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"THE INTEGRATED FOREST ECOSYSTEM MANAGEMENT PROJECT IN THE KYRGYZ REPUBLIC" (IFEMP)

CONSULTING SERVICES

NATIONAL FOREST INVENTORY EXECUTION AND CAPACITY BUILDING

Contract № KG/IFEMP/QCBS/NFI/01/2018

D1.4 Report on required sample sizes

REPORT

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forestry and land use

National Forest Inventory Execution and Capacity Building

RFP No.: # KG - IFEMP/QCBS/NFI-01-2018

D1.4 Report on required sample sizes

Design of the NFI & related anticipated variances

Client

State Agency for Environmental Protection and Forestry

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ACRONYMS

NFI	National Forest Inventory
NFI-FI	Field inventory of the National Forest Inventory
FMP	Forest Management Planning
GIS	Geographic Information System
PIU	Project Implementation Unit
SAEPF	State Agency for Environmental Protection and Forestry
WB	World Bank
GIS	Geographic Information System
IFEMP	Integrated Forest Ecosystem Management Project
INRMP	Integrated Natural Resources Management Plans
LCCS	Land Cover Classification System
Leskhoz	State Forest Enterprise
MA	Ministry of Agriculture, Melioration and Water resources of the Kyrgyz Republic
NFI	National Forest Inventory
NFI # 1	1st National Forest Inventory of the Kyrgyz Republic
NFI # 2	2nd National Forest Inventory of the Kyrgyz Republic
PIU	Project Implementation Unit
SAEPF	State Agency for Environmental Protection and Forestry
SFF	State Forest Fund
ToR	Terms of References
TTFI	Technical Team for Forest Inventory

1 INTRODUCTION

This report consists of two main parts:

In chapter 2 the revised NFI design is presented with a focus on the quantity and the distribution of the tracts, based on a critical review of the NFI#1 design and resulting needs for adaption to achieve the objectives of NFI#2, especially to derive solid estimates of the growing stock of the major forest types.

The design of the sample plots is presented in the revised field manual for the NFI#2.

In chapter 3 the expected anticipated variances considering the revised design and tract quantities are presented based on both, a reanalysis of NFI#1 data and of the FMP sample plot data available for the majority of the state forest enterprises (Leskhozes).

2 NFI#2 DESIGN

2.1.1 Background

Introduction

Kyrgyzstan is approximately 19.9 million ha, of this, 5.6% is comprised of forests and shrubs (1.12 million ha) and out of this percentage an estimated 677,000 ha are actually covered by forests. This was shown by the national survey results of SAEPF and FAO (2010). Approximately 90% of the forests in the Kyrgyz Republic are located at an altitude between 700 and 3,500 meters above sea level. Despite occupying a relatively small area, the forests are very diverse in species composition.

The forests can be divided into six main groups: 1) spruce forests 2) walnut-fruit forests 3) juniper forests 4) pistachio forests, 5) broad leaved 6) shrubs.

This definition will guide our approach on the NFI.

The majority of forests occurs in state forest enterprises.

Additionally, there are trees outside the forests or SFF, which consist mainly of planted poplar trees and fruit trees. These trees play an important role for communities, but are effectively under an open access regime. There are 277,000 ha of forests outside the SFF on municipal lands, mostly riparian forests and poplar plantations, which have a significant environmental role, but are under pressure from communities sourcing timber and fuelwood.

Technical principles

In order to comply with national and international standards as well as requirements by the client, the design development followed several principals, assumptions, considerations and a defined approach.

- a sample based forest inventory and its analysis will provide statistical results on a national level and analysis subunits that are defined by administrative regions, forest types, forest owner ship and combinations of these; and

- a national land cover map that can be utilized within FIMS by a wide range of users; it will also be used in the context of the sample based forest inventory and its analysis for post stratification

General considerations

When developing the methodology of NFI # 2 of the Kyrgyz Republic the following aspects are taken into consideration:

- principles for planning and establishment of an NFI and a national forest monitoring system as presented in the FAO report "Voluntary Guidelines on National Forest Monitoring (FAO 2017).
- developing and finalizing the methodology and its implementation in close collaboration with SAEPF, SIKFHIP and particularly the TTFI based on the design proposed in the proposal.
- consolidated information needs for NFI # 2
- retain the NFI # I field methodology where reasonable based on a critical reflection of the NFI # I field methodology and the consolidated information needs for NFI # 2
- consideration of measurement practices from FMP sample plot inventories
- major precision expectations of the NFI # 2 as specified in the ToR
- proven state of the art technology and methodology
- natural, socioeconomic and specifically the forest sector frame conditions in Kyrgyzstan.

2.1.2 Methodology

Introduction

The objective of the NFI is to provide solid and comprehensive information on all forests/shrub lands and with less intensity on other land cover classes that occur in Kyrgyzstan. Mapping and field data collection is associated with substantial efforts. Thus (1) clarity is necessary on the information that needs to be collected and (2) a cost-efficient methodology has to be applied that focuses on that information that is actually needed. To be efficient, this methodology needs to capitalize from all information that has already been collected in and for the forest sector, especially information from FMP, the forest type map 2008 prepared by the Swiss/Kyrgyz project and the NFI # 1. To be efficient this inventory needs further, more than the NFI # 1 did, to consider the specific spatial distribution of the forests and shrub lands and the relevance of the 6 most important forest/shrub land types. With the methodology of this NFI # 2, continuity needs to be ensured with NFI # 1 in order to enable a solid analysis of changes between NFI # 1 and NFI # 2. In view of future repetitions, the methodology needs as well to ensure that the analysis of future NFI repetitions will provide solid information on changes versus the previous NFI inventory cycle. The most relevant information gains from re-measurements are sound data on growth rates and productivity, survival and dying process, utilization and regeneration.

NFI # 1 characterization

The **NFI # 1** applied a systematic tract design with a moderate number of tracts. Both together has resulted in a low number of tracts that covered forests and these six major forest types. Pistachio forests and walnut forests occurred merely by one/respectively two tracts, the remaining four types occurred merely by less than 20 tracts. In total forest/shrub lands where assessed on 113 tracts. With this number of tracts, the NFI # 1 merely could provide information with sufficient statistical error on the total forest/shrub land as a whole. This is also visible from the report on the NFI # 1 that provides information on the statistical accuracy on the forest/shrub land area but not for the other information presented.

NFI # 2 methodological overview

The NFI #2 addressed need for higher accuracy of results in general and the specific need to get solid information on the major six forest types by the following changes that will ensure a higher number of field tracts in forests and other wooded land and a balanced representation of the six major forest types within the field plots.

To achieve this the following measures are taken:

Systematic distribution of tracts

The basic design will be a systematic grid of tracts, each tract consisting of three plots. Strata will be established to enable differing tract densities between the strata (Figure 1).

The grid is positioned linked to the FMP plot inventory to ensure that the plot in the south-west corner will be identical with a FMP sample plot location. This increases substantially the amount of re-measured plots and thus the information on growth, harvests and mortality.

The shorter distance between plots is chosen to ensure a higher share of tracts where all plots are situated in forest/shrubland that is distributed highly scattered.

The plot design of NFI#2 differs to NFI#1, main difference is the smaller the area for tree measurement and consists of concentric circles (6m/12 radius), details are provided in the revised field methodology (D1.2).

The plot design is described in depth the field manual.

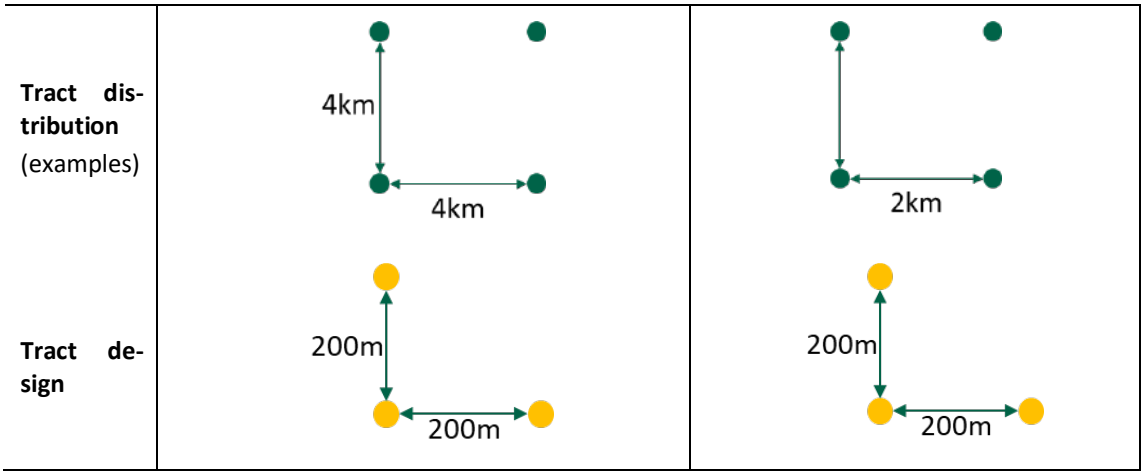

Figure 1: NFI # 2 – Design of tracts consisting of three plots

The NFI#1 plots are integrated in the new design by maintaining the four plots, but adopting the plot shape to circle in line with the plot design of the new inventory (see Figure 2).

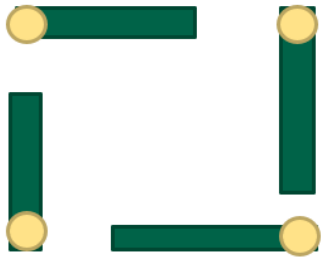

Figure 2: NFI#2 plot design of a former NFI#1 tract

To integrate the NFI#1 tracts (grid locations are degree based) into the NFI#2 grid (grid locations are km based as in the FMP inventory) for each NFI#1 tract the tract of the NFI#2 grid closest to the NFI#1 tract is omitted. Thus, the number of tracts of the final NFI#2 grid merely relate to the NFI#2 grid density per stratum. Merely the location of the former NFI#1 tract differs from the standard grid system.

Pre-clarification

Field assessments will be conducted on forest and other wooded land only; this is achieved by a pre-clarification using VHR remote sensing images at all sample plot locations. Plots that are clearly no forest/other wooded land are excluded from field work.

The approach is illustrated by examples in Figure 3.

To establish the grid densities a pre-clarification on a 4 km by 4 km grid was conducted to make solid data on the expected number of field tracts available for the establishment of the NFI#2 grid densities and related (see Figure 4).

Out of the pre-clarified plots that are identified for field visits the share of plots characterized “forest or other wooded land” is beyond 95% % and the share of plots characterized as “to be checked in the field” is below 5%.

		
Plot classified as forest in the pre-clarification. This plot will be visited in the field.	Plot classified as non-forest in the pre-clarification. This plot will be visited in the field.	Plot classified in the pre-clarification as a plot to be checked in the field, since a clear decision based on the imagery was not possible. This plot will be visited in the field.

Figure 3: Illustration of the pre-clarification by examples

The inner circle of 12m shows the area of tree measurement and the outer circle covers an area of 0.5 ha to provide an indication of the minimum area of the forest and other wooded land definition.

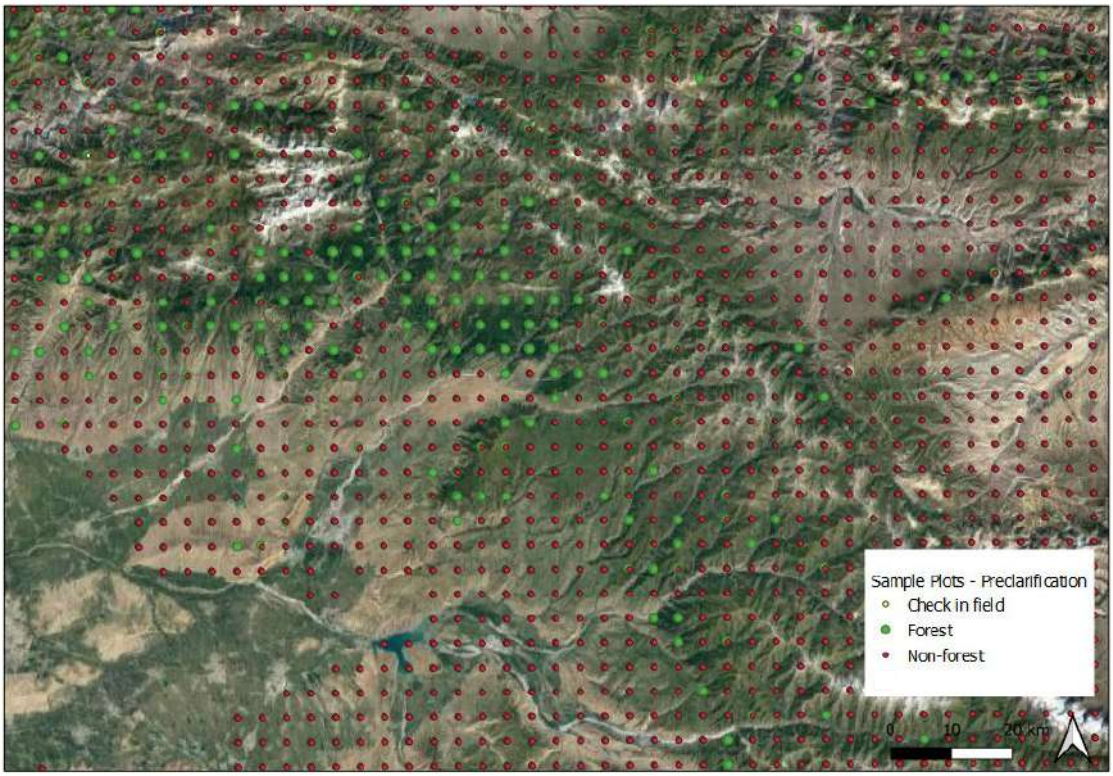

Figure 4: Illustration of the 4 km by 4km grid based pre-clarification

Pre-stratification

Forest and shrub lands in total cover about 6 % of the area of Kyrgyzstan. The main six forest types/shrub land are not equally distributed. Further the six types do not cover areas of equivalent dimension, especially the walnut forests and pistachio forests cover substantially smaller areas compared to the other forest types and shrub land (see Figure 5 and Table 1).

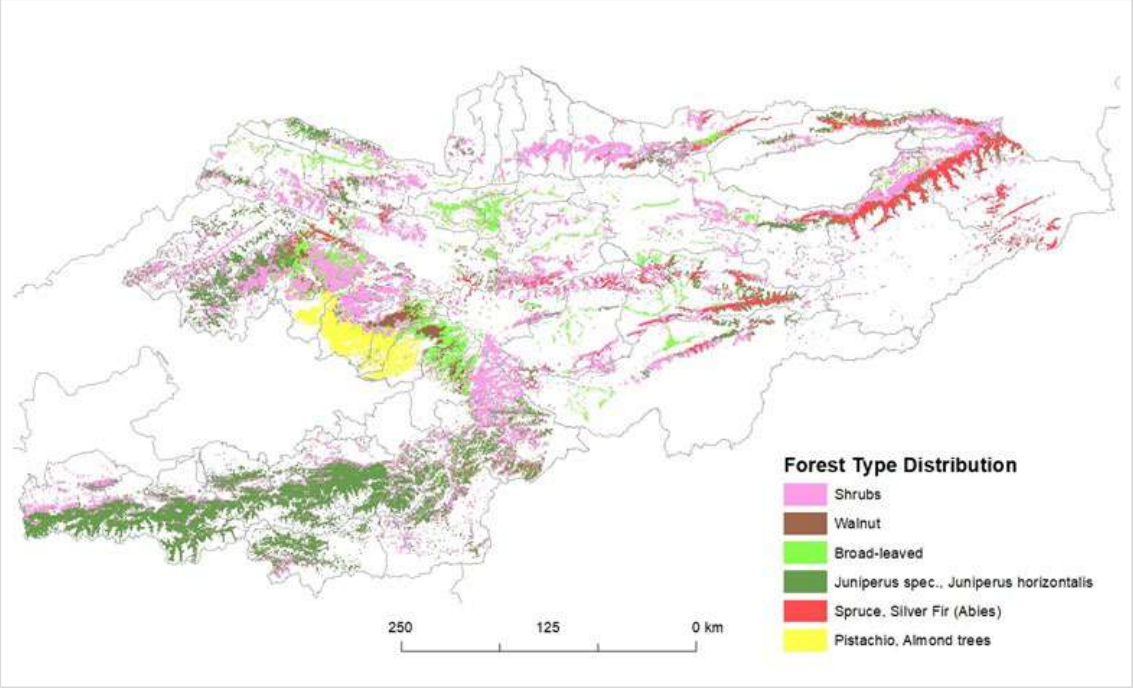

Figure 5: Forest type map prepared by the Swiss-Kirgizstan project in 2008

Table 1: Forest types spatial distribution according to the forest type map as prepared by the Swiss-Kirgizstan project in 2008

	6 forest/shrub land types					
	Shrubs	Juniper	Spruce, fir	Other broad-leaved	Walnut	Pistachio
Area Forest type map (1,000 ha) (Total: 1,391.1 T ha)	470.9	503.6	149.4	162.6	47.0	57.6
Relative area % out of the forest/shrub coverage	34%	36%	11%	12%	3%	4%

The TOR formulate the objective of a balances accuracy of the estimates of the wood volume for the six major forest types.

In order to achieve the envisaged balanced accuracy for the six forest /shrub land types a stratified approach is necessary; this since when using a pre-stratification and different densities of tracts per stratum the relative share of plots in different forest types can be influenced.

To implement a stratification the delineation of the strata was done using mainly the forest type map from 2008 as it provides solid information on the spatial distribution of the six forest types in the country. The pre-stratification was done using further available data sets, especially Google VHR images and expert knowledge on the distribution of the forest types in Kirgizia.

A schematic illustration of the stratification illustrating different densities is provided in Figure 6.

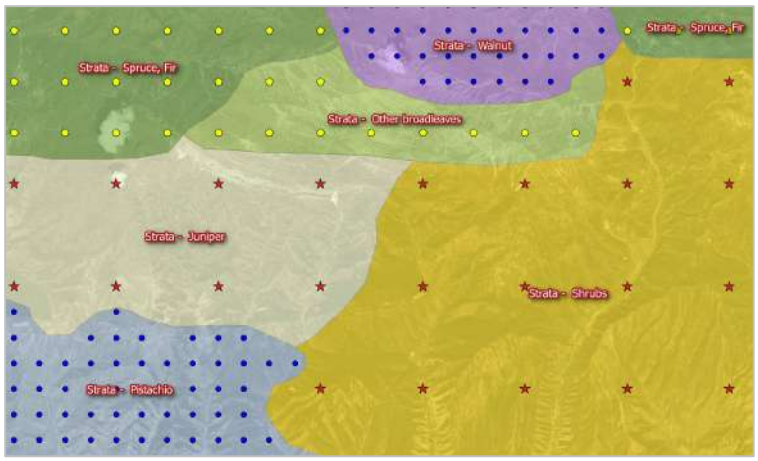

Figure 6: Schematic illustration of the pre-stratification with differing tract densities

The pre-stratification established for the NFI#2 is shown in Figure 7 and the corresponding area statistics are presented in Table 2.

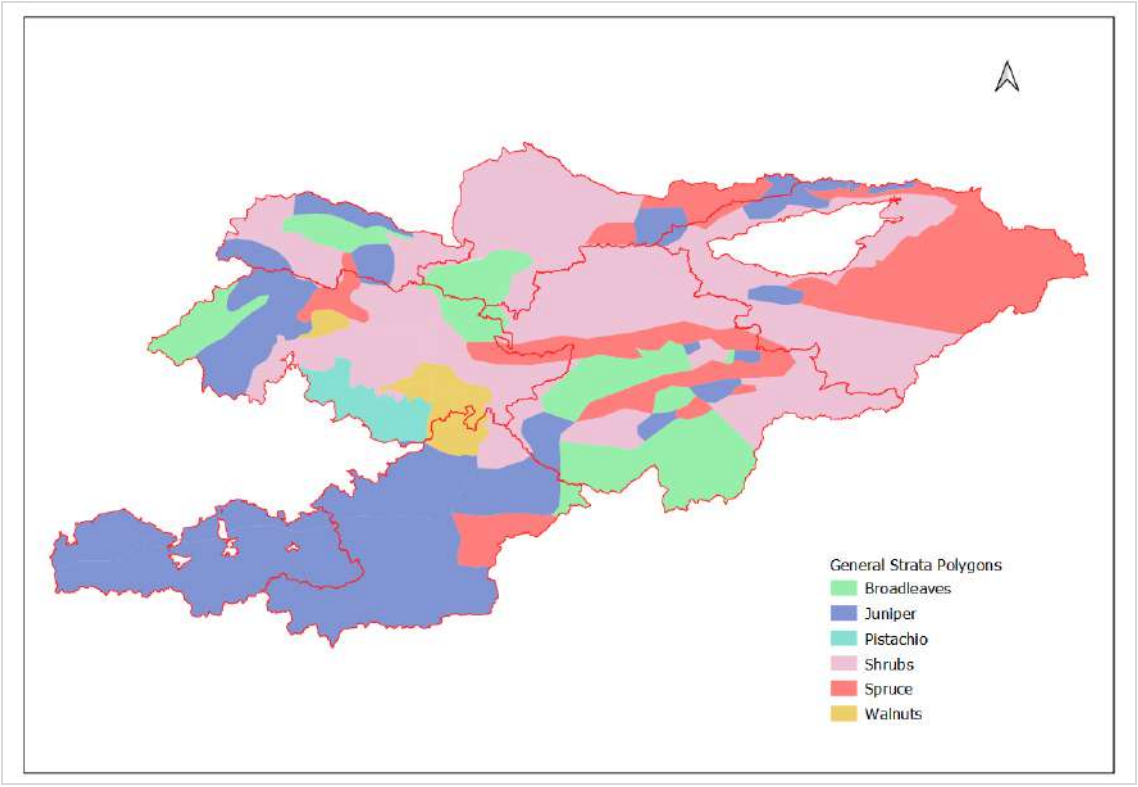

Figure 7: Pre-stratification for the NFI#2

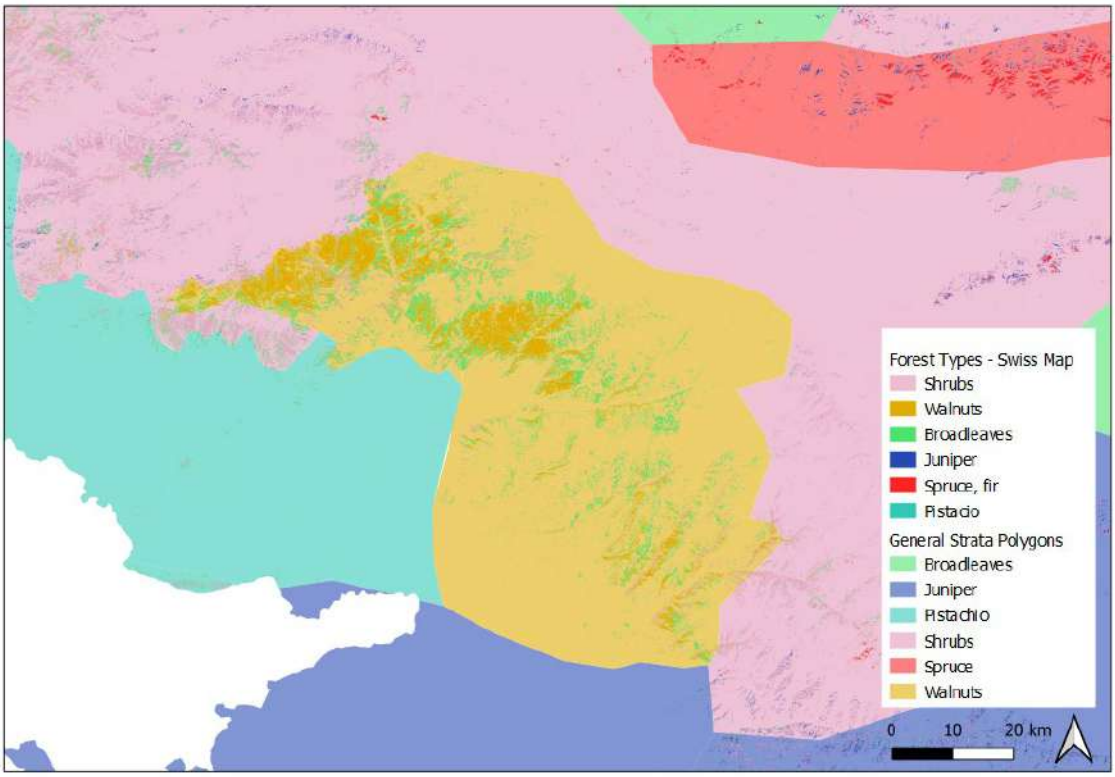

Figure 8: Subset of the strata in the region of the walnut forest type stratum overlaid with the Swiss forest type map

Table 2: Area by stratum for the NFI#2

Stratum	Stratum characterization	Stratum area [ha]	%
1	Spruce & fir forests dominated area (includes substantial share of shrub and juniper types)	3,387,157	18%
2	Juniper forests dominated area (includes substantial share of shrub types)	5,725,636	30%
3	Walnut forests dominated area (includes substantial share of other broadleaved forests)	500,423	3%
4	Pistachio forests dominated area	410,542	2%
5	Other broadleaved forests dominated area	2,384,555	12%
6	Shrub dominated area	6,939,668	36%
	Total area	19,347,981	100%

In order ensure a balanced number of plots in forest types the grid densities differ by stratum. It had to be regarded in the establishment of the grids that in several strata different forest types occur in mixture (see Figure 8 and the strata characterization in Table 2).

The tract densities per stratum have been optimized to ensure a balanced coverage of the forest types. This was enabled by the use of the plots that are identified as forest plots in the pre-clarification and for each plot of each tract the forest type map of 2008 that was used to identify the forest type classified on this map.

The resulting strata densities are shown in Table 3.

Table 3: Strata and expected field plots for the NFI#2

Stra-tum	Stratum characterization	Grid density	Total tracts	Estimated num-ber of field tracts
1	Spruce & fir forests dominated area (includes substantial share of shrub & juniper types)	2km*4km	4202	660
2	Juniper forests dominated area (includes substantial share of shrub types)	8km*16km (general density) 8 km by 8 km (in the Osh and Batken oblasts)	443[1]	80[2]
3	Walnut forests dominated area (includes substantial share of other broad-leaved forests)	2km*4km	620	260
4	Pistachio forests dominated area	2km * 2km	1004	200
5	Other broadleaved forests dominated area	4 km*4km	1496	60
6	Shrub dominated area	8km*16km	589	35
	Total		8355	1295[3]

Using this approach the predicted number of tracts to be visited in the field is ca. 1295 tracts.

In areas where forest types occur in mixture, a tract can include plots falling in several forest types, e.g. one plot in walnut forest and two plots falling in other broadleaved forest. This effect has been regarded when predicting the number of tracts that include a certain forest type.

The resulting numbers of tracts with minimum one plot in a certain forest type are shown in Table 4. The estimated number of tracts varies between ca. 250 for Juniper forest and ca.450 for Spruce and fir forests.

Table 4: Number of field tracts with at least one plot falling into the respective forest type

Stra-tum	Forest type	Estimated number of field tracts with at least one plot in the specific forest type (a single field tract can contain several forest types, therefor such tracts are counted as many times as forest types occur)
1	Spruce & fir forests	450
2	Juniper forests	250
3	Walnut forests	300
4	Pistachio forests	250
5	Other broadleaved forests	250
6	Shrub forests	350
	Total	1850

[1] Value based on the originally planned general density, due to the agreed increase of the grid density in the Osh and Batken oblasts this figure will be slightly higher.

[2] Value based on the originally planned general density, due to the agreed increase of the grid density in the Osh and Batken oblasts this figure will be slightly higher..

[3] Value based on the originally planned general density, due to the agreed increase of the grid density in the Osh and Batken oblasts this figure will be slightly higher..

These estimates of the number of field tracts with at least one plot falling into the respective forest type will in the next chapter be used to predict the accuracies (confidence intervals) achievable with these quantities of tracts. .

3 ANTICIPATED VARIANCES FOR THE ESTIMATE OF THE GROWING STOCK OF MAIN FOREST TYPES/SHRUBS

3.1 Introduction

Two data sets have been used to estimate the anticipated variance and expected precision of the estimates:

- NFI#1 data
- FMP inventory data

In this analysis it has been regarded that the new NFI#2 design is substantially different both from the NFI#1 design and the FMP inventory design.

Based on the NFI#1 tree data and the known position of each tree in the sample plot the forest type and the trees that occurred within the first 24 m of each NFI plot were used to simulate the plot of the new NFI#2 design (24 m length to consider the area of the sample plot for tree measurement). Further merely the 3 plots, that correspond to the new NFI tract design of 3 plots have been used.

Taking into account the tract design of the NFI#1 for the estimates a regression estimator has been used (formulae are provided in the appendix).

The sampling error of the estimator for the

"growing stock of a single forest type at national level"

can be determined based on the known land area by the following multiplication:

*"land area" * "volume of a single forest type per land area".*

Thus the "*volume of a single forest type per land area*" was estimated using the regression estimator and, as the national land area is known and no sampling error is associated with it, the relative sampling error of the *"growing stock of a single forest type at national level"*

For the analysis of the NFI#2 the land-cover map will be used for the estimation of all target variables in a post-stratification estimator. It is this assumed that by this measure the error component from the estimation of the area of a forest type is negligible.

Therefore, for the prediction of the sampling error of the

"Volume stock of a forest type in the country"

in the NFI#2 the sampling error of the

"Volume per ha of a forest type on area covered by the forest type" (the usual approach to use Volume per ha in the context of forests)

that does not consider the error component of the forest type area provides a good approximation.

In the analysis both estimates for both,

a) The volume stock of a forest type in the country.
b) The volume per ha of a forest type on area covered by the forest type

are presented.

The FMP inventory is conducted on concentric sample plots with circles similar to the NFI#2 design. When using the FMP inventory data for the prediction of the sampling error of the NFI#2 an estimate of the effect of the tract design of the NFI#2 versus the single plot design of the FMP is thus necessary.

The sampling errors of the FMP inventory are determined using formulae of the simple random sampling.

3.2 NFI#1 based estimates

The NFI#1 based predictions are presented in Table 5 and Table 6. The findings shown in Table 5 are shown for completeness, as in the volume per land area estimation the error component of estimating the forest type area is included.

As we assume that this error component can be neglected the results shown in Table 6 are relevant for the prediction of NFI#2 accuracies as they do not include the error component resulting from the estimating the forest type area.

These findings can be used for the identification of the necessary number of tracts to achieve an accuracy of +/- 5% for a 95% confidence interval. And as well for the prediction of the half width of the interval for a given number of tracts (Table 7). These findings are further visualized in Figure 9. As the NFI#1-re-analysis for shrub forests is based on tree volume only and NFI#2 will consider shrub volume as well, the results for shrubs are not fully representative are not shown in Figure 9 therefore.

With the NFI#1 data out of the six forest types merely 4 could be analyses since for pistachio forests and for walnut forests in the NFI#1 too view tracts included this forest types.

Table 5: Volume per land area, NFI#1 based

	Spruce	**Juniper**	**Walnut**	**Pistachio**	**Other broad-leaved**	**Shrubs**
Number of NFI#1 Tracts	767	767	767	767	767	767
Number of NFI#1 tracts that covered the forest type	13	18	1 (not sufficient for an estimate)	0 (not sufficient for an estimate)	24	50
Ratio Estimate	0.893	0.208			0.197	0.023
Variance of Ratio Estimate	0.122	0.015			0.007	0
One-fold SE of Ratio Estimate	0.35	0.122			0.086	0.017
One-fold rel. SE of Ratio Estimate (%)	19.95	29.853			22.152	37.843
Two-fold rel. SE of Ratio Estimate (%)	39.163	58.603			43.487	74.288

Table 6: Volume per forest type area, NFI#1 based (used for NFI#2 sampling error prediction of total volume stock per forest type in the country)

	Spruce	Juniper	Walnut	Pistachio	Other broad-leaved	Shrubs
Number of NFI#1 Tracts	767	767	767	767	767	
Number of NFI#1 Tracts that covered the forest type	13	18	1 (not sufficient for an estimate)	0 (not sufficient for an estimate)	24	
Ratio Estimate	128.879	19.681			15.729	0.862
Variance of Ratio Estimate	1327.769	92.558			38.377	0.42
One-fold rel. SE of Ratio Estimate (%) (ca. 68% confidence level)	12.977	23.169			19.039	37.43
Two-fold rel. SE of Ratio Estimate (%) (95% confidence level)	28.273	48.883			39.385	75.219

Table 7: Predicted sampling error in dependence of numbers of tracts; NFI#1 analysis based

Relative sampling errors (SE%) for certain numbers of tracts in the inventory	Spruce	Juniper	Pistachio	Walnut	Other broad-leaved	Shrubs
one-fold SE% for n=100	5.138	10.452			9.724	26.805
95% confidence level SE% for n=100	10.194	20.739			19.294	53.188
one-fold SE% for n=200	3.655	7.437			6.919	19.072
95% confidence level SE% for n=200	7.208	14.665			13.643	37.609
one-fold SE% for n=300	2.991	6.085			5.661	15.604
95% confidence level SE% for n=300	5.886	11.974			11.14	30.708
one-fold SE% for n=400	2.593	5.275			4.907	13.527
95% confidence level SE% for n=400	5.097	10.37			9.647	26.594
one-fold SE% for n=500	2.32	4.721			4.392	12.107
95% confidence level SE% for n=500	4.559	9.275			8.629	23.786
one-fold SE% for n=600	2.119	4.311			4.011	11.056
95% confidence level SE% for n=600	4.162	8.467			7.877	21.714

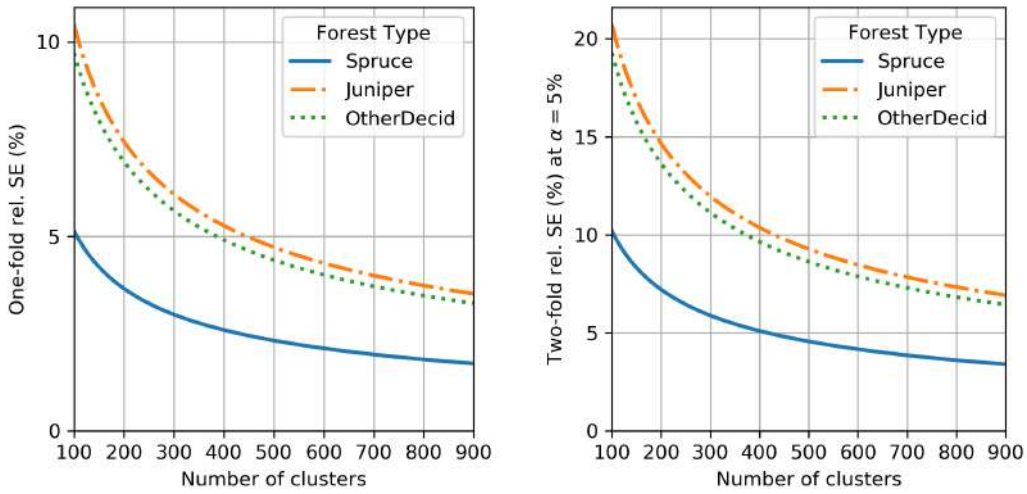

Figure 9: Onefold sampling error [ca. 68% confidence level] (left), sampling error for 95% confidence intervals [ca. two fold] (right), NFI#1 based estimates

Figure 9 shows that the 5% confidence level can be reached merely for the spruce type with tract numbers below 500. As the NFI#1 data analysis is based on a moderate number of tracts the findings can be interpreted as indicative only.

The use of the one-fold sampling error is an alternative for the presentation of the results in tabular form for the NFI#2in Kirgizia. For that reason it is presented in this chapter in addition. The one-fold sampling error is roughly half of the quantity of the sampling error of the 95% confidence level and has a 68% percent confidence level.

3.3 FMP data based estimates

For the FMP sample plot data the assignment of plots to forest types is based on the tree species distribution on the actual plot. The findings from the reanalysis of tree data of the FMP plots are shown in Table 8. Focus of the analysis where the pure forest types, as for shrub forest the estimation of the volume is not regarded crucial and it is regarded adequate to simply foresee a number of tracts for the shrub land that corresponds to the number of tracts of the 5 basic forest types.

To use the findings of the FMP analysis for predictions on the NFI#2 the assumption was made that the reduction of the error level due to the different design (single plot instead of tracts) is equivalent to the reduction of the coefficient of variation (CV%) by 30%.. The predictions shown in Table 9 and in Figure 10 are based on this assumption.

Table 8: Volume per forest type area, FMP data based (used for NFI#2 sampling error prediction of volume stock in the country)

	Spruce	Juniper	Walnut	Pistachio	Other broadleaved
Sample Size	13457	6635	12119	578	10806
Mean Volume	183.929	49.568	144.57	15.846	52.209
CV%	83.376	92.697	78.586	131.368	106.505

Relative sampling error [%]	1.182	1.872	1.174	9.002	1.685

Table 9: Predicted sampling error in dependence of numbers of tracts; FMP analysis based

	Spruce	Juniper	Walnut	Pistachio	Other broad-leaved
95% confidence level SE% n = 100	9.6005	10.6743	9.0489	15.1501	12.264
n=200	6.7886	7.5481	6.3987	10.7128	8.6716
n=300	5.5426	6.1628	5.2248	8.7472	7.0805
n=400	4.7999	5.3375	4.5248	7.5747	6.132
n=500	4.2938	4.774	4.0467	6.7753	5.4845
n=600	3.9193	4.3582	3.6939	6.1852	5.0064
n=700	3.6288	4.0348	3.4202	5.726	4.6354
n=800	3.3943	3.7744	3.199	5.3564	4.3358
n=900	3.2004	3.5581	3.0163	5.0498	4.088
n=1000	3.0359	3.3754	2.8616	4.7908	3.878

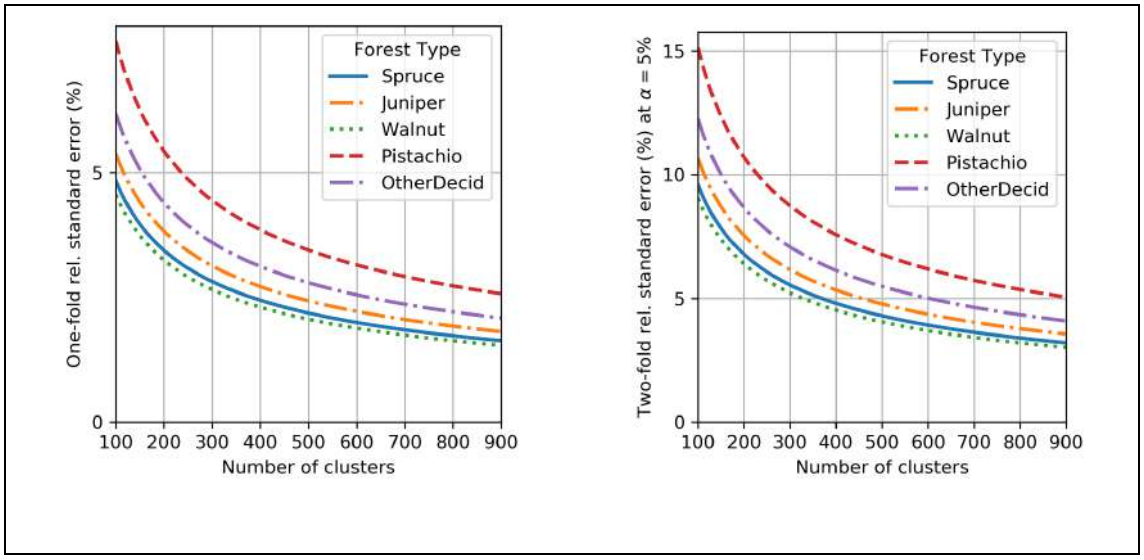

Figure 10: Onefold sampling error [ca. 68% confidence level] (left), sampling error for 95% confidence intervals [ca. two fold] (right), FMP based estimates

The FMP based estimates provide results for all 5 basic forest types and clearly show that sampling errors in a range between 4.0% and up to 8.8% are predicted for range of 300 to 500 tracts.

With a moderate increase of the number of tracts no substantial improvements in single classes would be possible, as any precision increase envisaged via an increase of the number of tracts is

not linear (see Figure 9 and Figure 10); e.g. to half the sampling error, the number of tracts has to be increased four times.

3.4 Summary

For the actual predictions for NFI#2 the estimated number of tracts per forest type, that have been derived in chapter 2 (see Table 4) have been to be used. The findings both for the are presented in Table 10.

Table 10: Summary table

Stratum	Forest type	Estimated number of field tracts with at least one plot in the specific forest type	Expected SE% (95% confidence interval) NFI#1 based	Expected SE% (95% confidence interval) FMP inventory data based[4] (rounded)
1	Spruce & fir forests	450	4,806	4.5
2	Juniper forests	250	13,117	6.8
3	Walnut forests	300		5.2
4	Pistachio forests	250		9.6
5	Other broadleaved forests	250	12,203	7.7
6	Shrub forests	350	28,430	

Color's indicating the level of achievement of the target: Dark green: fully achieved, light green: nearly fully achieved; orange: not achieved, but regarded acceptable.

The summary table shows that the NFI#1 and FMP data analysis differs in the predictions, except for spruce/fir forests. As the NFI#1 based predictions are based on small numbers of tracts only the FMP based predictions are the main basis for the prediction and show that the envisaged 5% target, expressed in the TOR is met for 2 types (spruce/fir and walnut), nearly met for two further types(juniper and other broadleaved forests). Merely for pistachio forests the 5% target cannot be met and is the prediction is in the dimension of 10%. This, although in the pistachio stratum the highest density of tracts is foreseen. The reason for this larger deviation is the higher variability in pistachio forests compared to other forest types.

For shrub forests the prediction is not as relevant as for the other types and thus the estimated tract number of 350 is regarded adequate as it is in the dimension of the other five forest types.

Summarizing, with the ca. 1300 planned and budgeted field tracts it is envisaged that the planned precision objectives expressed in the TOR can be met in their essence. .

[4] Values based on the originally planned general density, due to the agreed increase of the grid density in the Juniper stratum in the the Osh and Batken oblasts this figure will be slightly higher the expected that the precision will be slightly higher, especially for the Juniper forest type.

4 ANNEX

4.1 Annex 1: References

Cochran, W.G. (1977): Sampling Techniques (3. Edition). John Wiley and Sons, New York, 428 p.

Särndal C. E., Swenson, B. & Wretman, J. (1992): Model Assisted Survey Sampling. Springer, New York, 694 p.

4.2 Annex2: Estimation formulae

Ratio estimation formulae

The Ratio in the estimation domain (the area the estimate is made for, e.g. entire Kirgizia or a sub-region) is

$$R = \frac{Total\ of\ X}{Total\ of\ Y}$$

It is estimated by the ratio estimator

$$\hat{R} = \frac{\sum_1^n x_{ci}}{\sum_1^n y_{ci}}$$

where,

$n =$ number of clusters (tracts)

$x_{ci} =$ total of variable x per cluster i
(e.g. sum of tree volume of forest type beech forest over all plots of a cluster)

$y_{ci} =$ total of variable y per cluster i
(e.g. sum of area of forest type beech forest over all plots of a cluster)

Using this approach, all clusters in the estimation domain are always included in the analysis.

The variance for the ratio estimate can be determined by

$$\hat{V}(\hat{R}) = \frac{1}{n\bar{y}_s^2}\frac{\sum_1^n {x_{ci}}^2 - 2\hat{R}\sum_1^n x_{ci}y_{ci} + \hat{R}^2\sum_1^n {y_{ci}}^2}{n-1}$$

Where $\bar{y}_s$ is the sample mean of y_{ci}.
The sampling error of the ratio estimate can be determined as

$$SE_{\hat{R}} = t\sqrt{\hat{V}(\hat{R})}$$

with students *t* depending on n and the confidence level to be considered;
and the corresponding relative sampling error as

$$SE\%_{\hat{R}} = 100 * \ SE_{\hat{R}}/\hat{R}.$$

For the presentation of the sampling error the choice of the confidence level is required.
In case of the the onefold sampling error (with S ~68%) for large n students *t* has the value ~1.

Simple random sampling

The following formulae are used in the case of an analysis based on simple random sampling.

Mean ($\bar{y}$)	$\bar{y} = \frac{\sum y_i}{n}$
Variance (${s^2}_y$)	${s^2}_y = \frac{\sum(y-\bar{y})^2}{n-1}$
Standard deviation (s_y)	$s_y = \sqrt{{s^2}_y}$
Coefficient of variation (CV) expressed as percent	$CV = \frac{s_y}{\bar{y}} * 100$
Standard error of the mean ($s_{\bar{y}}$)	$s_{\bar{y}} = \sqrt{\frac{{s^2}_y}{n}}$
Sampling error (SE)	$SE = t * s_{\bar{y}}$
Relative sampling error (RSE) expressed as percent	$RSE = \frac{SE}{\bar{y}} * 100$
Required sample size (n_{req}) needed to achieve allowable error percent (A) expressed as percent of the mean (e.g. 5%)	$n_{req} = \left(\frac{t * CV}{A}\right)^2$
Relative sampling error (RSE_{new}) for new sample size in comparison to an initial sample size	$RSE_{new} = RSE_{init} * \sqrt{\frac{n_{init}}{n_{new}}}$

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