina* (Wall.) Nees*	Acanthaceae
2.	*Barleria cristata* Roxb. *	Acanthaceae
3.	*Berberis aristata* DC. *+	Berberidaceae
4.	*Carissa spinarum* L.	Apocynaceae
5.	*Clerodendrum infortunatum* L. *	Lamiaceae
6.	*Colebrookea oppositifolia* Lodd. *	Lamiaceae
7.	*Coriaria nepalensis* Wall.	Coriariaceae
8.	*Dendrocalamus strictus* (Roxb.) Nees	Poaceae
9.	*Dioscorea floribunda* M. Martens & Galeotti	Dioscoreaceae
10.	*Eupatorium odoratum* L.	Asteraceae
11.	*Euphorbia royleana* Boiss.	Euphorbiaceae
12.	*Flemingia macrophylla* Bold. *	Fabaceae
13.	*Flemingia strobilifera* (L.) W.T. Aiton	Fabaceae
14.	*Glochidion velutinum* Wight	Phyllanthaceae
15.	*Helicteres isora* C. Presl*	Malvaceae
16.	*Himalrandia tetrasperma* (Wall. ex Roxb.) T. Yamaz. *	Rubiaceae
17.	*Indigofera tinctoria* L. *	Fabaceae
18.	*Inula cappa* (Buch.-Ham. ex D. Don) DC. *	Asteraceae
19.	*Lantana camara* L. *	Verbenaceae
20.	*Laptodermis lanceolata*	Rubiaceae
21.	*Lespedeza capitata* Michx.	Fabaceae
22.	*Litsea japonica* Mirb.	Lauraceae
23.	*Maesa indica* Hook. f.	Primulaceae
24.	*Murraya koenigii* (L.) Spreng. *+	Rutaceae
25.	*Myrsine africana* L. *	Primulaceae
26.	*Phoenix dactylifera* L.	Arecaceae
27.	*Phyllanthus amarus* Schumach. & Thonn.	Phyllanthaceae
28.	*Plectranthus lanuginosus* (Hochst. ex Benth.) Agnew*	Lamiaceae
29.	*Pyracantha crenulata* M. Roem. *	Rosaceae
30.	*Rhus parviflora* Roxb. *	Anacardiaceae
31.	*Rosa acicularis* Lindl.	Rosaceae
32.	*Rubus ellipticus* Lindl. *+	Rosaceae
33.	*Solanum aculeatissimum* Lindl. *	Solanaceae
34.	*Symplocos nairii* A.N. Henry	Symplocaceae
35.	*Teucrium quadrifarium* Buch.-Ham. ex D. Don	Lamiaceae
36.	*Thalictrum* L.	Ranunculaceae
37.	*Urena labata* L. *	Malvaceae

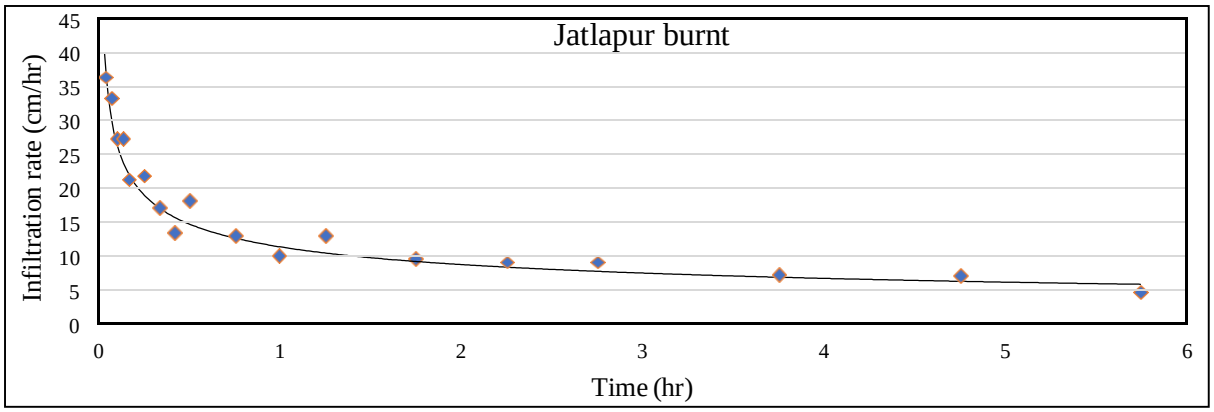
38.	*Woodfordia fruticosa* (L.) Kurz*	Lythraceae
39.	*Ziziphus Nummularia*$^{*+}$	Rhamnaceae
40.	*Reinwardtia indica* Dumort.	Linaceae
41.	*Artemisia nilagirica* (Cl.) Pamp. *	Asteraceae
42.	*Asparagus racemosus* Willd. *	Asparagaceae

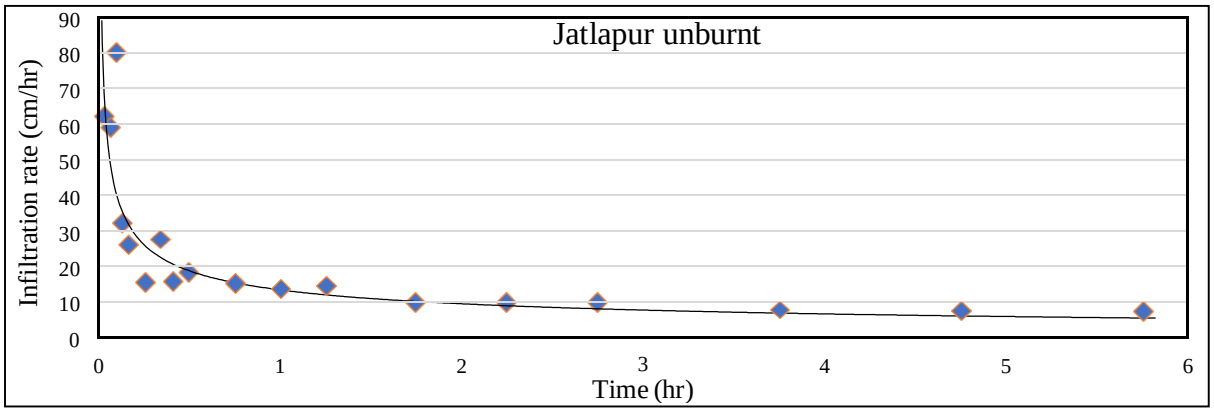
Shrubs having economic importance of both wild edible (+) and MAPs (*).

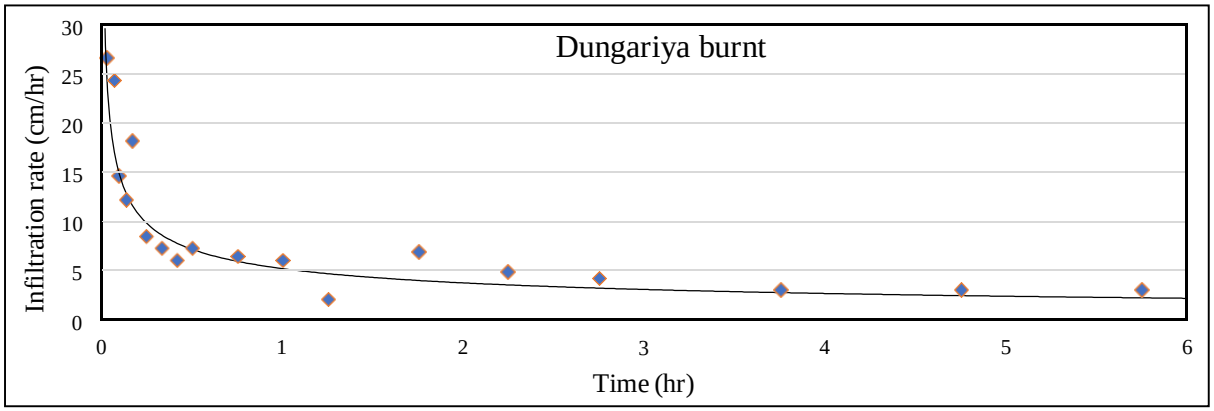
INFILTRATION CHARACTERISTICS OBSERVED DURING FIELD INVESTIGATIONS

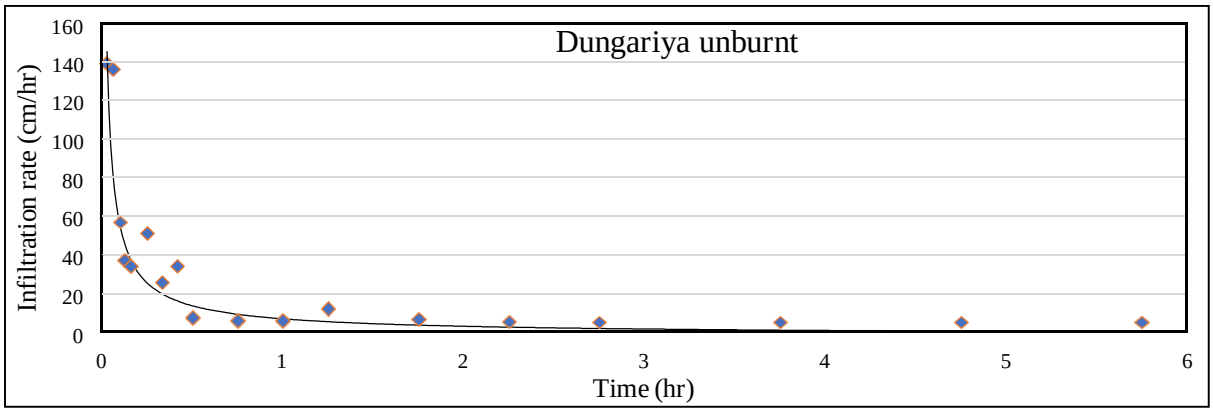
(A) Infiltration characteristics at the selected burnt & unburnt plots in Uttarakhand

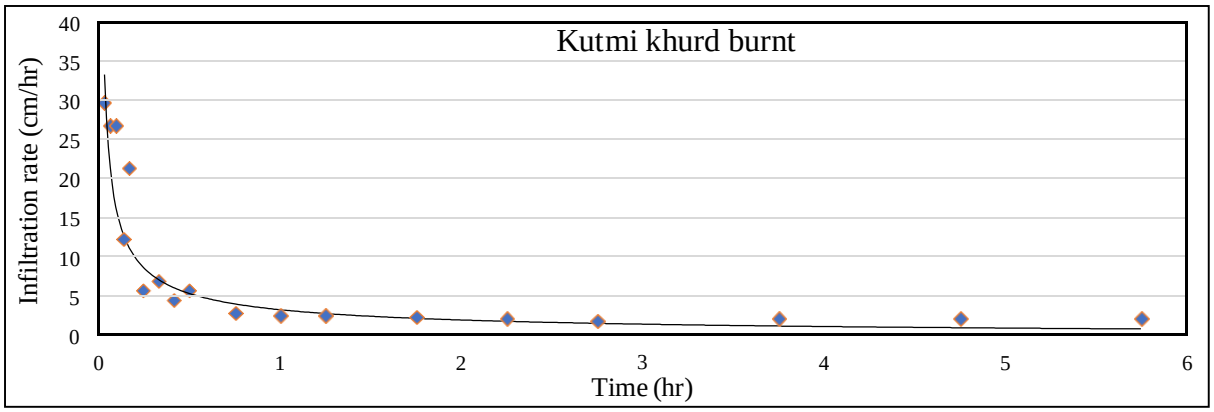


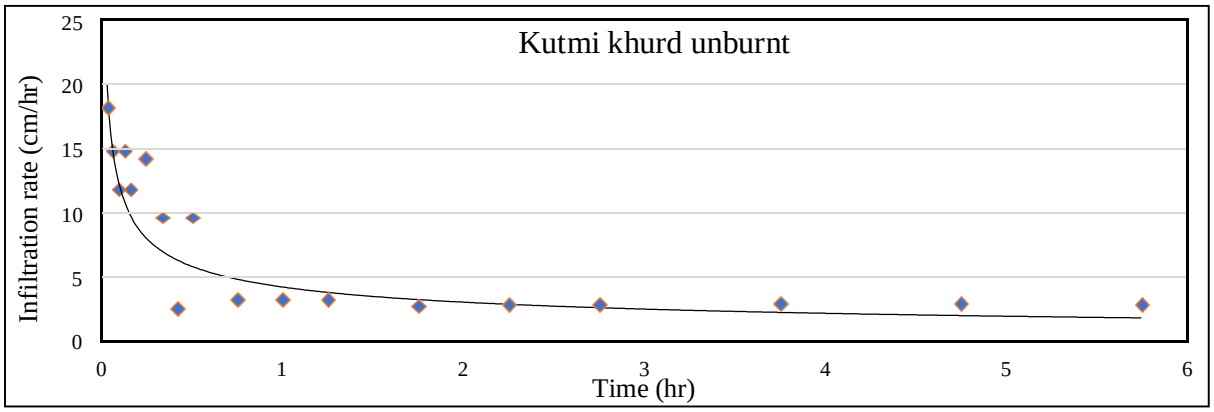

Jatlapur burnt
Infiltration rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
40
45
0
1
2
3
4
5
6

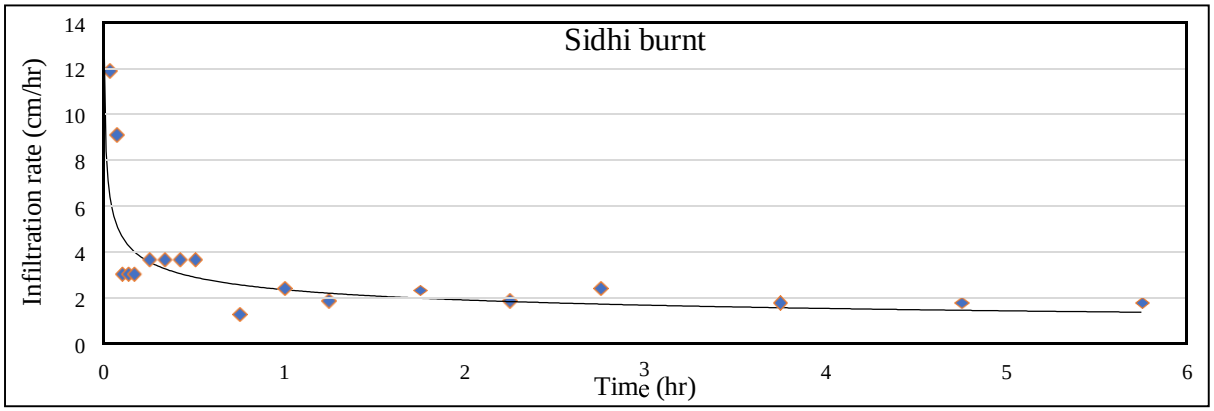

Jatlapur unburnt
Infiltration rate (cm/hr)
Time (hr)
0
10
20
30
40
50
60
70
80
90
0
1
2
3
4
5
6

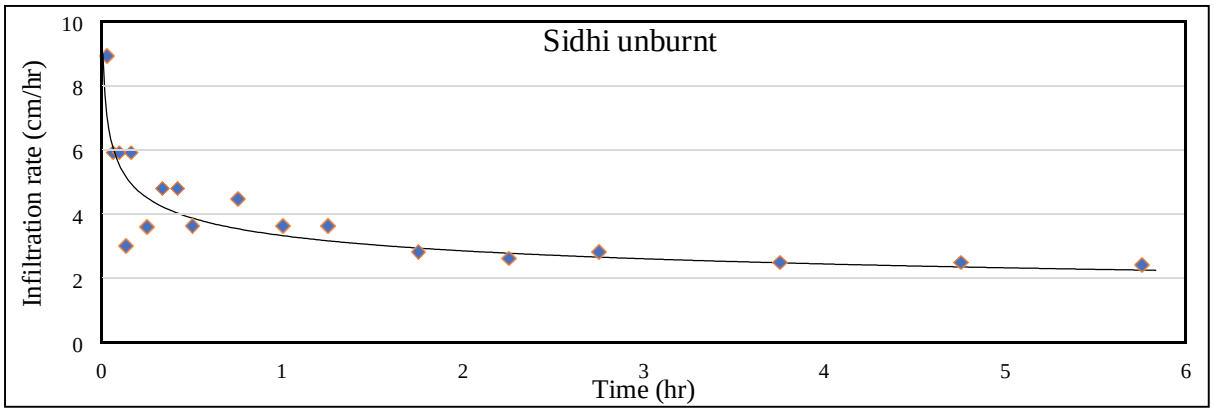

Dungariya burnt
Infiltration rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
0
1
2
3
4
5
6

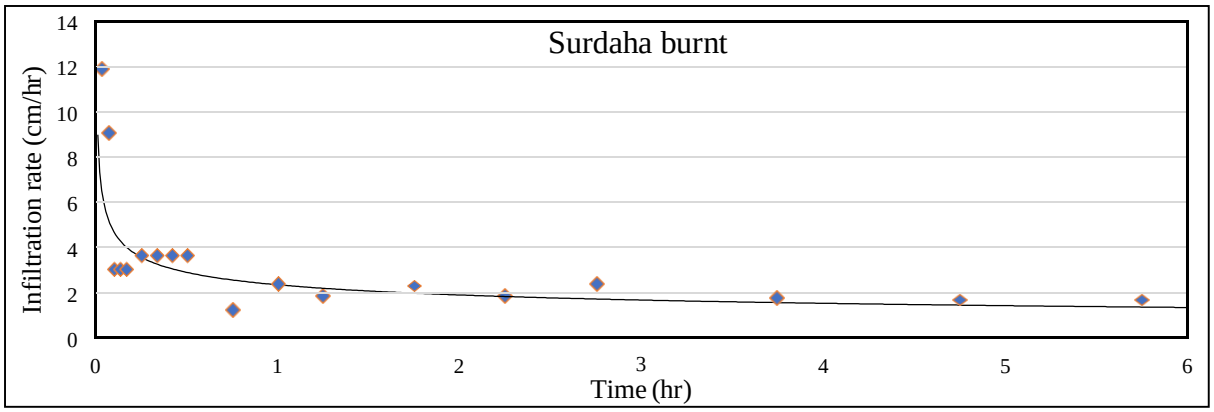

Dungariya unburnt
Infiltration rate (cm/hr)
Time (hr)
0
20
40
60
80
100
120
140
160
0
1
2
3
4
5
6

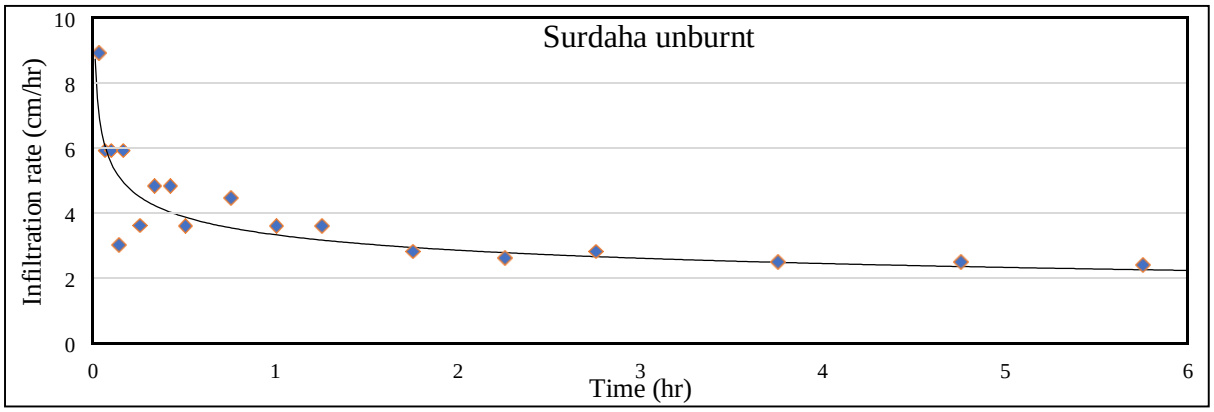

Kutmi khurd burnt
Infiltration rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6

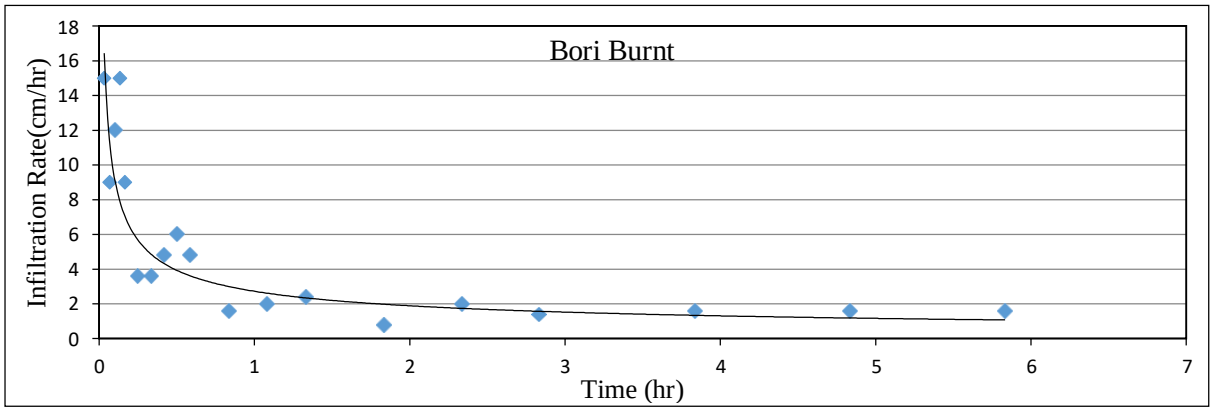

Kutmi khurd unburnt
Infiltration rate (cm/hr)
Time (hr)
0
5
10
15
20
25
0
1
2
3
4
5
6

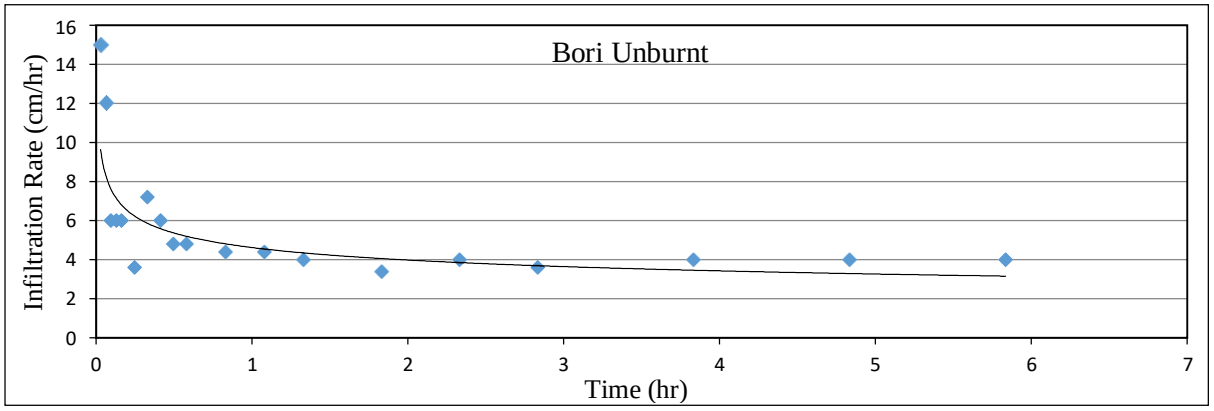

Sidhi burnt
Infiltration rate (cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6

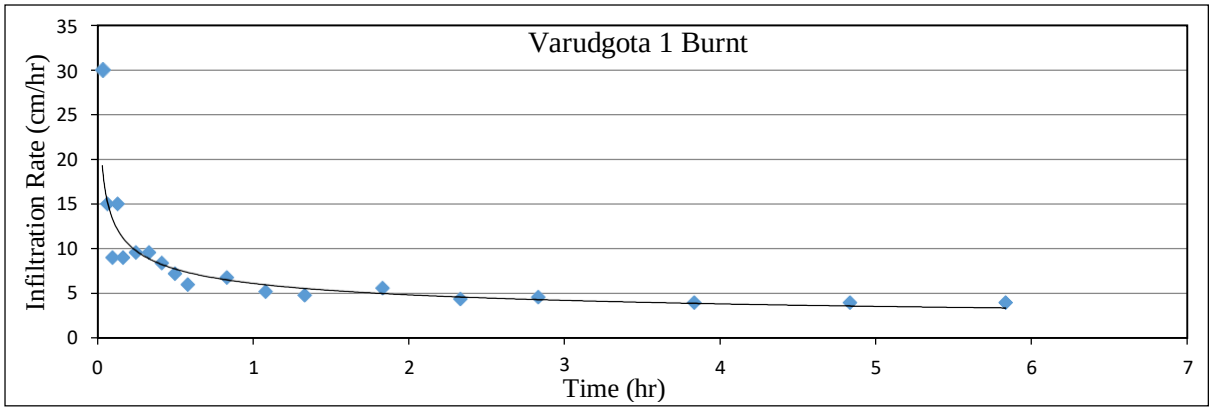

Sidhi unburnt
Infiltration rate (cm/hr)
Time (hr)
0
2
4
6
8
10
0
1
2
3
4
5
6

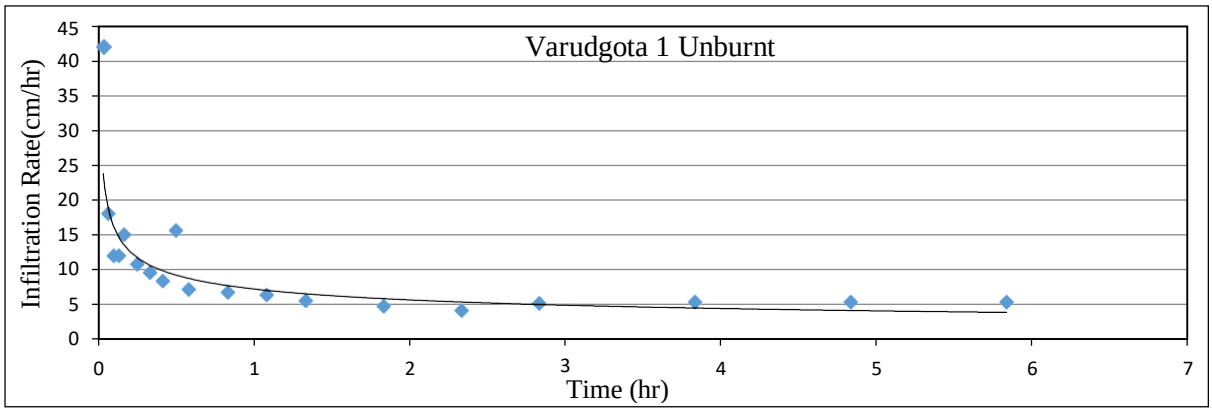

Surdaha burnt
Infiltration rate (cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6

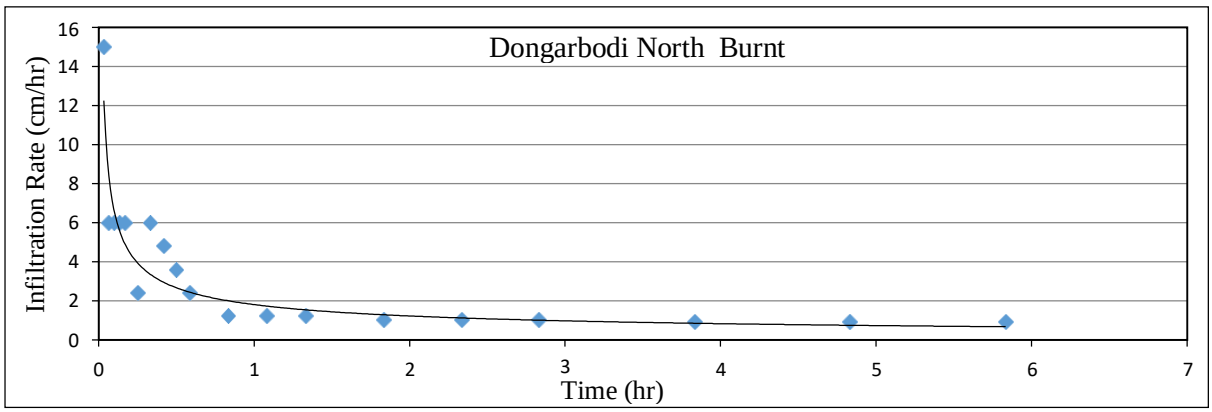

Surdaha unburnt
Infiltration rate (cm/hr)
Time (hr)
0
2
4
6
8
10
0
1
2
3
4
5
6

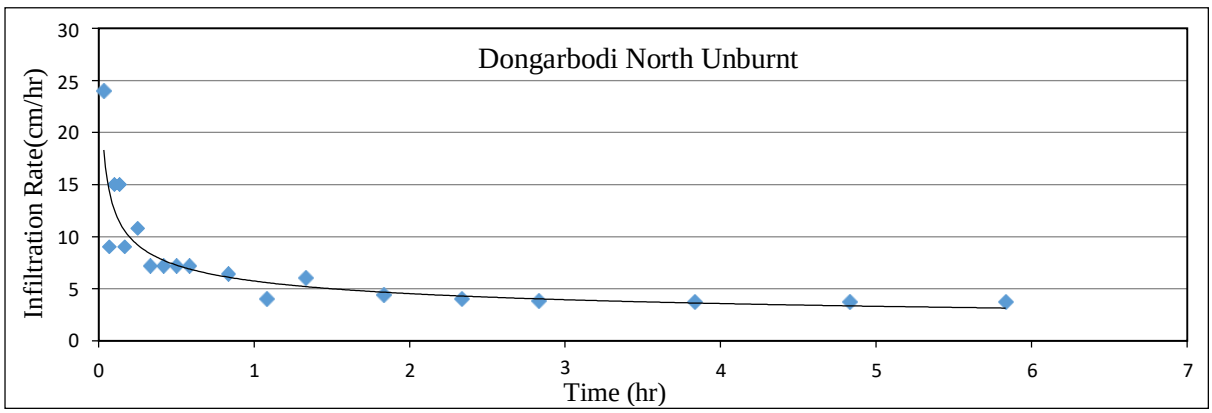

Bori Burnt
Infiltration Rate(cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
16
18
0
1
2
3
4
5
6
7

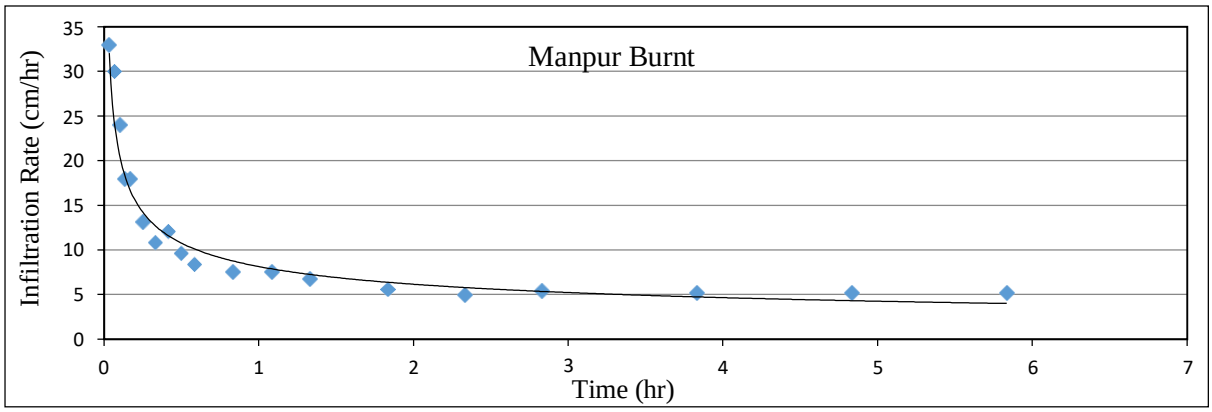

Bori Unburnt
Infiltration Rate (cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7

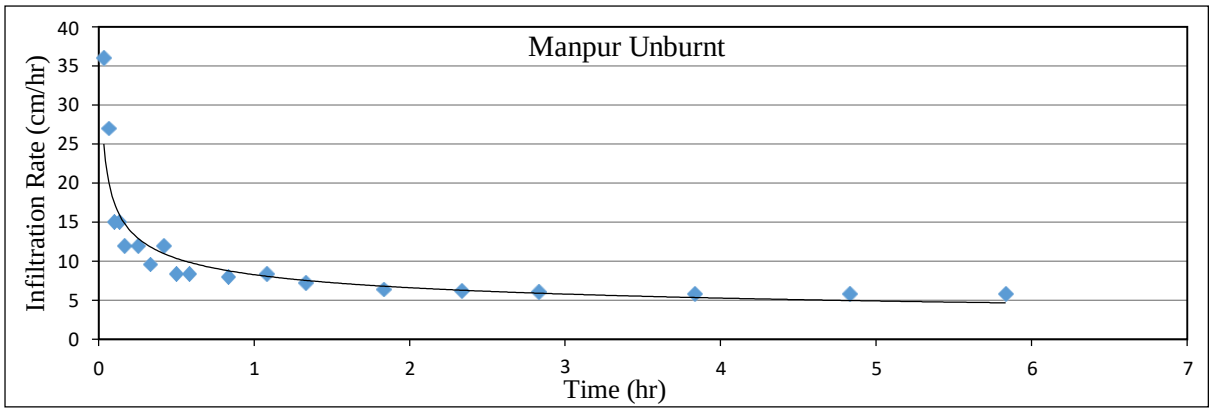

Varudgota 1 Burnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7

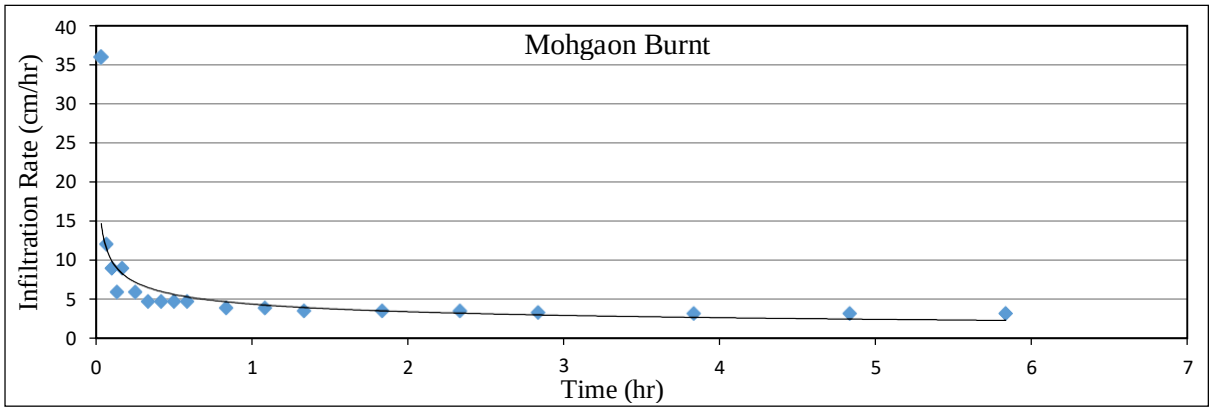

Varudgota 1 Unburnt
Infiltration Rate(cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
40
45
0
1
2
3
4
5
6
7

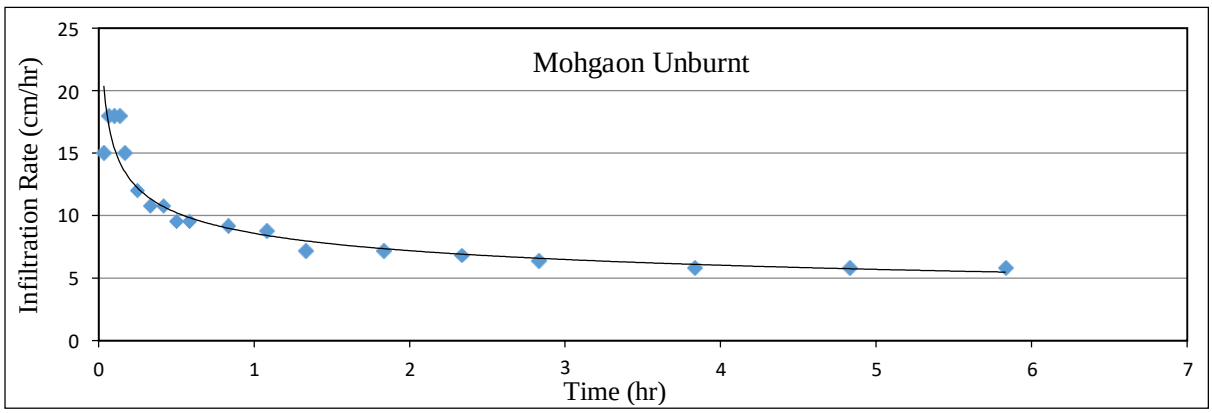

Dongarbodi North Burnt
Infiltration Rate (cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7

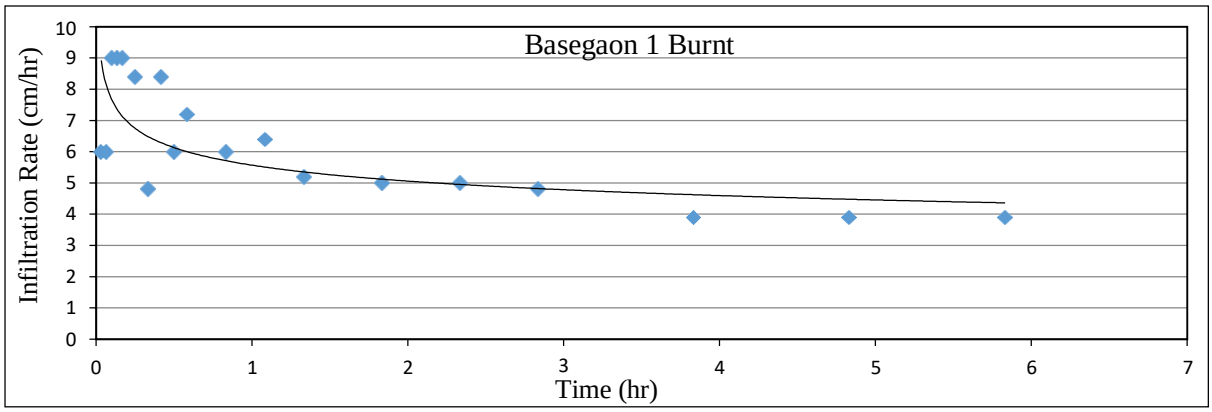

Dongarbodi North Unburnt
Infiltration Rate(cm/hr)
Time (hr)
0
5
10
15
20
25
30
0
1
2
3
4
5
6
7

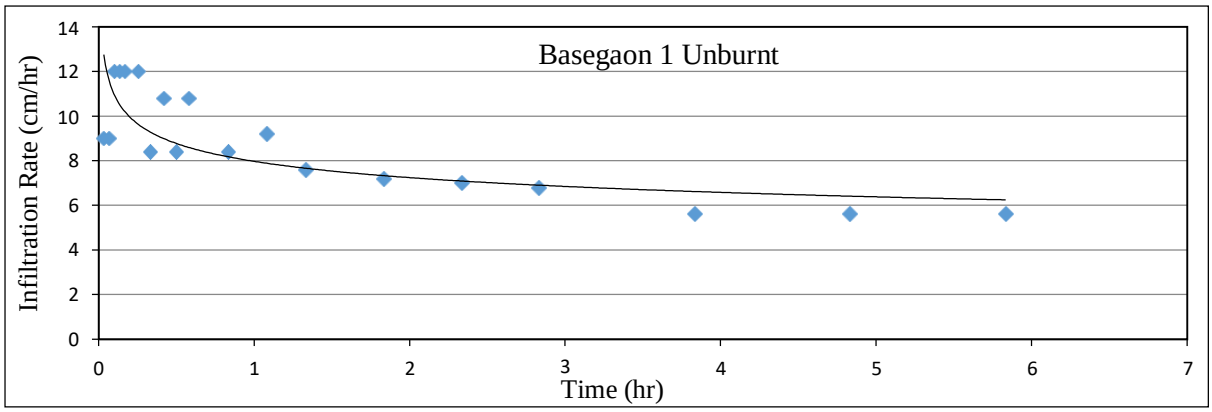

Manpur Burnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7

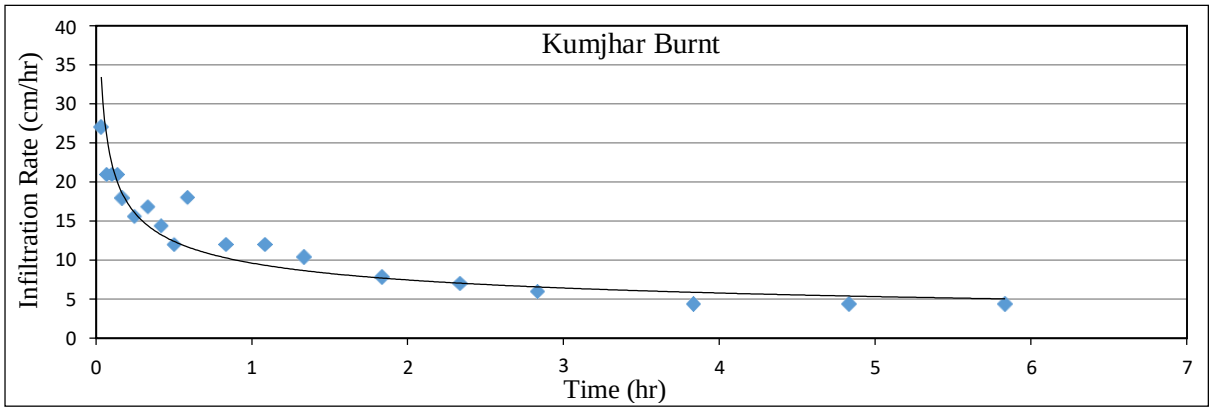

Manpur Unburnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7

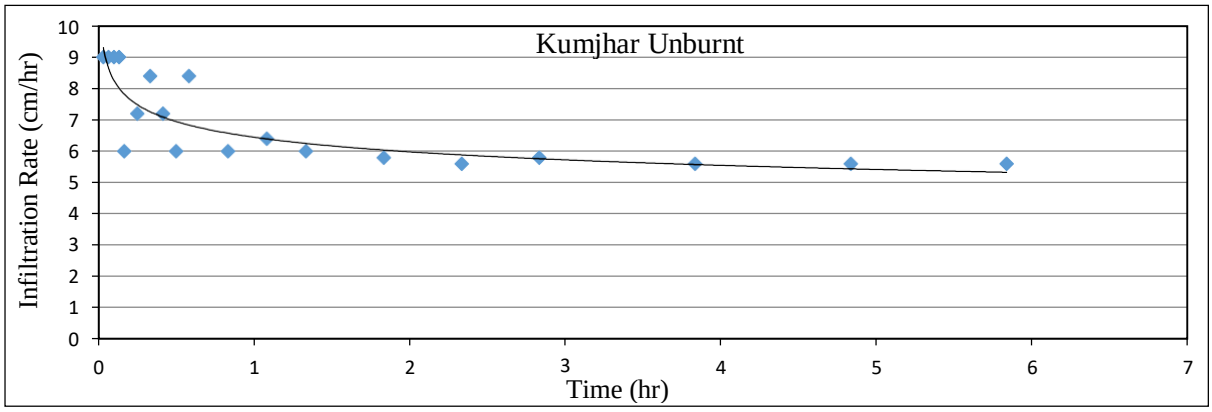

Mohgaon Burnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7

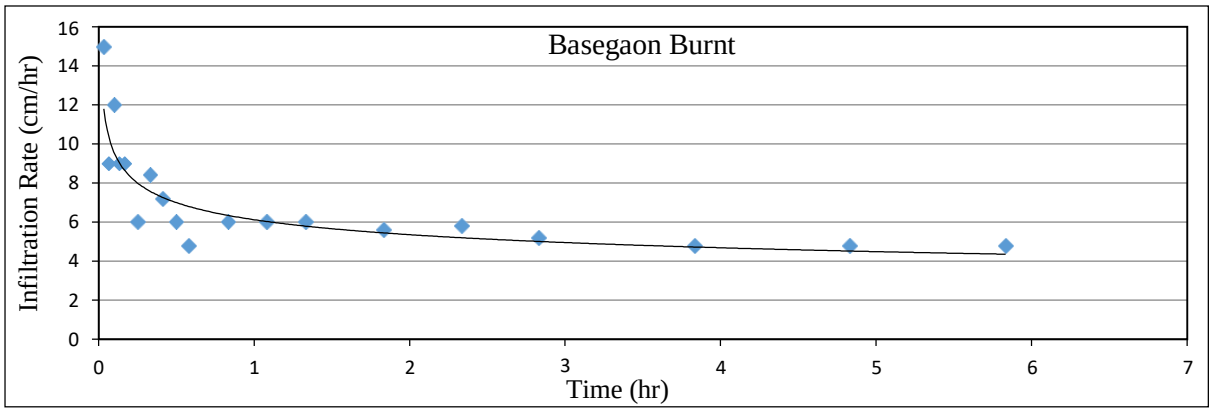

Mohgaon Unburnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
0
1
2
3
4
5
6
7

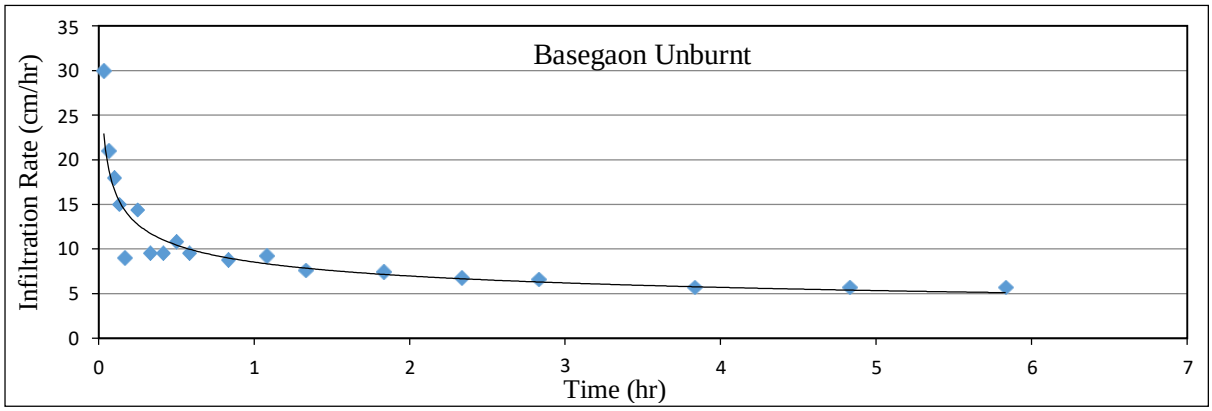

Basegaon 1 Burnt
Infiltration Rate (cm/hr)
Time (hr)

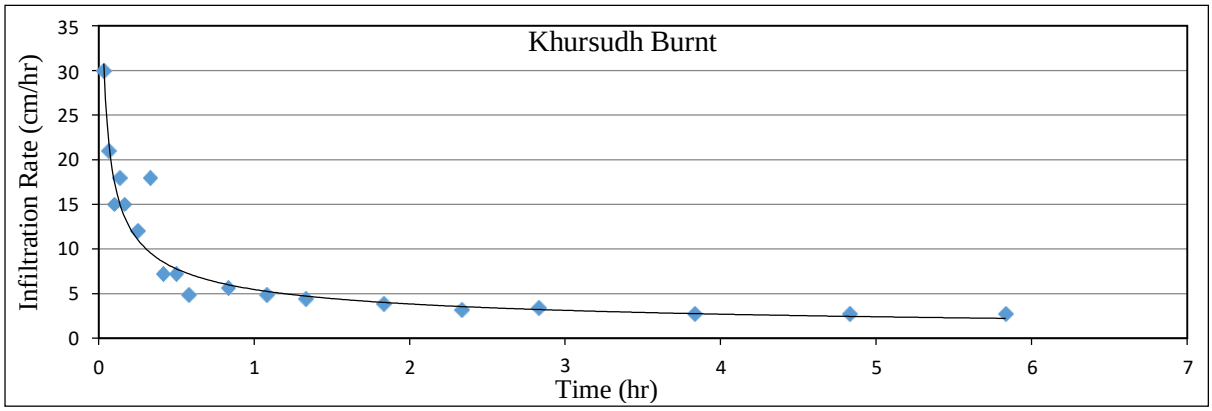

Basegaon 1 Unburnt
Infiltration Rate (cm/hr)
Time (hr)

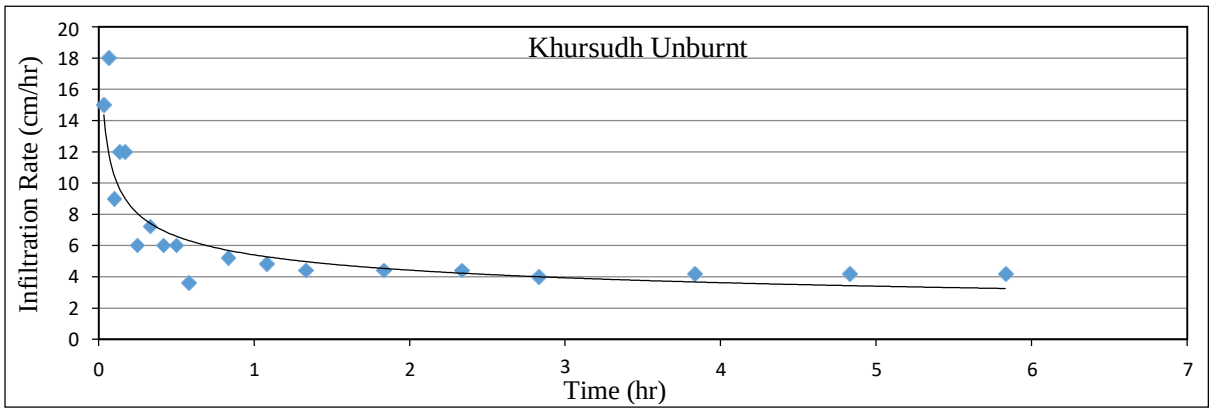

Kumjhar Burnt
Infiltration Rate (cm/hr)
Time (hr)

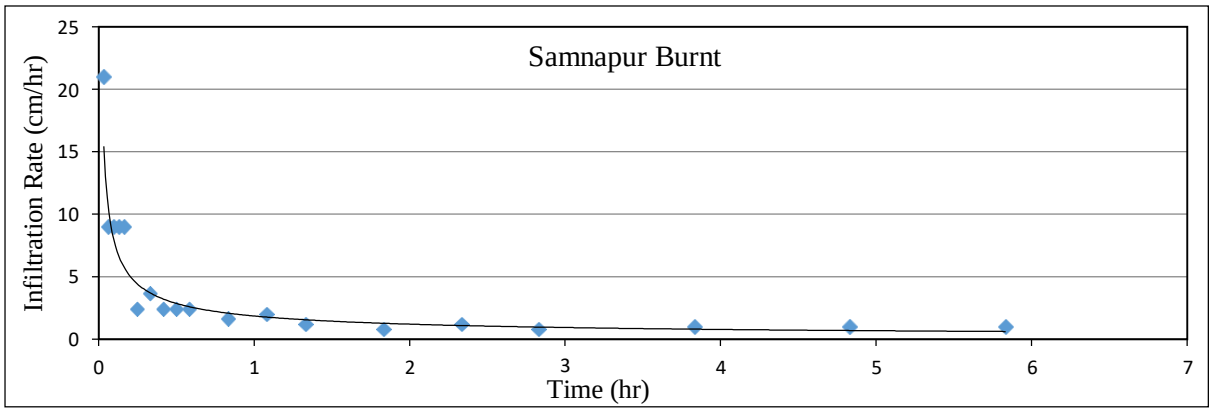

Kumjhar Unburnt
Infiltration Rate (cm/hr)
Time (hr)

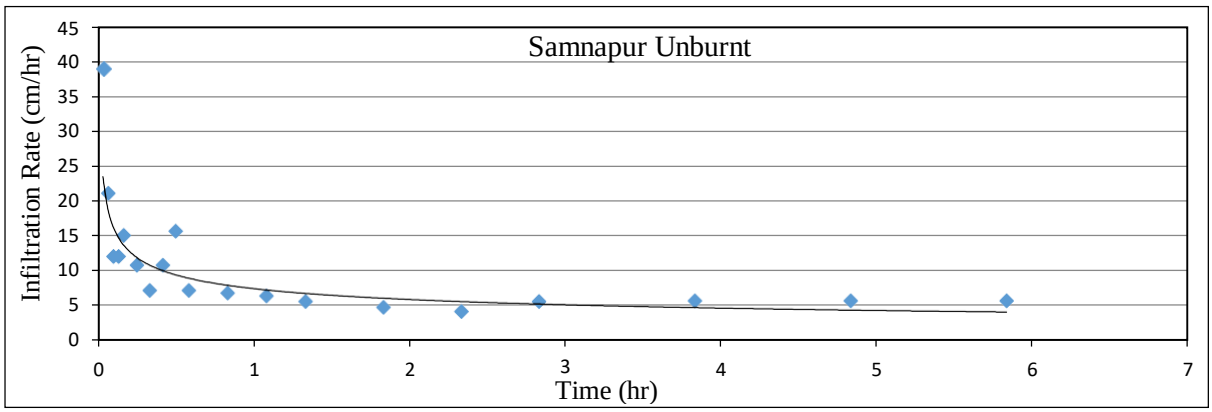

Basegaon Burnt
Infiltration Rate (cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
16
0
1
2
3
4
5
6
7


Basegaon Unburnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7

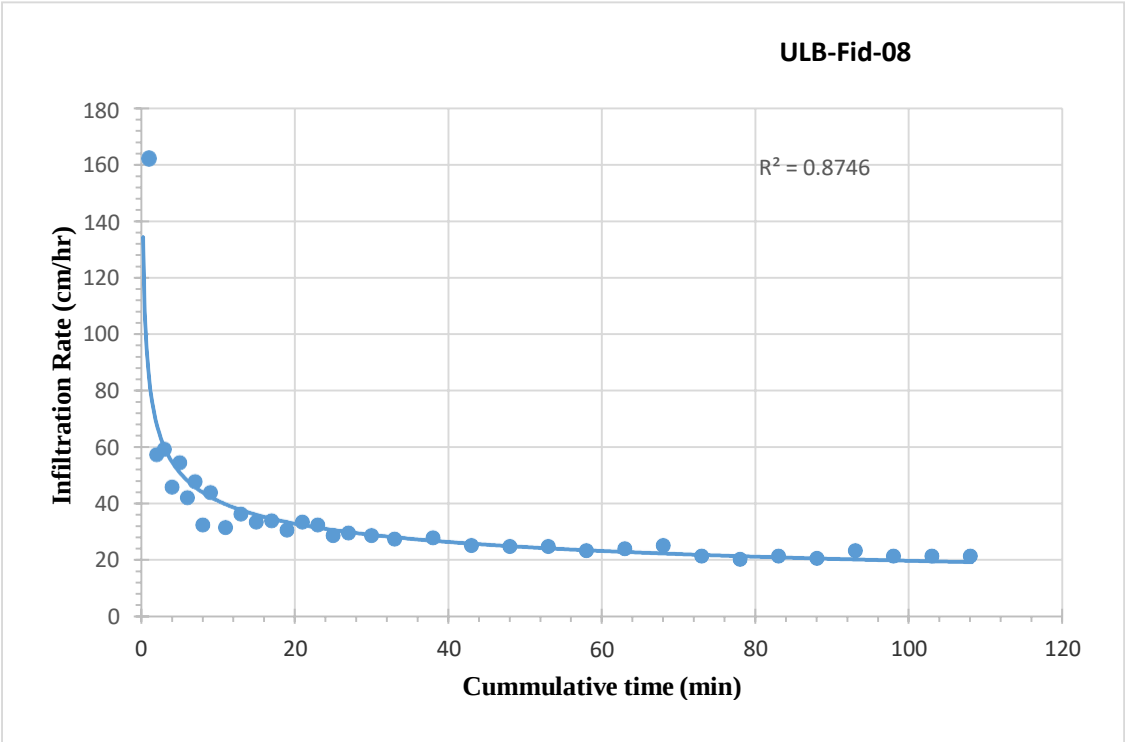

Khursudh Burnt
Infiltration Rate (cm/hr)
Time (hr)
0
5
10
15
20
25
30
35
0
1
2
3
4
5
6
7

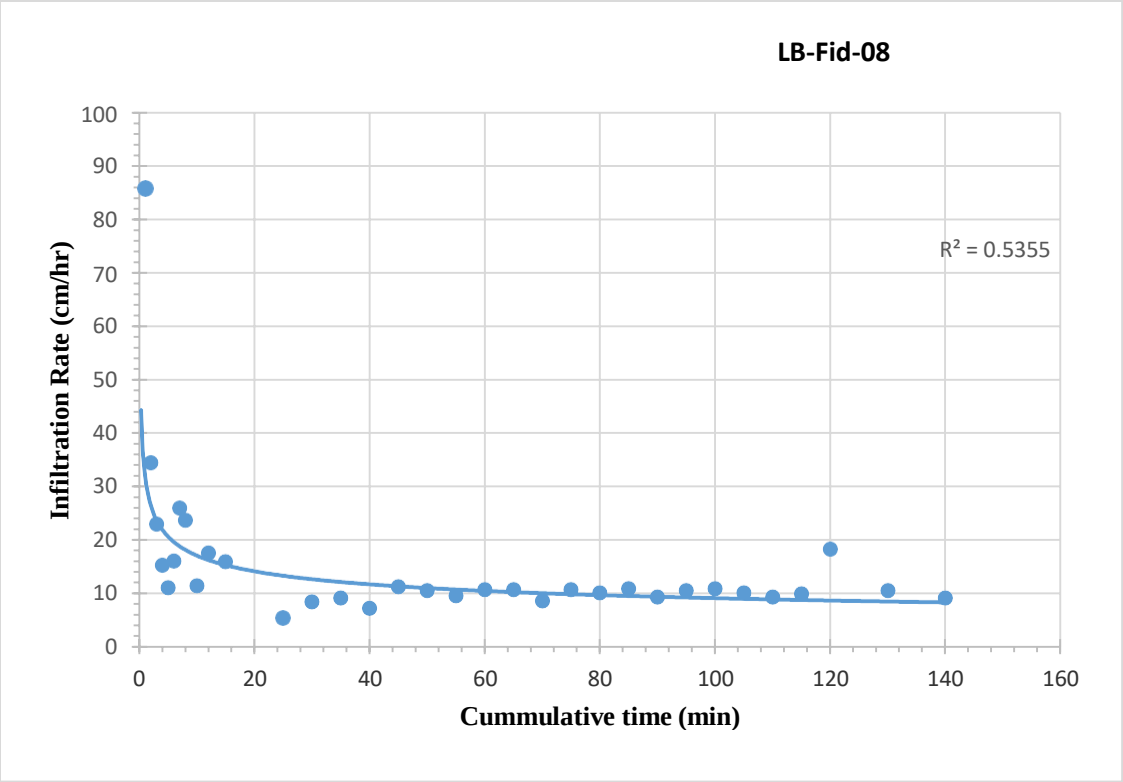

Khursudh Unburnt
Infiltration Rate (cm/hr)
Time (hr)
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5
6
7

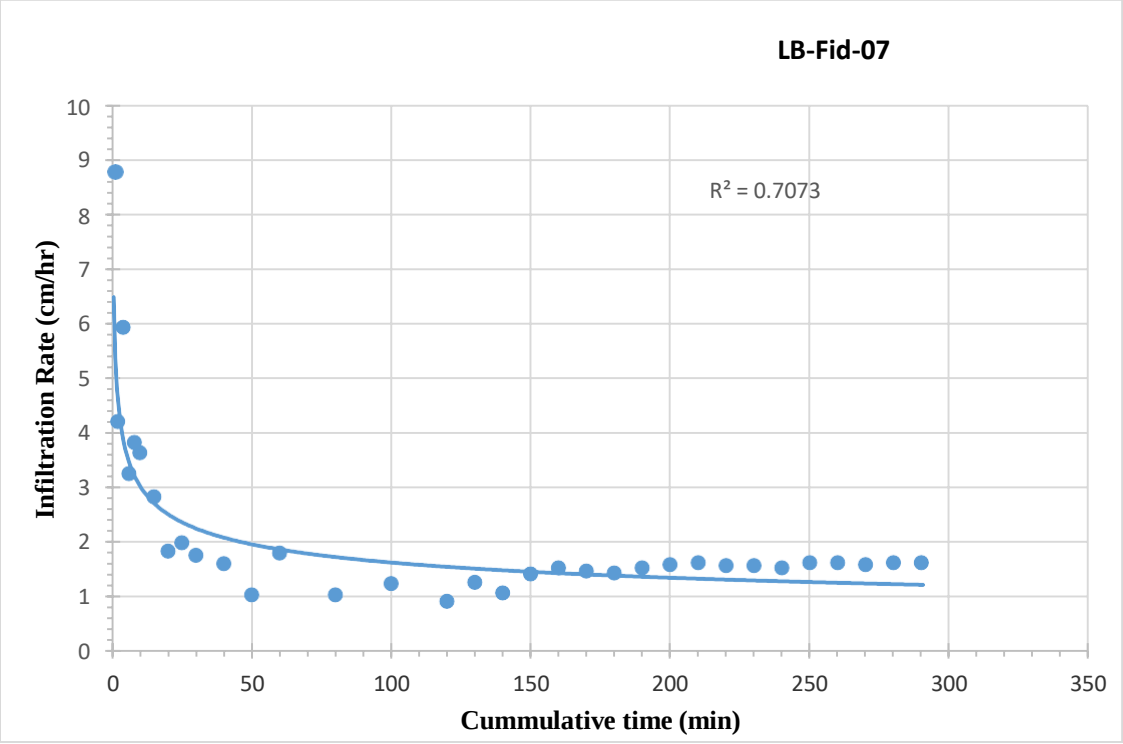


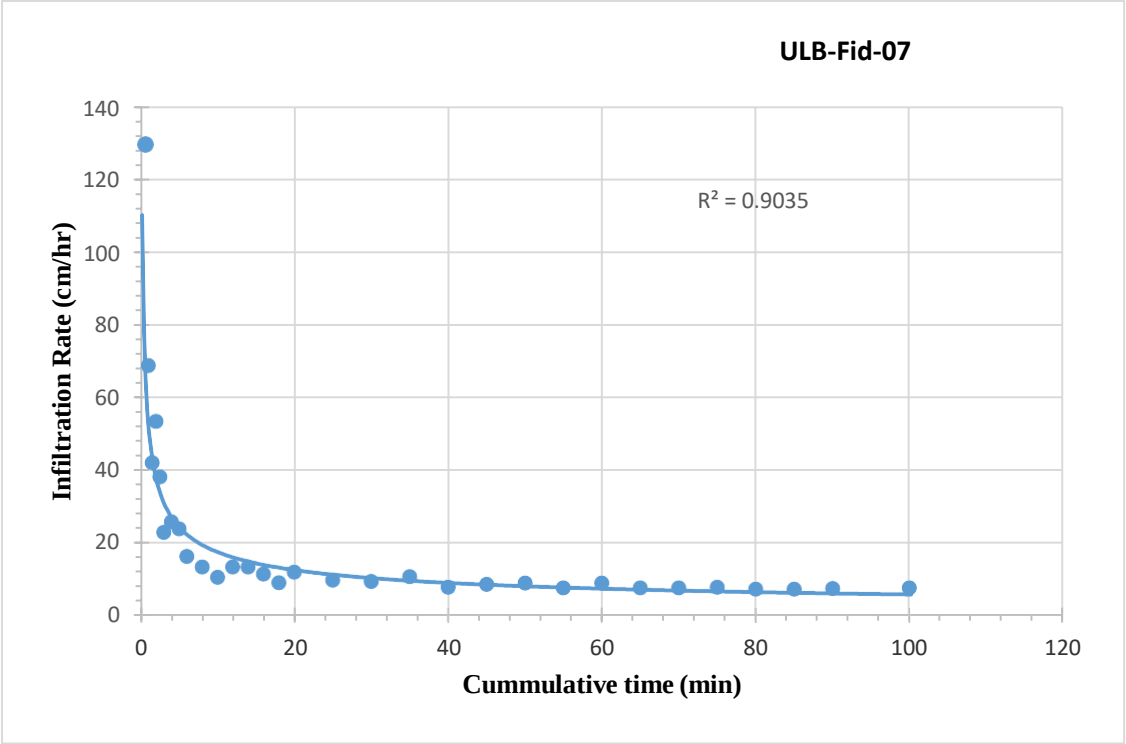


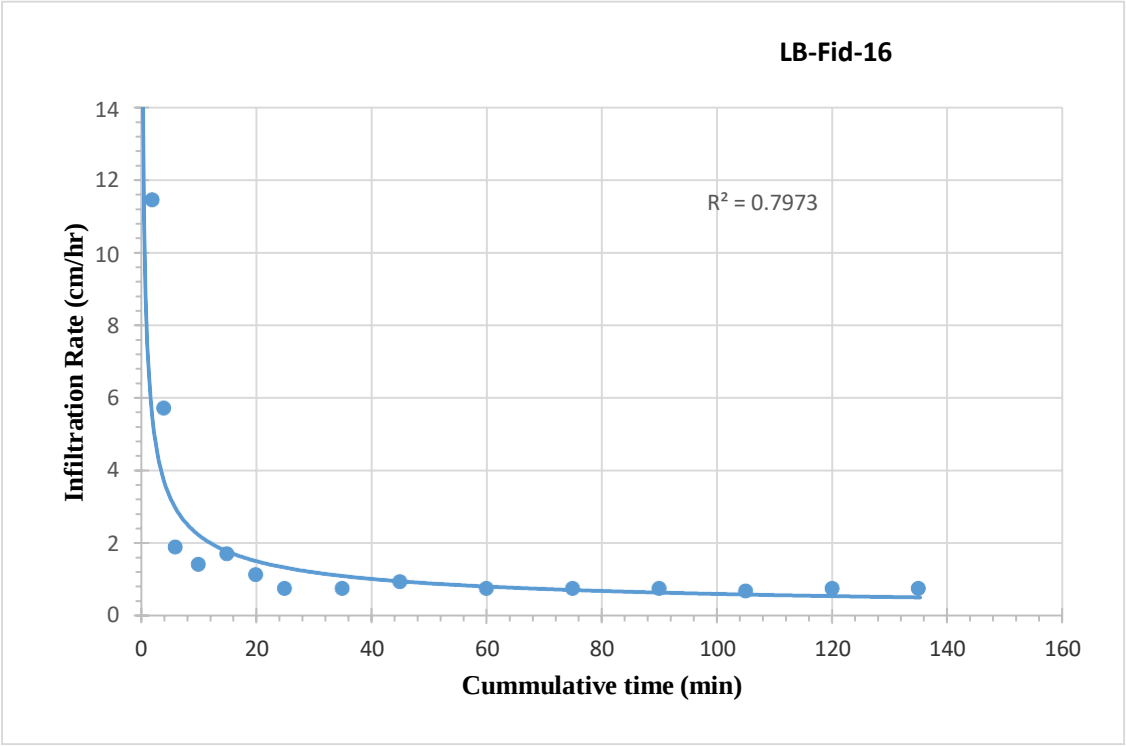
(B) Infiltration characteristics at the selected burnt & unburnt plots in Uttarakhand

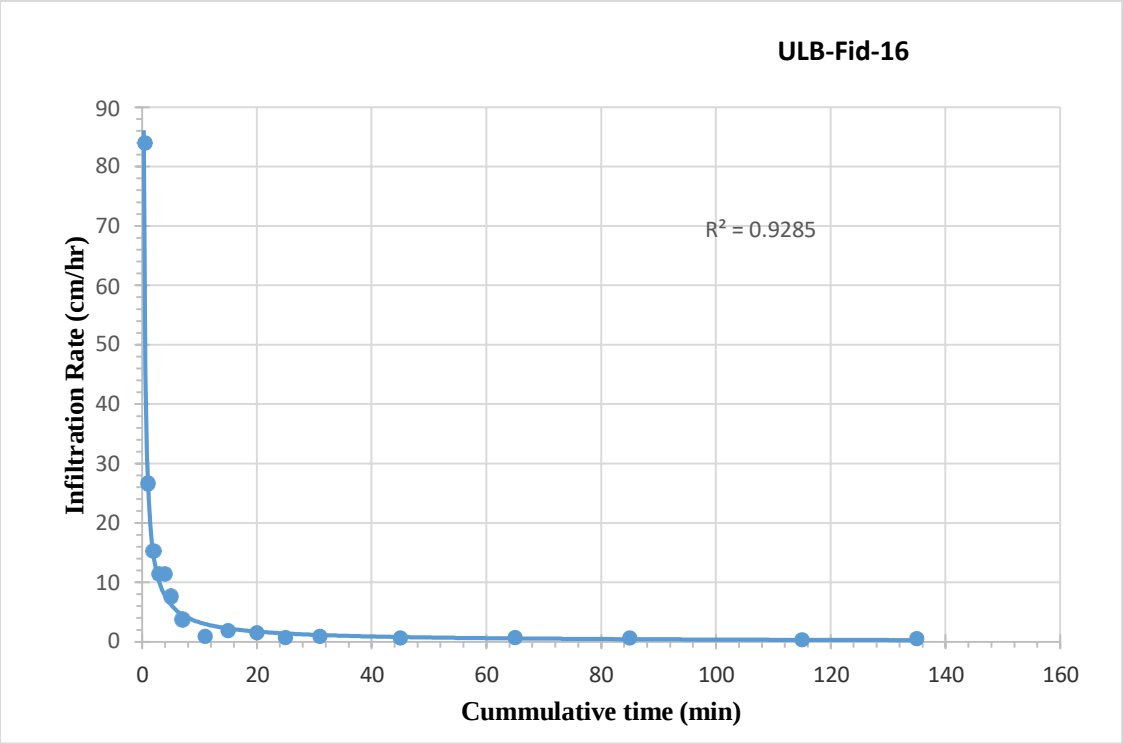


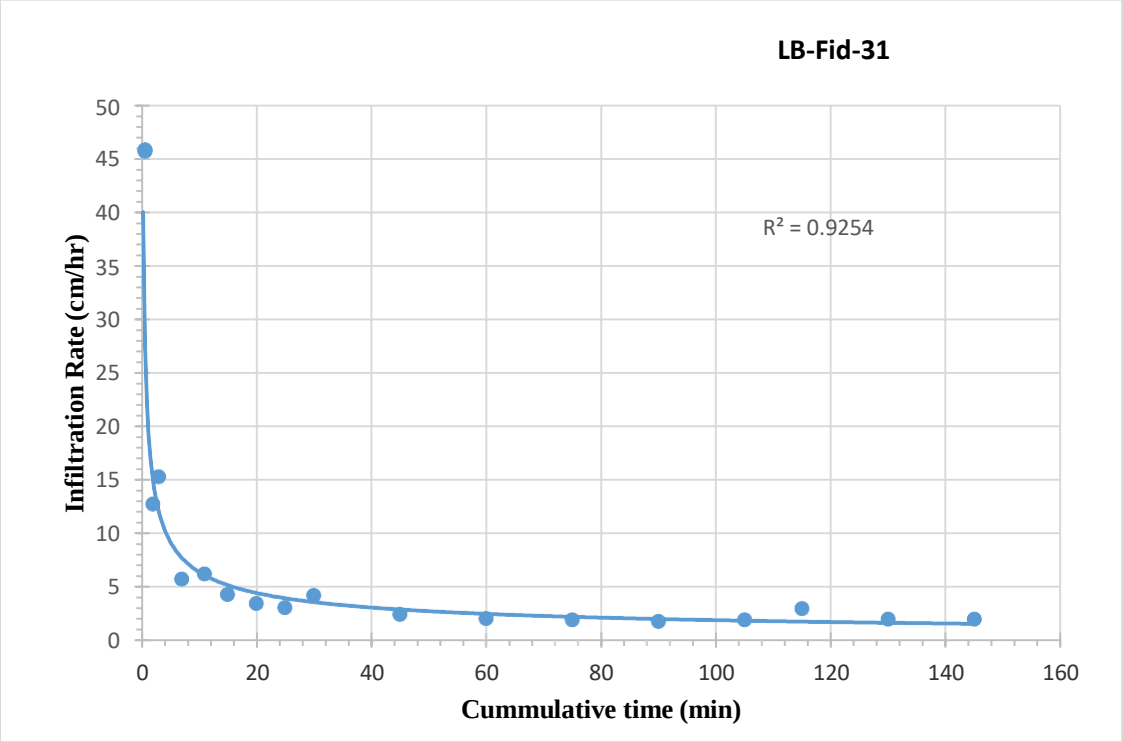

LB-Fid-08
Infiltration Rate (cm/hr)
Cummulative time (min)
R² = 0.5355
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
160

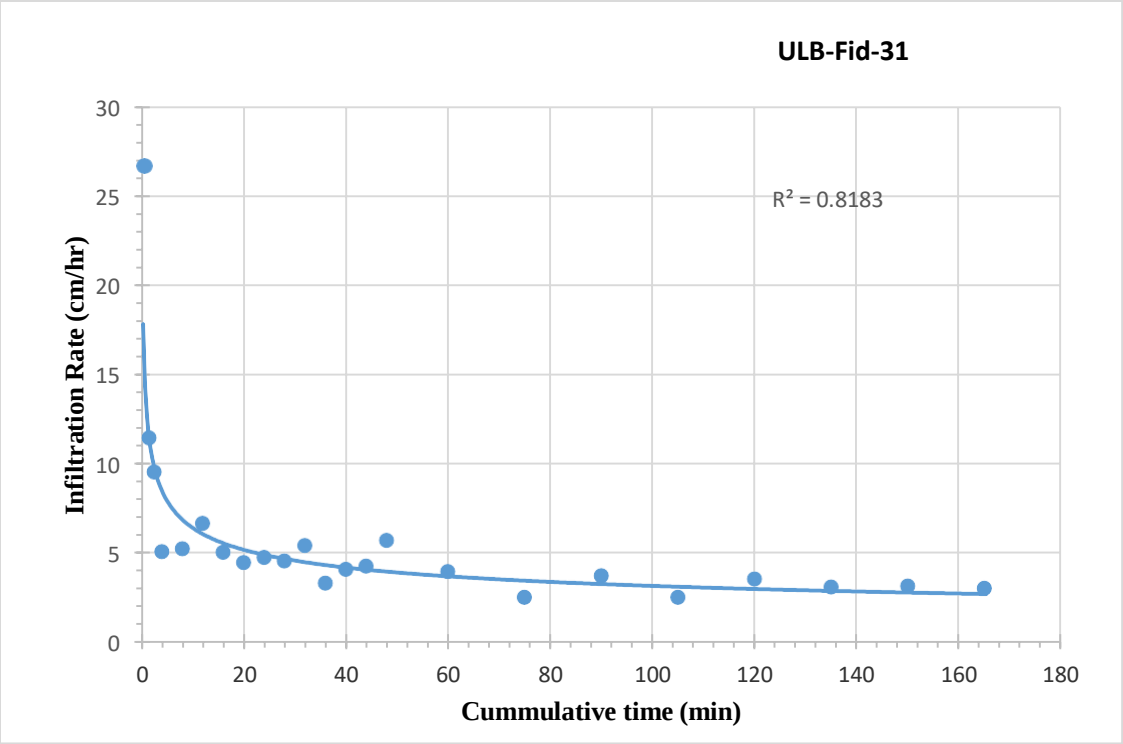

LB-Fid-07
Infiltration Rate (cm/hr)
Cummulative time (min)
R² = 0.7073
0
1
2
3
4
5
6
7
8
9
10
0
50
100
150
200
250
300
350

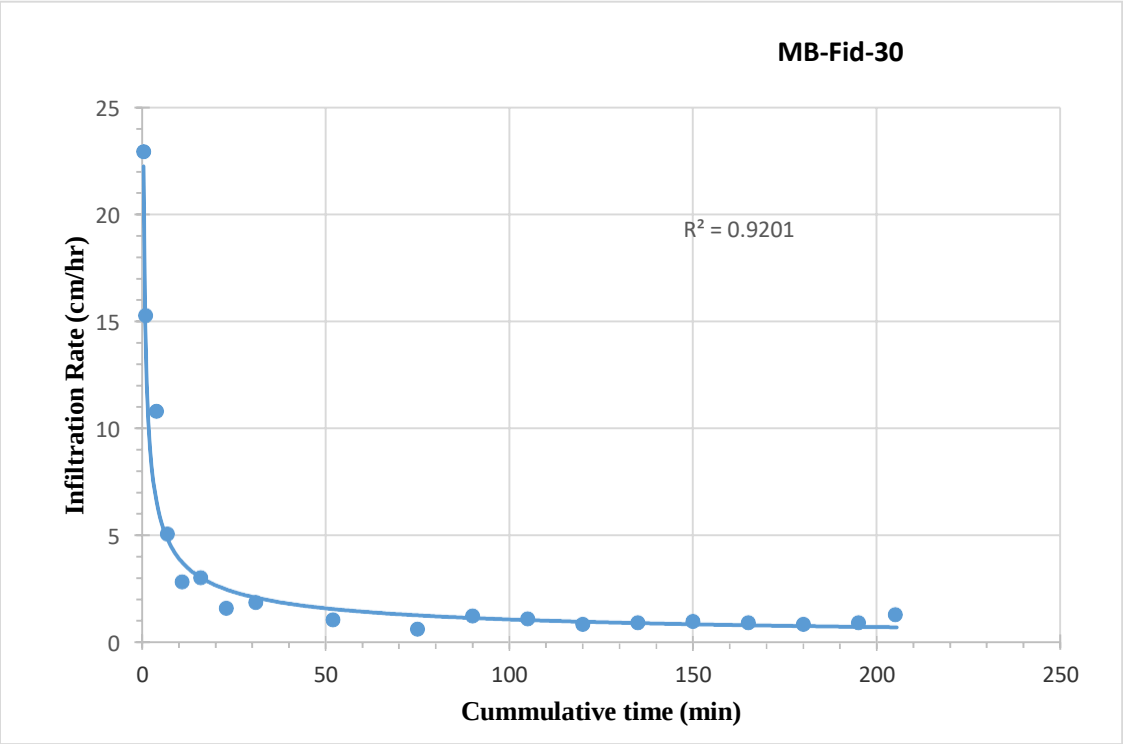

ULB-Fid-07
R² = 0.9035
Infiltration Rate (cm/hr)
Cummulative time (min)
0
20
40
60
80
100
120
140

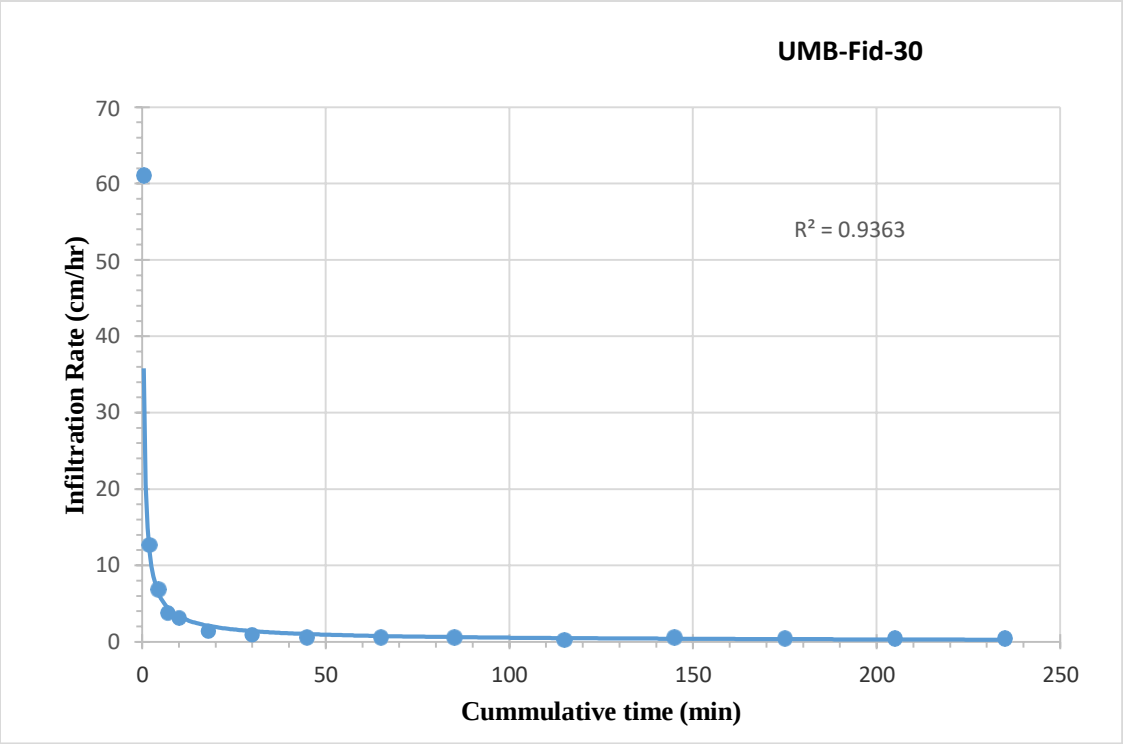

LB-Fid-16
R² = 0.7973
Infiltration Rate (cm/hr)
Cummulative time (min)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140
160

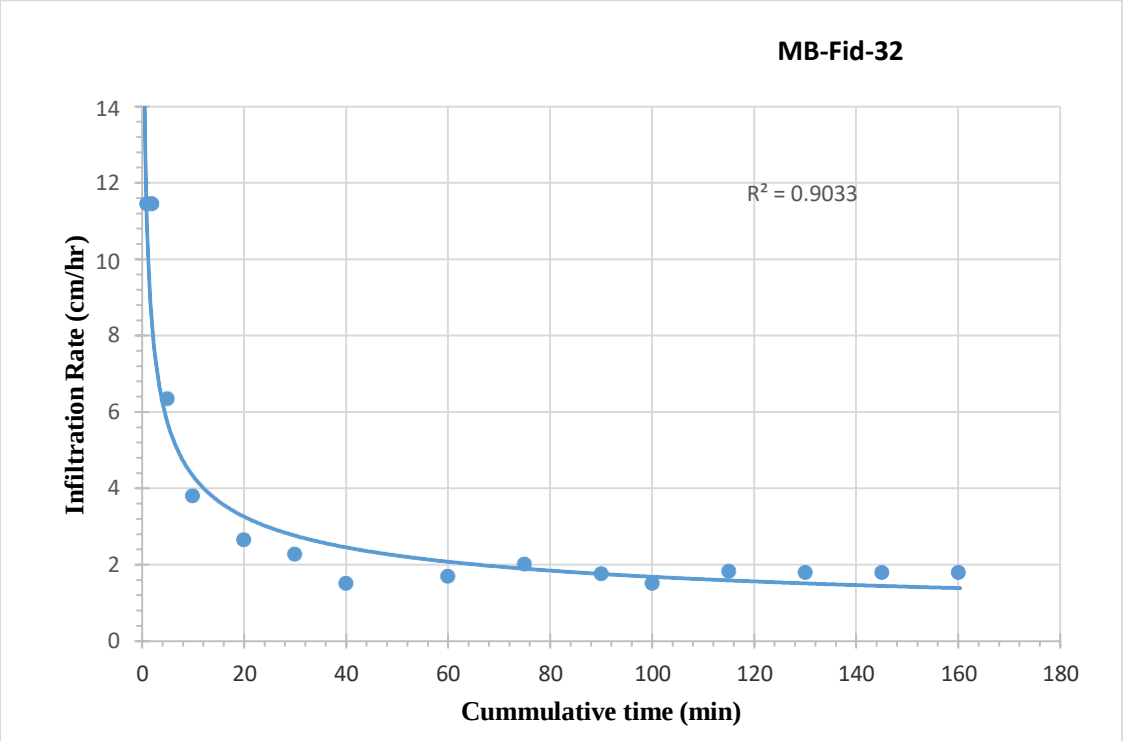

ULB-Fid-16
R² = 0.9285
Infiltration Rate (cm/hr)
Cummulative time (min)
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
120
140
160

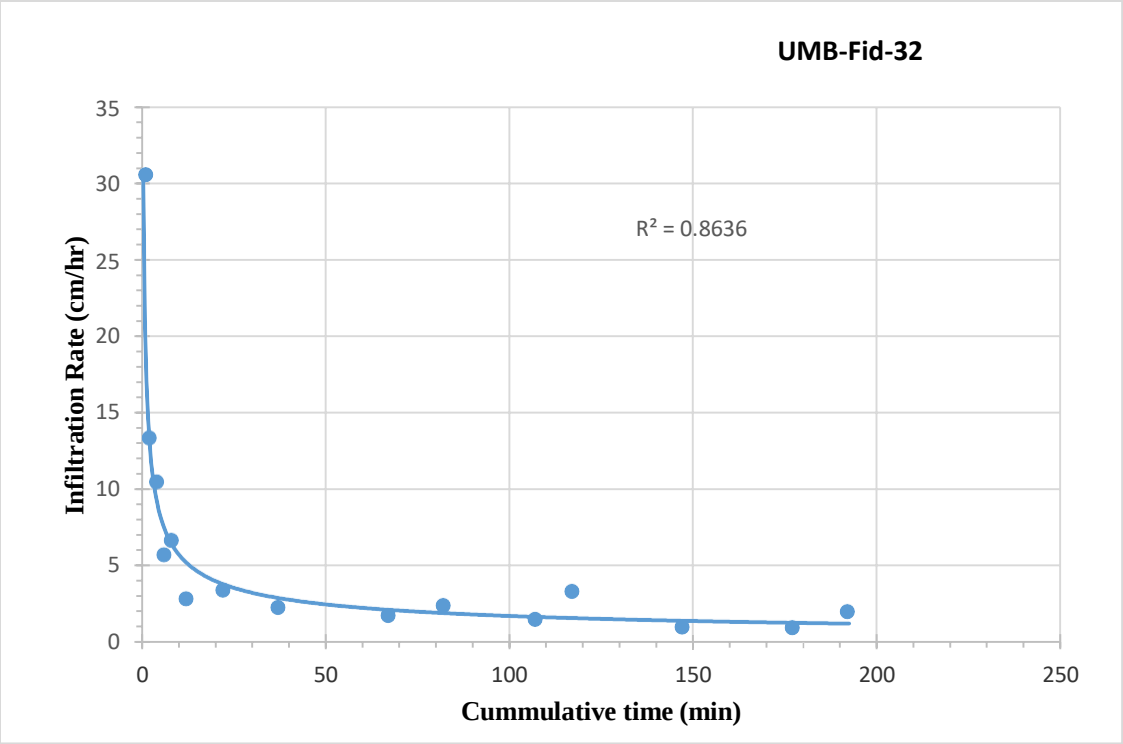

LB-Fid-31
R² = 0.9254
Infiltration Rate (cm/hr)
Cummulative time (min)
0
5
10
15
20
25
30
35
40
45
50
0
20
40
60
80
100
120
140
160


ULB-Fid-31
R² = 0.8183
Infiltration Rate (cm/hr)
Cummulative time (min)
0
5
10
15
20
25
30
0
20
40
60
80
100
120
140
160
180


MB-Fid-30
R² = 0.9201
Infiltration Rate (cm/hr)
Cummulative time (min)
0
5
10
15
20
25
0
50
100
150
200
250


UMB-Fid-30
R² = 0.9363
Infiltration Rate (cm/hr)
Cummulative time (min)
0
10
20
30
40
50
60
70
0
50
100
150
200
250


MB-Fid-32
R² = 0.9033
Infiltration Rate (cm/hr)
Cummulative time (min)
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140
160
180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10
15
20
25
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35
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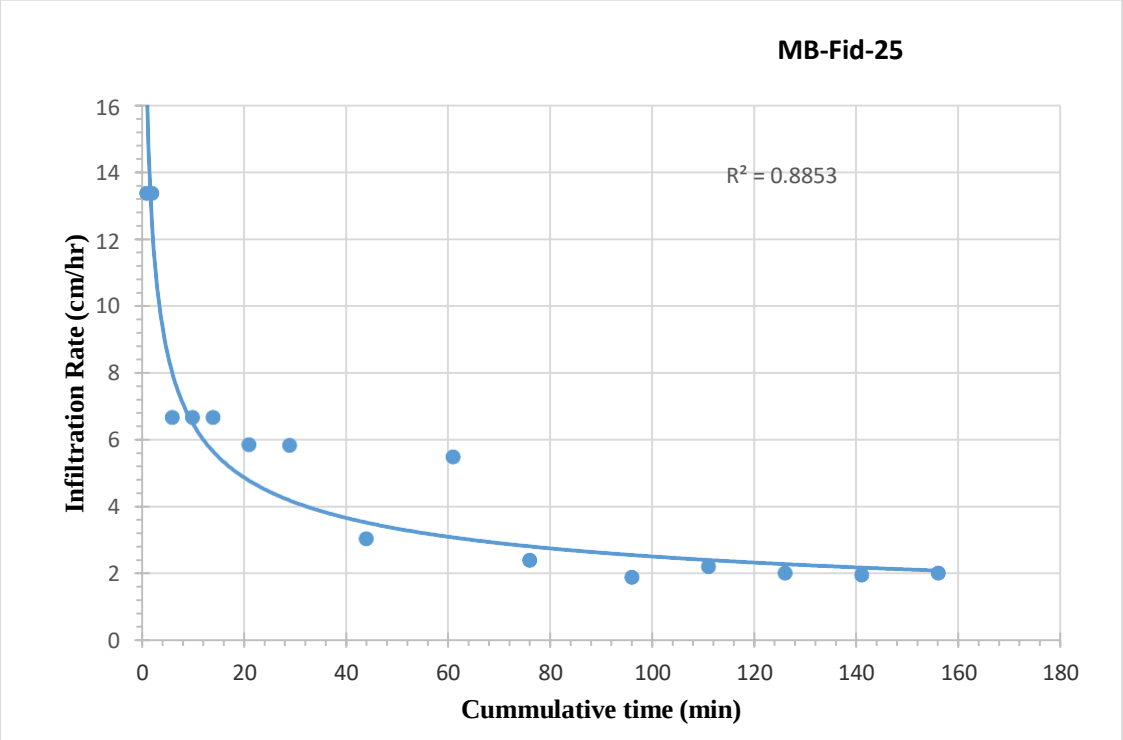
50
100
150
200
250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Infiltration Rate (cm/hr)
Cummulative time (min)
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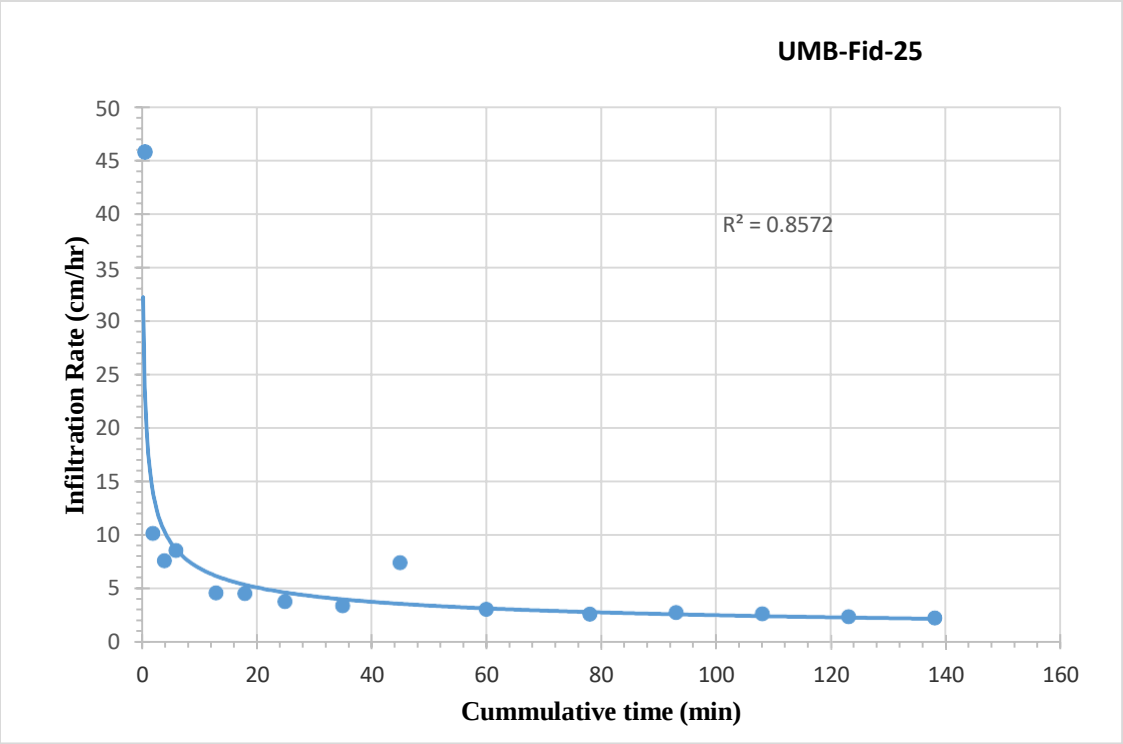
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120
140
160
180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Cummulative time (min)
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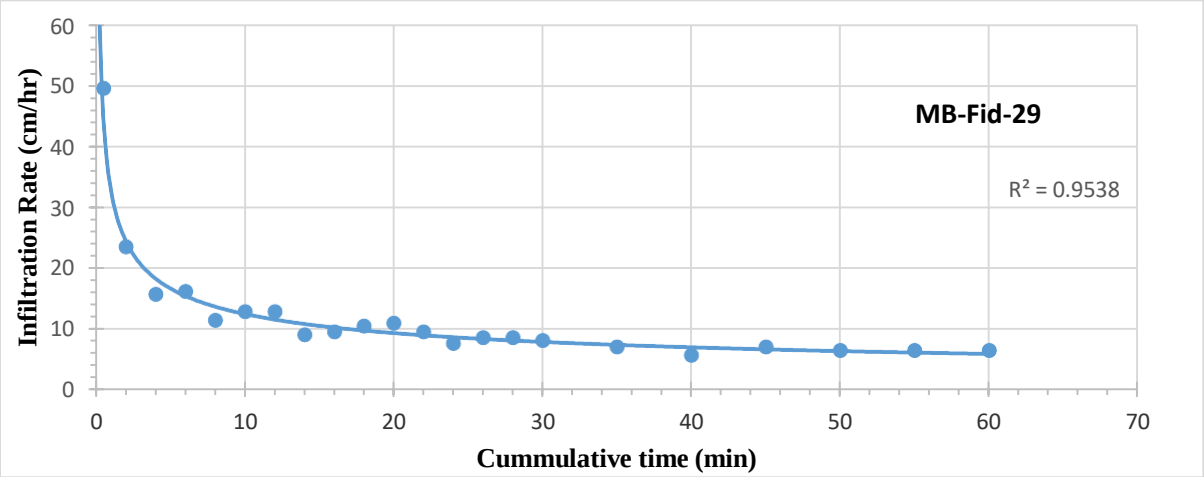
15
20
25
30
35
40
45
50
0
20
40
60
80
100
120
140
160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Cummulative time (min)
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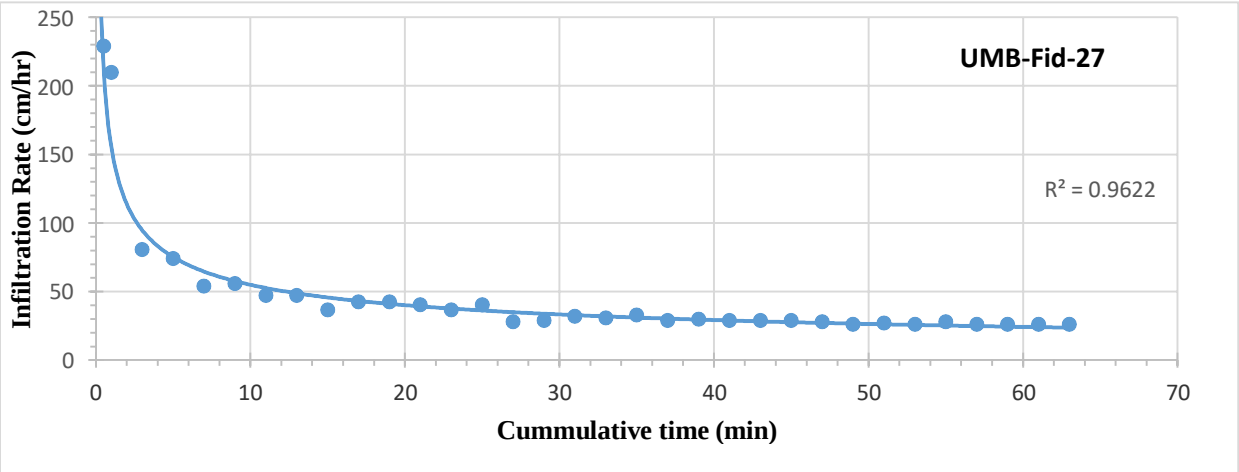
30
40
50
60
0
10
20
30
40
50
60
70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Infiltration Rate (cm/hr)
Cummulative time (min)
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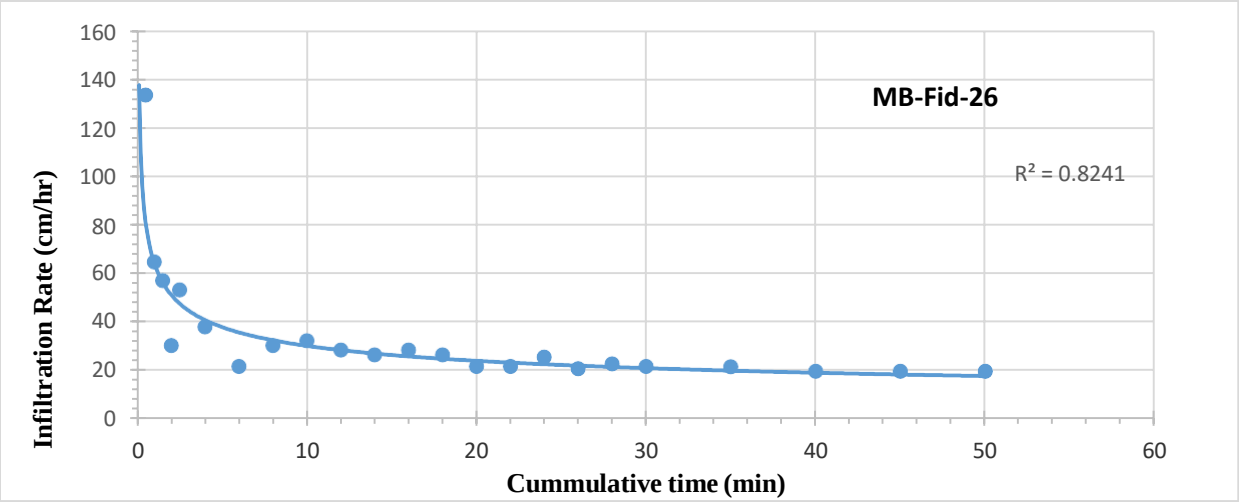
100
150
200
250
0
10
20
30
40
50
60
70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Infiltration Rate (cm/hr)
Cummulative time (min)
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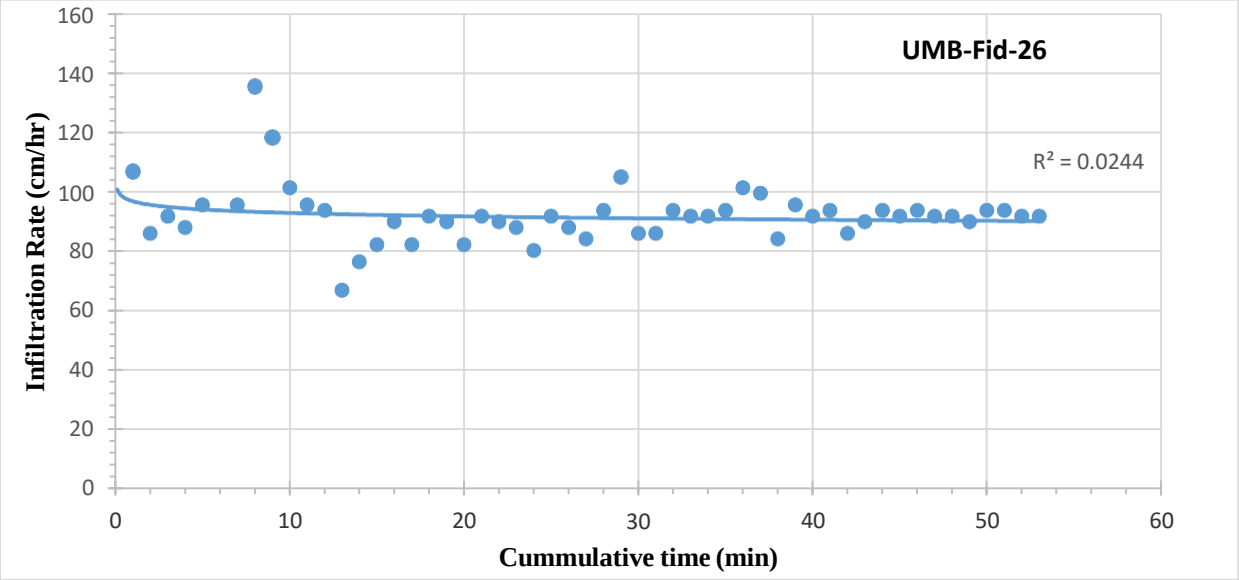
40
60
80
100
120
140
160
0
10
20
30
40
50
60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Cummulative time (min)
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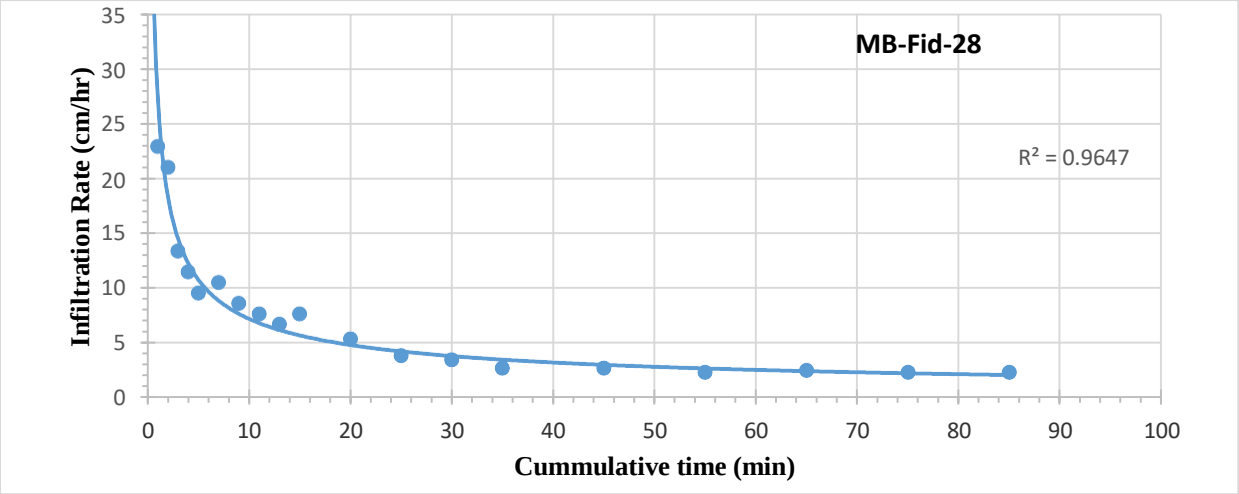
140
160
0
10
20
30
40
50
60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Infiltration Rate (cm/hr)
Cummulative time (min)
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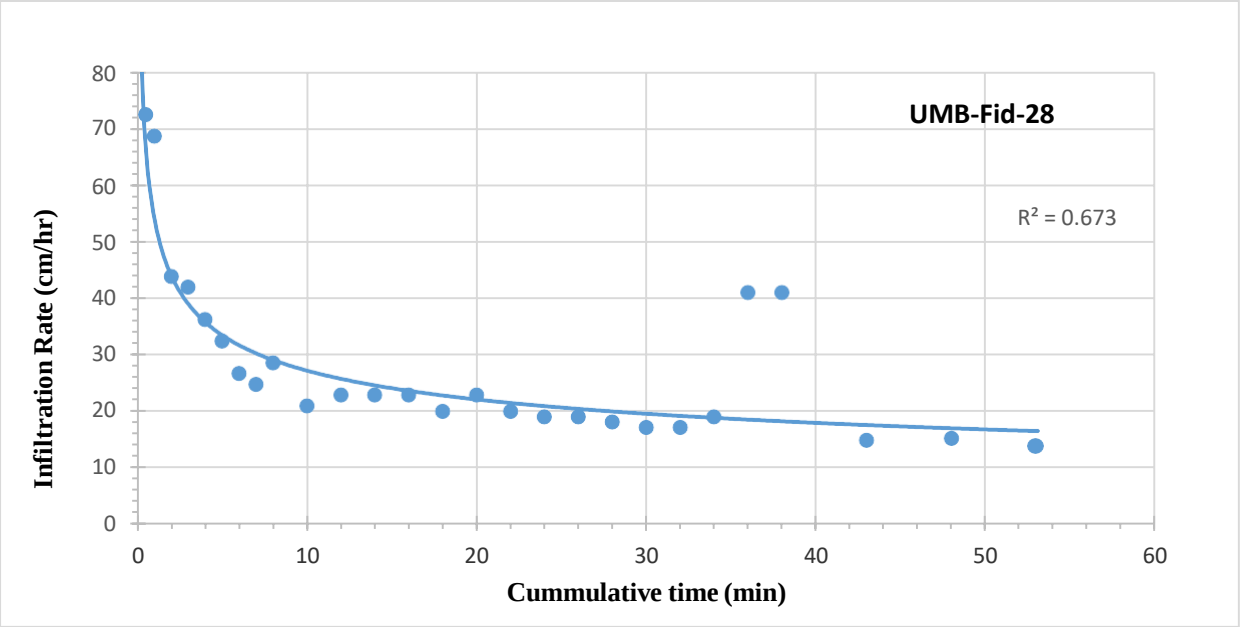
15
20
25
30
35
0
10
20
30
40
50
60
70
80
90
100


UMB-Fid-28
R² = 0.673
Infiltration Rate (cm/hr)
Cummulative time (min)
0
10
20
30
40
50
60
70
80

Annexure IV

Burned Polygon Covered (Till November 15, 2021)

Sl. No.	POLY_ID	Forest Type Group	SEVERITY	AREA	FCM	ALTITUDE	SLOPE	ASPECT	DISTRICT	DIVISION	BLOCK	BEAT	FOREST_BLO	COMPT_NO	longitude	latitude	Date for Survey
1.	1552	Tropical Dry Deciduous Forests	Low Burnt	42.80	MDF	0-900	0-3	South	HARIDWAR	HARDWAR FOREST DIVISION	CHIRIYAPUR RANGE	KOTAWALI BEAT	KOTAWALI	10	78^{0}18' 46.505" E	29^{0}48' 19.676" N	05.12.2020
2.	4007	Sub-Tropical Pine Forests	Low Burnt	202.4	MDF	900-1800	18-36	North	DEHRADUN	CHAKRATA FOREST DIVISION	BAWAR RANGE	DARAGAD BEAT	DARAGAD	0	77^0 50' 50.844" E	30^0 51' 49.153" N	02.12.2020
3.	386	Sub tropical Pine Forests	Low Burnt	9.251	MDF	0-900	18-36	West	DEHRADUN	CIVIL & SOYAM KALSI DIVISION	LANGHA RANGE	BATOLI-II BEAT	BATOLI BLOCK	5	77^0 56' 41.129" E	30^0 27' 16.965" N	04.12.2020
4.	4002	Sub Tropical Pine Forests	Low Burnt	537.1	MDF	900-1800	18-36	South	UTTARKASHI	TONS FOREST DIVISION	PUROLA RANGE	PUROLA BEAT	PUROLA	0	78^0 4' 26.879" E	30^0 54' 5.968" N	03.12.2020
5.	336	Himalayan Moist Temperate Forests	Moderately Burnt	105.04	MDF	900-1800	18-36	North	TEHRI	TEHRI H FOREST DIVISION	Balganga RANGE	Syansu	Jhatuliya	Jhatuliya	78^0 22' 15.605" E	30^0 29'472.502" N	19.10.2020
6.	397	Himalayan Moist Temperate Forests	Moderately Burnt	11.04	Scrub	900-1800	18-36	North	TEHRI	TEHRI H FOREST DIVISION	TEHRI RANGE	Nailbagi BEAT	Devtadanada	Devtadanada	78^0 24' 58.015" E	30^0 27' 18.711" N	18.10.2020
7.	548	Sub Tropical Pine Forests	Moderately Burnt	15.76	MDF	900-1800	18-36	South	Tehri	TEHRI FOREST DIVISION	Tehri RANGE	Maniyar Beat	Maniyar	9	78^0 24' 47.699" E	30^0 21' 55.652" N	17.10.2020
8.	367	Himalayan Moist Temperate Forests	Moderately Burnt	8.6	MDF	900-1800	18-36	East	TEHRI	TEHRI H FOREST DIVISION	Balganga RANGE	Naolbagi Beat	Argad Beat	1	78^0 36' 31.352" E	30^0 29' 2.953" N	20.10.2020
9.	1783	Sub Tropical Pine	Moderately Burnt	99.50	MDF	900-1800	11-18	South	ALMORA	ALMORA FOREST DIVISION	ALMORA RANGE	GANANATH CENTRAL BEAT	GANANATH	11	79^0 40' 11.121" E	29^0 45' 43.611" N	21.01.2021

		Forests															
10.	2201	Sub Tropical Pine Forests	Moderately Burnt	19.99	MDF	2200-2500	11-18	East	ALMORA	ALMORA FOREST DIVISION	RANIKHET RANGE	GANIADEOLI BEAT	GANIADEOLI	5	79^0 25' 4.289" E	29^0 37' 24.238" N	23.01.2021
11.	4603	Sub Tropical Pine Forests	Moderately Burnt	391.271	MDF	900-1800	11-18	South	ALMORA	ALMORA FOREST DIVISION	SOMESHWAR RANGE	PUNARKOT BEAT	PUNARKOT	7	79^0 35' 51.256" E	29^0 42' 3.441" N	22.01.2021
12.	1238	Sub Tropical Pine Forests	Moderately Burnt	138.9	MDF	900-1800	18-36	North	ALMORA	ALMORA FOREST DIVISION	JAURASI RANGE	NAGAR BEAT	NAGAR	7	79^0 19' 26.797" E	29^0 54' 1.084" N	24.01.2021
13.	2179	Sub Tropical Pine Forests	Moderately Burnt	10.37	MDF	1800-2200	18-36	North	ALMORA	ALMORA FOREST DIVISION	ALMORA RANGE	BADECHINA BEAT	PHARKANAULI	1	79^0 44' 44.937" E	29^0 38' 4.057" N	20.01.2021
14.	2045	Sub Tropical Pine Forests	Moderately Burnt	9.99410	VDF	900-1800	18-36	West	ALMORA	BINSAR WILDLIFE SANCTUARY DIVISION	BINSAR WILDLIFE SANCTUARY RANGE	DHAULCHINA BEAT	BINSAR NORTH	4	79^0 48' 9.708" E	29^0 41' 7.735" N	25.01.2021
15.	2041	Sub Tropical Pine Forests	Moderately Burnt	261.23	MDF	900-1800	18-36	North	ALMORA	CIVIL SOYAM ALMORA DIVISION	KANARICHINA RANGE	CHARCHALI BEAT	PANUWANAULA_EAST	18	79^0 54' 28.466" E	29^0 40' 56.511" N	26.01.2021
16.	2374	Sub Tropical Pine Forests	Moderately Burnt	15.05	OF	1800-2200	11-18	East	NAINITAL	NAINITAL FOREST DIVISION	NORTH GOLA RANGE	KAPLESHWAR BEAT	KAPLESHWAR BLOCK	6	79^0 39' 8.091" E	29^0 31' 10.753" N	28.01.2021
17.	2655	TOF/Plantations	Low Burnt	36.84	MDF	0-900	0-3	South	NAINITAL	TARAI WEST DIVISION	SOUTH JASPUR RANGE	TUMARIA BEAT	JASPUR BLOCK	39	78^0 55'45.193" E	29^0 22' 2.906" N	30.01.2021
18.	1008	Tropical Moist Deciduous Forests	Low Burnt	45.00	MDF	0-900	0-3	South	HARIDWAR	RAJAJI NATIONAL PARK DIVISION	HARIDWAR RANGE	KHARKHARI NORTH BEAT	KHARKHARI BLOCK	0	78^0 10' 1.027" E	29^0 59' 12.042" N	23.12.2020

19.	1020	Tropical Dry Deciduous Forests	Low Burnt	331.3	MDF	0-900	11-18	South	HARIDWAR	RAJAJI NATIONAL PARK DIVISION	HARIDWAR RANGE	RANIPUR EAST BEAT	RANIPUR BLOCK	0	78⁰ 8' 36.240" E	29⁰57' 35.779" N	22.12.2020
20.	1430	Himalayan Moist Temparate Forest	Moderate burnt	26.154	VDF	900-1800	18-36	West	PITHORAGARH	PITHORAGARH FOREST DIVISION	DIDIHAT RANGE	NAWLARA	JARAPANI	1	80°10'3.694" E	29°51'50.855" N	20.02.2021
21.	1867	Sub Tropical Pine Forests	Moderate burnt	29.22	MDF	1800-2200	5-11	West	PITHORAGARH	PITHORAGARH FOREST DIVISION	DIDIHAT RANGE	OGLA BEAT	DEVCHULA BLOCK	1	80°17'5.215" E	29°45'3.182" N	23.02.2021
22.	4446	Sub Tropical Pine Forests	Moderate burnt	225.8	MDF	900-1800	18-36	South	PITHORAGARH	PITHORAGARH FOREST DIVISION	ASKOT RANGE	SOUTH DAPHIA BEAT	DAPHIA BLOCK	3	80°21'19.271" E	29°52'7.755" N	22.02.2021
23.	1518	Sub Tropical Pine Forests	Modera e Burnt	26.69	MDF	1800-2200	11-18	West	BAGESHWAR	BAGESHWAR DIVISION	BAGESHWAR RANGE	CHHATINA BEAT	CHHATINA BLOCK	1	79°47' 41.155" E	29°50' 29.006" N	13.03.2021
24.	1265	Sub Tropical Pine Forests	Moderately Burnt	223.9	MDF	900-1800	18-36	West	BAGESHWAR	BAGESHWAR DIVISION	GARHKHET RANGE	GARHKHET-I BEAT	KHABDOLI_SOUTH	13	79°41' 45.883" E	29° 53' 45.352" N	14.03.2021
25.	1293	Sub Tropical Pine Forests	Moderately Burnt	232.8	MDF	900-1800	18-36	South	BAGESHWAR	BAGESHWAR DIVISION	DHARAMGARH RANGE	PUNGAR-I BEAT	PUNGAR	4	79°50' 44.327" E	29°52' 52.520" N	17.03.2021
26.	1313	Sub Tropical Pine Forests	Moderately Burnt	104.734	MDF	1800-2200	18-36	West	BAGESHWAR	BAGESHWAR DIVISION	BAGESHWAR RANGE	KHABDOLI_SOUTH BEAT	KHABDOLI_SOUTH	8	79°44' 7.012" E	29°52' 59.338" N	16.03.2021
27.	1388	Sub Tropical Pine Forests	Moderately Burnt	185.689	VDF	900-1800	18-36	North	BAGESHWAR	BAGESHWAR DIVISION	BAIJNATH RANGE	SHIKHARKOT-III BEAT	AKUWA BINASARI/SHIKHARKOT	0	79°41' 40.723" E	29°52' 5.397" N	19.03.2021
28.	4452	Sub Tropical Pine Forests	Moderately Burnt	73.390	MDF	900-1800	18-36	South	BAGESHWAR	BAGESHWAR DIVISION	BAGESHWAR RANGE	CHHATINA BEAT	PHALYANTI	1	79°47' 23.668" E	29°51' 43.070" N	18.03.2021
29.	4507	Sub Tropical Pine Forests	Moderately Burnt	7.1192	VDF	900-1800	18-36	North	BAGESHWAR	BAGESHWAR DIVISION	BAGESHWAR RANGE	JAULKANDE BEAT	JAULKANDE	3	79°45' 44.887" E	29°49' 6.926" N	15.03.2021
30.	534	Himalayan Moist Temparate Forest	Moderately Burnt	7.17497	OF	900-1800	18-36	East	CHAMOLI	KEDARNATH WILDLIFE DIVISION	GOPESHWAR RANGE	KATHUD BEAT	TRISHULA BLOCK I	5	79° 18' 37.737" E	30° 23' 10.486" N	15.04.2021
31.	552	Himalayan Moist Temparate	Moderately Burnt	319.62	OF	900-1800	18-36	South	CHAMOLI	KEDARNATH WILDLIFE DIVISION	NAGNATH RANGE	BAMNATH I BEAT	TRISHULA BLOCK II	17	79┬°14' 23.762" E	30┬°21' 59.419" N	14.04.2021

		Forest															
32.	4344	Himalayan Moist Temparate Forest	Moderately Burnt	281.89	MDF	900-1800	18-36	North	CHAMOLI	BADRINATH FOREST DIVISION	PINDAR WEST RANGE	AMSOR BEAT	NALGAON BLOCK	8	79°21' 7.816" E	30° 9' 36.743" N	16.04.2021
33.	4204	Himalayan Moist Temparate Forest	Low Burnt	214.52	MDF	1800-2200	18-36	West	CHAMOLI	BADRINATH FOREST DIVISION	NANDPRAYAG RANGE	SIRTOLI BEAT	SUNALA BLOCK	1	79°18' 45.663" E	30°18' 35.207" N	12.04.2021
34.	4255	Himalayan Moist Temparate Forest	Low Burnt	883.12	MDF	1800-2200	18-36	North	CHAMOLI	BADRINATH FOREST DIVISION	NANDPRAYAG RANGE	SAINJ BEAT	KUNJAKOT BLOCK III	7	79°19' 3.551" E	30°16' 6.806" N	13.04.2021
35.	2090	Himalayan Moist Temparate Forest	Moderately Burnt	18.47	MDF	0-900	11-18	West	PITHORA GARH	PITHORAGARH FOREST DIVISION	GANGOLIHAT RANGE	Lamkeshwar Beat	NAG BLOCK	1	80°1' 58.924" E	29° 40' 20.295" N	17.04.2021
36.	3484	Tropical Moist Deciduous Forests	Moderately Burnt	27.4792	Dandа Range	VDF	0-900	11-18	North	CHAMPAWAT	HALDWANI FOREST DIVISION	DANDA RANGE	DURGAPIPAL BEAT	DURGAPIPAL	4	79┬ 53' 48.073" E	29┬ 8' 36.115" N
37.	3690	Tropical Moist Deciduous Forests	Moderately Burnt	86.0592	Haldwani Range	MDF	0-900	0-3	South	NAINITAL	TARAI CENTRAL DIVISION	HALDWANI RANGE	TANDA CENTER BEAT	TANDA BLOCK	109	79┬ 26' 53.546" E	29┬ 6' 7.058" N
38.	3625	Tropical Moist Deciduous Forests	Moderately Burnt	56.761	Jaulasal Range	VDF	0-900	18-36	West	NAINITAL	HALDWANI FOREST DIVISION	JAULASAL RANGE	HATGADH BEAT	HATGADH	8	79┬ 48' 14.482" E	29┬ 7' 14.384" N
39.	3300	Tropical Moist Deciduous Forests	Moderately Burnt	5.8800	Nandhaur Range	VDF	0-900	18-36	North	NAINITAL	HALDWANI FOREST DIVISION	NANDHAUR RANGE	RATARAO BEAT	RATARAO	4	79┬ 45' 18.295" E	29┬ 10' 41.157" N
40.	3884	ToF/ Plantations	Moderately Burnt	103.8	Kilpura Range	MDF	0-900	0-3	South	UDHAMSINGH NAGAR	TARAI EAST FOREST DIVISION	KILPURA RANGE	WEST KILPURA-I BEAT	WEST KILPURA BLOCK	51	79┬ 59' 57.145" E	29┬ 1' 47.897" N
41.	2655	ToF/ Plantations	Low Burnt	36.84	South Jaspur Range	MDF	0-900	0-3	South	NAINITAL	TARAI WEST DIVISION	SOUTH JASPUR RANGE	TUMARIA BEAT	JASPUR BLOCK	39	78┬ 55' 45.193" E	29┬ 22' 2.906" N
42.	3700	ToF/ Plantations	Low Burnt	4.2330	Kishanpur Range	MDF	0-900	0-3	East	NAINITAL	TARAI EAST FOREST DIVISION	KISHANPUR RANGE	KISHANPUR SOUTH BEAT	KISHANPUR BLOCK	8	79┬ 36' 10.083" E	29┬ 6' 38.254" N

Annexure- V

Soil Sample Analysis

Sr.No.	Polygon ID	Control/Fire	Dry weight of soil (gm)	Volume (cm^3)	Bulk Density (gm/cm3)	% Organic Carbon
1	1312	Control	313	240	1.3	0.81
2	1316	Control	358	240	1.49	0.72
3	1316	Fire	321	240	1.34	0.91
4	1357	Control	350	240	1.46	0.34
5	1357	Fire	284	240	1.18	1.55
6	1358	Control	306	240	1.28	1.06
7	1358	Fire	330	240	1.38	0.73
8	1443	Fire	333	240	1.39	0.59
9	1443	Control	324	240	1.35	0.44
10	4524	Fire	230.7	220	1.05	2.21
11	4524	Control	233.8	220	1.06	1.52
12	6534	Control	259	240	1.08	1.27
13	6534	Fire	258	240	1.08	1.71
14	6865	Control	300	240	1.25	1.51
15	6993	Fire	338	220	1.54	1.83
16	6993	Control	252	220	1.15	2.54
17	7596	Fire	396	240	1.65	0.59
18	7596	Control	418	240	1.74	1.24
19	9169	Fire	330.8	240	1.38	0.95
20	9169	Control	342.3	240	1.43	1.16
21	10369	Fire	329.7	220	1.5	0.47
22	10369	Control	319.4	220	1.45	1.27
23	11001	Control	330	220	1.5	1.75
24	11001	Fire	338	220	1.54	1.13
25	11546	Control	322	220	1.46	0.73
26	11546	Fire	306	220	1.39	1.39
27	11563	Fire	350	220	1.59	0.75
28	11563	Control	346	220	1.57	0.64
29	11791	Fire	350	220	1.59	0.79
30	11791	Control	280	220	1.27	0.69
31	11995	Fire	390	220	1.77	0.58
32	11995	Control	374	220	1.7	0.43
33	12459	Fire	362	220	1.65	1.75

34	12459	Control	548	220	2.49	0.88
35	12508	Fire	432.7	220	1.97	0.49
36	12508	Control	345.7	220	1.57	0.95
37	12563	Fire	419.3	220	1.91	0.44
38	12563	Control	349.5	220	1.59	1.85
39	12628	Fire	315.3	220	1.43	0.74
40	12628	Control	407.6	220	1.85	0.96
41	14057	Fire	330	220	1.5	0.81
42	14057	Control	358	220	1.63	2
43	14676	Fire	336	240	1.4	0.76
44	14676	Control	310	240	1.29	0.34
45	14683	Control	329	240	1.37	0.34
46	14683	Fire	317	240	1.32	0.81
47	15203	Fire	235.5	220	1.07	2.92
48	15203	Control	228.3	220	1.04	0.08
49	15522	Fire	253	240	1.05	0.95
50	15762	control	262	240	1.09	1.77
51	16068	Control	355	240	1.48	0.76
52	16068	Fire	266	240	1.11	1.25
53	16181	Fire	324	240	1.35	0.69
54	16181	Control	335	240	1.4	1.69
55	16311	Fire	365	240	1.52	0.31
56	16455	Fire	327.4	220	1.49	1.03
57	16455	Control	330.6	220	1.5	1.68
58	16470	Fire	324.1	220	1.47	1.22
59	16470	Control	341	220	1.55	0.54
60	16529	Fire	414	220	1.88	0.65
61	16529	Control	394	220	1.79	1.95
62	16581	Fire	360	220	1.64	0.44
63	16581	Control	325	220	1.48	0.9
64	16627	Control	336	220	1.53	0.67
65	16627	Fire	273	220	1.24	2.7
66	16826	Control	481	220	2.19	1.11
67	16826	Fire	510	220	2.32	1.08
68	16846	Control	349	220	1.59	0.65
69	16846	Fire	295	220	1.34	1.3
70	16860	Fire	400	220	1.82	1.41
71	16860	Control	350	220	1.59	1.12

Annexure- VI

Unique Species List

Sr. no.	*Species Name*	Habit
1	*Acacia catechu*	Tree
2	*Acacia Chandra*	Tree
3	*Acacia lanceolata*	Tree
4	*Acacia leucophloea*	Tree
5	*Acacia nilotica*	Tree
6	*Acalypha malabarica*	Herb
7	*Achyranthes aspera*	Herb
8	*Acmella ciliate*	Herb
9	*Adina cordifolia*	Tree
10	*Aegle marmelos*	Tree
11	*Ageratum conyzoides*	Herb
12	*Ailanthus excelsa*	Tree
13	*Albizia amara*	Tree
14	*Albizia lebbeck*	Tree
15	*Albizia odoratissima*	Tree
16	*Alternanthera sessilis*	Herb
17	*Alysicarpus ovalifolius*	Herb
18	*Alysicarpus vaginalis*	Herb
19	*Andrographis paniculata*	Herb
20	*Anogeissus latifolia*	Tree
21	*Argemone Mexicana*	Herb
22	*Aristida sp.*	Herb
23	*Asparagus racemosus*	Climber
24	*Azadirachta indica*	Tree
25	*Azanza lampas*	Shrub
26	*Balanites aegyptiaca*	Tree
27	*Bambusa arundinacea*	Tree
28	*Barleria montana*	Herb
29	*Barleria prionitis*	Herb
30	*Bauhinia malabarica*	Tree
31	*Bauhinia purpurea*	Tree
32	*Bauhinia racemosa*	Tree
33	*Bauhinia vahlii*	Climber
34	*Bauhinia variegata*	Tree
35	*Biophytum sensitivum*	Herb
36	*Blumea glomerata*	Herb
37	*Blumea lacera*	Herb
38	*Bombax ceiba*	Tree
39	*Boswellia serrata*	Tree
40	*Bridelia retusa*	Tree

41	*Buchanania cochinchinensis*	Tree
42	*Butea monosperma*	Tree
43	*Butea superba*	Climber
44	*Cajanus scarabaeoides*	Climber
45	*Calotropis gigantea*	Shrub
46	*Canscora diffusa*	Herb
47	*Cardiospermum halicacabum*	Climber
48	*Careya arborea*	Tree
49	*Carissa bispinosa*	Shrub
50	*Carissa carandas*	Shrub
51	*Carissa spinarum*	Shrub
52	*Casearia graveolens*	Tree
53	*Casearia tomentosa*	Tree
54	*Cassia fistula*	Tree
55	*Cassine glauca*	Tree
56	*Catunaregam spinosa*	Tree
57	*Celastrus paniculatus*	Climber
58	*Celosia argentea*	Herb
59	*Centella asiatica*	Herb
60	*Chloroxylon swietenia*	Tree
61	*Chromolaena odorata*	Shrub
62	*Cissampelos pareira*	Climber
63	*Cleistanthus collinus*	Tree
64	*Cocculus hirsutus*	Climber
65	*Cochlospermum religiosum*	Tree
66	*Colebrookea oppositifolia*	Shrub
67	*Commelina benghalensis*	Herb
68	*Corchorus aestuans*	Herb
69	*Crotalaria albida*	Herb
70	*Crotalaria calycina*	Herb
71	*Cryptolepis buchananii*	Climber
72	*Curculigo orchioides*	Herb
73	*Curcuma aromatica*	Herb
74	*Cyanthillium cinereum*	Herb
75	*Cyclea peltate*	Climber
76	*Cymbopogon coloratus*	Herb
77	*Cyperus rotundus*	Herb
78	*Dalbergia lanceolaria*	Tree
79	*Dalbergia latifolia*	Tree
80	*Dalbergia sissoo*	Tree
81	*Dendrocalamus strictus*	Herb
82	*Desmodium dichotomum*	Herb
83	*Desmodium gangeticum*	Herb
84	*Desmodium oojeinense*	Tree
85	*Desmodium triflorum*	Herb

86	*Diospyros melanoxylon*	Tree
87	*Diospyros montana*	Tree
88	*Ehretia laevis*	Tree
89	*Elephantopus scaber*	Herb
90	*Emilia sonchifolia*	Herb
91	*Eranthemum roseum*	Herb
92	*Euphorbia hirta*	Herb
93	*Euphorbia indica*	Herb
94	*Evolvulus alsinoides*	Herb
95	*Evolvulus nummularius*	Climber
96	*Ficus arnottiana*	Tree
97	*Ficus benghalensis*	Tree
98	*Ficus racemose*	Tree
99	*Flacourtia indica*	Tree
100	*Flemingia strobilifera*	Shrub
101	*Gardenia gummifera*	Tree
102	*Gardenia latifolia*	Tree
103	*Gardenia resinifera*	Tree
104	*Garuga pinnata*	Tree
105	*Gmelina arborea*	Tree
106	*Grewia asiatica*	Tree
107	*Grewia flavescens*	Shrub
108	*Grewia orbiculate*	Shrub
109	*Grewia tiliifolia*	Tree
110	*Gymnosporia senegalensis*	Shrub
111	*Hardwickia binata*	Tree
112	*Helicteres isora*	Shrub
113	*Hemidesmus indicus*	Climber
114	*Hemigraphis latebrosa*	Herb
115	*Holarrhena pubescens*	Tree
116	*Holoptelea integrifolia*	Tree
117	*Hyptis suaveolens*	Herb
118	*Indigofera linnaei*	Herb
119	*Ixora parviflora*	Shrub
120	*Ixora pavetta*	Tree
121	*Justicia procumbens*	Herb
122	*Justicia quinqueangularis*	Herb
123	*Kydia calycina*	Tree
124	*Lagerstroemia parviflora*	Tree
125	*Lannea coromandelica*	Tree
126	*Lantana camara*	Shrub
127	*Lepidagathis cristata*	Herb
128	*Madhuca longifolia*	Tree
129	*Malvastrum coromandelianum*	Herb
130	*Manilkara hexandra*	Tree

131	*Mecardonia procumbens*	Herb
132	*Melastoma malabathricum*	Shrub
133	*Miliusa tomentosa*	Tree
134	*Mitragyna parvifolia*	Tree
135	*Morinda tinctoria*	Tree
136	*Murdannia simplex*	Herb
137	*Nelsonia canescens*	Herb
138	*Nyctanthes arbor-tristis*	Tree
139	*Oldenlandia corymbose*	Herb
140	*Oplismenus burmannii*	Herb
141	*Oroxylum indicum*	Tree
142	*Oxalis corniculate*	Herb
143	*Paspalidium flavidum*	Herb
144	*Phoenix sylvestris*	Tree
145	*Phyllanthus emblica*	Tree
146	*Phyllanthus sp.*	Herb
147	*Phyllanthus reticulatus*	Shrub
148	*Phyllanthus tenellus*	Herb
149	*Phyllanthus urinaria*	Herb
150	*Phyllanthus virgatus*	Herb
151	*Phyllodium pulchellum*	Herb
152	*Pimpinella tomentosa*	Herb
153	*Plumbago zeylanica*	Herb
154	*Poa cilianesis*	Herb
155	*Pogostemon benghalensis*	Herb
156	*Pterocarpus marsupium*	Tree
157	*Ruellia prostrata*	Herb
158	*Ruellia tuberosa*	Herb
159	*Rungia pectinate*	Herb
160	*Schleichera oleosa*	Tree
161	*Schrebera swietenioides*	Tree
162	*Scoparia dulcis*	Herb
163	*Semecarpus anacardium*	Tree
164	*Senna tora*	Shrub
165	*Shorea robusta*	Tree
166	*Sida acuta*	Herb
167	*Sida cordifolia*	Herb
168	*Smilax zeylanica*	Climber
169	*Solanum violaceum*	Shrub
170	*Soymida febrifuga*	Tree
171	*Spatholobus parviflorus*	Climber
172	*Spermacoce hispida*	Herb
173	*Spermacoce verticillate*	Herb
174	*Sterculia urens*	Tree
175	*Stereospermum chelonoides*	Tree

176	*Syzygium aromaticum*	Tree
177	*Syzygium cumini*	Tree
178	*Tectona grandis*	Tree
179	*Tephrosia purpurea*	Herb
180	*Terminalia arjuna*	Tree
181	*Terminalia bellirica*	Tree
182	*Terminalia chebula*	Tree
183	*Terminalia elliptica*	Tree
184	*Terminalia tomentosa*	Tree
185	*Themeda triandra*	Herb
186	*Tridax procumbens*	Herb
187	*Triumfetta rhomboidea*	Shrub
188	*Urena lobata*	Shrub
189	*Ventilago denticulate*	Climber
190	*Vicoa indica*	Herb
191	*Vitex negundo*	Tree
192	*Waltheria indica*	Shrub
193	*Woodfordia fruticose*	Shrub
194	*Wrightia arborea*	Tree
195	*Wrightia tinctoria*	Tree
196	*Xanthium strumarium*	Herb
197	*Ziziphus jujuba*	Tree
198	*Ziziphus mauritiana*	Tree
199	*Ziziphus nummularia*	Shrub
200	*Ziziphus oenoplia*	Shrub
201	*Ziziphus rugosa*	Tree
202	*Ziziphus xylopyrus*	Tree