EUROPEAN COMMISSION
DIRECTORATE-GENERAL
JOINT RESEARCH CENTRE
Directorate D – Sustainable Resources
Bio-Economy Unit

Measuring *Forest Area Density* to quantify Forest Fragmentation.

Available in the free software *GuidosToolbox*. This is a living document, please check for the latest version at: **https://forest.jrc.ec.europa.eu/en/activities/lpa/gtb/**

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1. Background

Fragmentation is a very complex topic. Typically, it is a summary descriptor addressing a variety of spatial attributes of a forest map (i.e., total forest area, average patch size, number of forest patches, spatial aggregation and/or dispersion of forest patches, compactness, amount of forest edges, amount of forest perforations, inter-patch connectivity, etc.).

A fragmentation assessment scheme should account for key aspects of fragmentation, such as the area and shape of continuous forest, forest integrity (amount, shape and area of perforations inside intact forests), and the spatial inter-patch distance distribution of forest patches separated by non-forest lands.

- Forest fragmentation must be derived from the principle aspect of forest cover, which is the amount of forest. Any other aspect, like pattern, patch shape, connectivity, etc. is necessarily constrained by forest amount. Therefore, no other aspect can be fully interpreted without also measuring forest amount.
- Forest fragmentation is scale dependent and observer dependent. There is no single scale or observer that is not arbitrary. The solution is to report fragmentation at multiple scales, in a way that different observers can make their own choices about scales and thresholds of concern.

Scope of this report and for consideration:

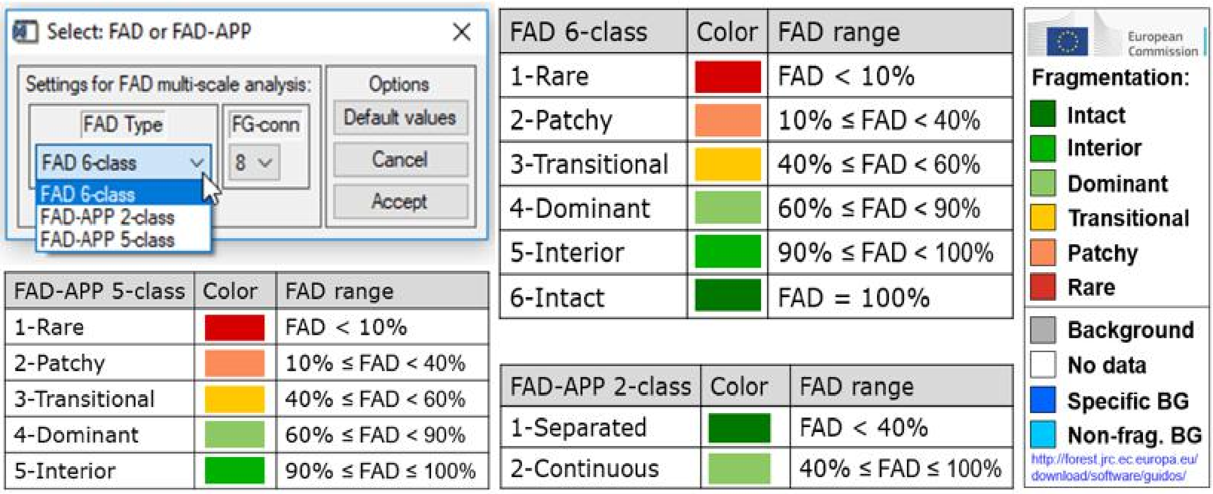
Illustration of a map analysis methodology to describe and measure forest fragmentation and temporal changes. The methodology outlined in this document (FAD) is based on a reporting scheme used by the USDA-Forest Service (USFS) for reporting to the Montréal Process. In collaboration with the USFS, the methodology has been further enhanced to provide additional reporting schemes summarized in this document. The methodology provides a map product, statistical summary, and a dedicated change analysis scheme for several fragmentation classes. The fragmentation analysis scheme is available in two forms:

a) FAD: concurrent multi-scale analysis at 5 fixed observation scales + multi-scale summary
b) FOS: same as FAD analysis but at a user-defined single observation scale

2. Forest fragmentation assessment scheme

2.1 The methodology

The assessment scheme for reporting on fragmentation measures the spatial density of forest cover, ***Forest Area Density (FAD)*** (Riitters et al., 2002, 2012), at five observation scales using a moving window analysis with square neighborhood areas of length 7, 13, 27, 81, 243 pixels. These neighborhood areas were selected to span a wide range of scales representing an approximately geometric progression of window area with scale. For example, when using CORINE land cover maps with a spatial pixel resolution of 1 hectare, the observation scales correspond to neighborhood areas of approximately: 0.5, 1.7, 7.3, 65, 590 km^2. The result is a set of five maps (one for each observation scale) showing forest area density (FAD) values in [0,100] % for neighborhood areas over each forest pixel. The user can choose to calculate FAD (density) values per-pixel (FAD 6-class) or aggregate them per patch, Average-Per-Patch (FAD-APP). The FAD values in the visual display of each of the five FAD maps are color-coded into the following forest fragmentation classes:



FAD 6-class	Color	FAD range
1-Rare		FAD < 10%
2-Patchy		10% ≤ FAD < 40%
3-Transitional		40% ≤ FAD < 60%
4-Dominant		60% ≤ FAD < 90%
5-Interior		90% ≤ FAD < 100%
6-Intact		FAD = 100%

FAD-APP 5-class	Color	FAD range
1-Rare		FAD < 10%
2-Patchy		10% ≤ FAD < 40%
3-Transitional		40% ≤ FAD < 60%
4-Dominant		60% ≤ FAD < 90%
5-Interior		90% ≤ FAD ≤ 100%

FAD-APP 2-class	Color	FAD range
1-Separated		FAD < 40%
2-Continuous		40% ≤ FAD ≤ 100%

Figure 1: Summary of FAD/FAD-APP fragmentation class thresholds, names, and color assignment. FAD is a per-pixel classifier while FAD-APP summarizes the average density value per patch.

In the next step, and for each of the five observation maps, the proportion of forest pixels in each fragmentation class is calculated and summarized in a bar plot showing forest fragmentation over observation scale. Here, the observation scales are labelled as 1, 2, 3, 4, 5 corresponding to window lengths 7, 13, 27, 81, 243 pixels, respectively. In addition, summary fragmentation statistics are saved as a text-file and a csv-file to allow for further analysis in a spreadsheet application.

Finally, the five fragmentation maps are aggregated into a summary map, showing the average FAD value calculated over all 5 observation scales, which is displayed color-coded into the respective fragmentation class (see Figure 3).

2.2 The input data:

The input image for the FAD analysis must be a binary raster map. It must have the values 1 byte for background (non-forest) and 2 byte for foreground (forest). All background data pixels will fragment the foreground.

Optionally, the input can have the values:
0 byte – missing data: These pixels will show in white color in the output image.
3 byte – specific background: These background pixels (e.g. water) will show in dark blue color in the output image.
4 byte – non-fragmenting background: In contrast to all other background pixels these background pixels will not have a fragmenting effect on the foreground. These pixels will show in light blue color in the output image.

Note: Because input data pixels with 4 byte do not have a fragmenting effect, changing background to non-fragmenting background will lead to a reduction of foreground fragmentation and consequently change the fragmentation statistics.

2.3 The output data:

The result of the FAD analysis is a set of images and documents featuring:

1. Six categories of forest fragmentation in decreasing order from Intact to Rare forest.
2. Statistical summary indices at five different observation scales and a multi-scale assessment across all five individual observation scales.
3. Geographic maps of fragmentation categories at five observation scales + multi-scale.

The next section will illustrate the FAD methodology on an example map located in the north of Finland and derived from CORINE 2012 land cover data.

3. Example application

This section illustrates features and output examples of the FAD fragmentation assessment scheme using an example forest map in the North of Finland, derived by recoding CORINE Land Cover 2012 data having a spatial resolution of 100 m. The methodology can be applied in the same way for any other definition of a forest map and at local, regional, or national scale. The example below is just indicative to show the features of FAD.

All image processing (cutting the sample area from the CORINE 2012 data in the North of Finland, recoding to the FAD input masks (option A, B, C below), and FAD processing (6 seconds for each map) was done in GuidosToolbox. The following images are screen snapshots.

The following summary describes three options for conducting a FAD fragmentation analysis.
Option A = the standard case of analyzing a forest mask.
Option B = Option A + assigning *specific background* (3 byte) to visually focus on the interaction of this specific background and the foreground fragmentation.
Option C = Option A (or B) + assigning *non-fragmenting background* (4 byte) to land cover that will not be included in the calculation of foreground fragmentation (it will be treated the same as other missing data).

Option A: Using a forest map

In option A, the forest map is derived by recoding the CORINE classes as follows:

CORINE class	FAD input value (byte)
0, 48-50 (no data or unclassified)	0 - Missing
1 – 22, 26 – 44 (artificial, agriculture, wetlands)	1 - Background
23, 24, 25 (forests)	2 - Foreground

Table 1: Recoding from CORINE land cover to a custom forest map.

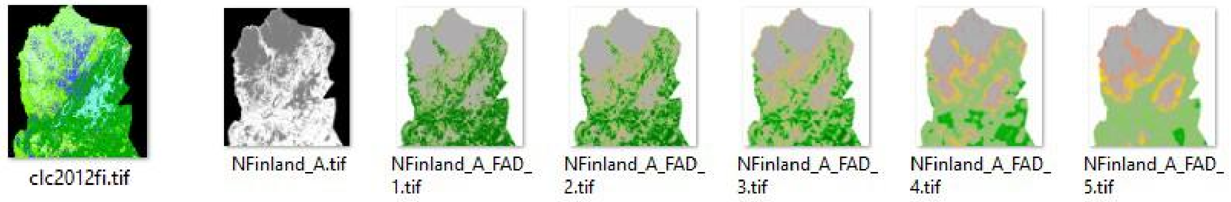


Figure 2: CORINE 2012 land cover and forest mask in the North of Finland (left) and fragmentation maps at five increasing (local to regional) observation scales.

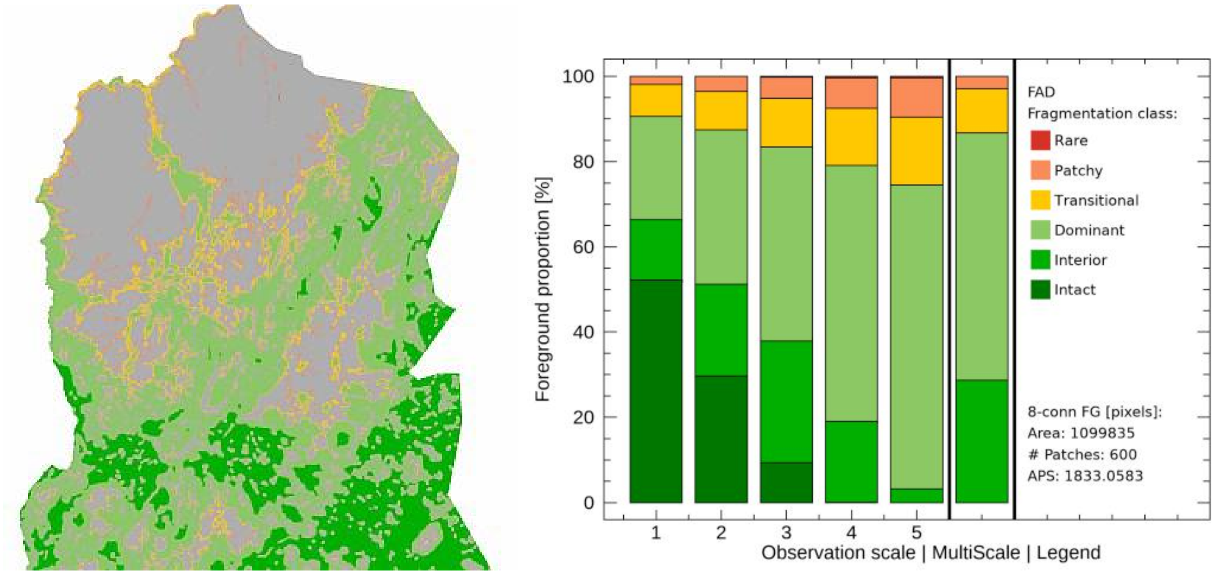


Figure 3: Aggregated (multi-scale) map of fragmentation classes over five observation scales (left) and bar plot of summary statistics (right) including total amount of forest area, number of forest patches and average patch size.

From the map images in Figure 2, one can see the degree of forest fragmentation at any given observation scale or in Figure 3, aggregated across all 5 observation scales (multi-scale summary). The grouping in six fragmentation classes allows locating hotspots of highly fragmented forest areas (*Rare forest* – red color) or any other fragmentation classes like *interior forest*, where the forest area density is greater than 90 % (darker green). The bar plot in Figure 3 and the statistics in Table 2 summarize the forest fragmentation analysis in tabular format.

```
FAD: Foreground Area Density summary analysis for image:
C:\GuidosToolbox\data\NFinland_A.tif
================================================================================
8-conn FG: area, # patches, aps [pixels]: 1099835, 600, 1833.0583
Fragmentation class: foreground proportion at observation scale/area:
Observation scale:     1          2          3          4          5         mscale
Neighborhood area:    7x7       13x13      27x27      81x81     243x243
================================================================================
        Rare:       0.0033     0.0242     0.2450     0.3786     0.3976     0.0186
      Patchy:       1.9327     3.5649     4.9045     7.1666     9.1789     2.8774
Transitional:       7.5076     8.9589    11.3673    13.3002    15.8747    10.3957
    Dominant:      24.1627    36.2559    45.5856    60.1687    71.3635    58.0553
    Interior:      14.1438    21.5234    28.4999    18.8959     3.1853    28.6529
      Intact:      52.2498    29.6727     9.3977     0.0900     0.0000     0.0000
================================================================================
      FAD_av:      88.4863    83.7177    78.7418    72.7682    67.8558    78.3146
```

Table 2: Statistical summary table (provided in txt and csv-format) showing percent of fragmentation classes at the five observation scales and for the multi-scale analysis.

Option B: Using a forest map + specific background (3 byte)

In option B, the forest map is derived by recoding the CORINE classes as follows:

CORINE class	FAD input value (byte)
0, 48-50 (nodata or unclassified)	0 - Missing
1 – 22, 26 – 34 (artificial, agriculture, scrub)	1 - Background
23, 24, 25 (forests)	2 - Foreground
35 – 44 (wetland, peat bogs, marshes, water)	3 - Specific Background

Table 3: Recoding from CORINE land cover to a custom forest map, including the optional class *Specific Background* (3 byte).

Motivation/Purpose: A user may be interested to highlight a specific background type, for example, wetland & water bodies to investigate the forest fragmentation near to that specific background. Specific background is displayed in dark blue color in the resulting map allowing to easily see the degree of forest fragmentation in the vicinity of the selected specific background, here wetlands.
In a similar fashion, one could assign urban as specific background to investigate forest fragmentation near urban areas, and then do the same for agriculture, then compare fragmentation near urban with fragmentation near agriculture.

Note: The additional input class *specific background* has no effect on the foreground fragmentation and the fragmentation statistics. The effect is only visual: a specific part of the background is displayed in dark blue in the resulting maps. The forest coverage and fragmentation classes are identical in Figure 4.

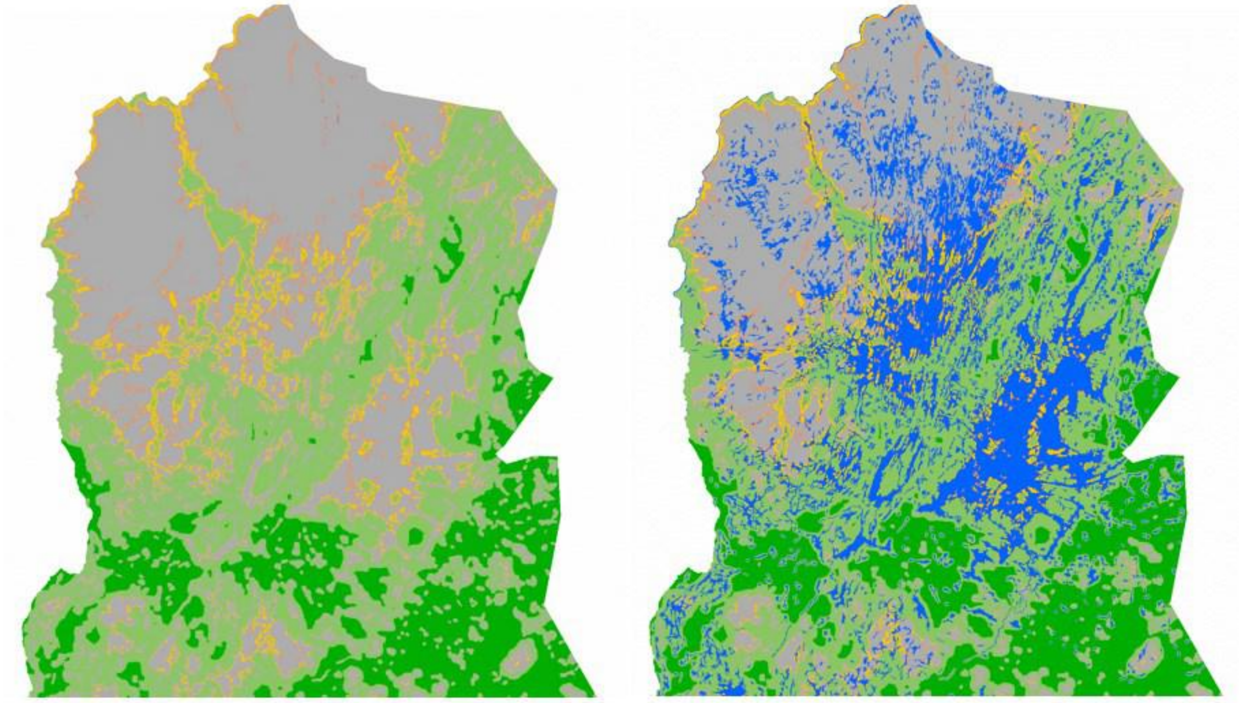


Figure 4: Aggregated forest fragmentation map from Option A (left) and from Option B (right) with specific background (wetlands and water bodies) highlighted in dark blue.

Option C: Using a forest map + non-fragmenting background (4 byte)

In option C, the forest map is derived by recoding the CORINE classes as follows:

CORINE class	FAD input value (byte)
0, 48-50 (nodata or unclassified)	0 - Missing
1 – 22, 26 – 34 (artificial, agriculture, scrub)	1 - Background
23, 24, 25 (forests)	2 - Foreground
35 – 39 (wetland, peat bogs, marshes)	3 - Specific Background
40-44 (water bodies)	4 - Non-fragmenting Background

Table 4: Recoding from CORINE land cover to a custom forest map, including the optional class *Specific Background* (3 byte) and *Non-fragmenting Background* (4 Byte).

Motivation/Purpose: A user may wish to assign a certain background type to not have a fragmenting effect on foreground. For example, water bodies within forests could be an integral part of forests and as such they should not fragment continuous forest areas. Such a setup can be achieved by setting the related non-fragmenting background pixels in the input image to the value 4 byte (Table 4). With this setting, the amount of fragmenting background is reduced and foreground near to non-fragmenting background will no longer be fragmented.
With Option C, the user can fine-tune the fragmentation analysis for any type of background. For example, one could assign lakes to not fragment forests (4 byte) while rivers will fragment forests (3 byte). In a similar fashion, and in a mountainous area, one could assign rock formations to 4 byte to ensure they will not fragment the forest cover.

Note: The use of the additional input class *non-fragmenting background* has two effects:

a) Visual – the related part of the background is displayed in light blue color.
b) Data – compared to Option A and B, Option C will change the foreground fragmentation, classes and statistics because a part of the background is now assigned to be non-fragmenting. However, the total amount of forest area is the same in all three options.

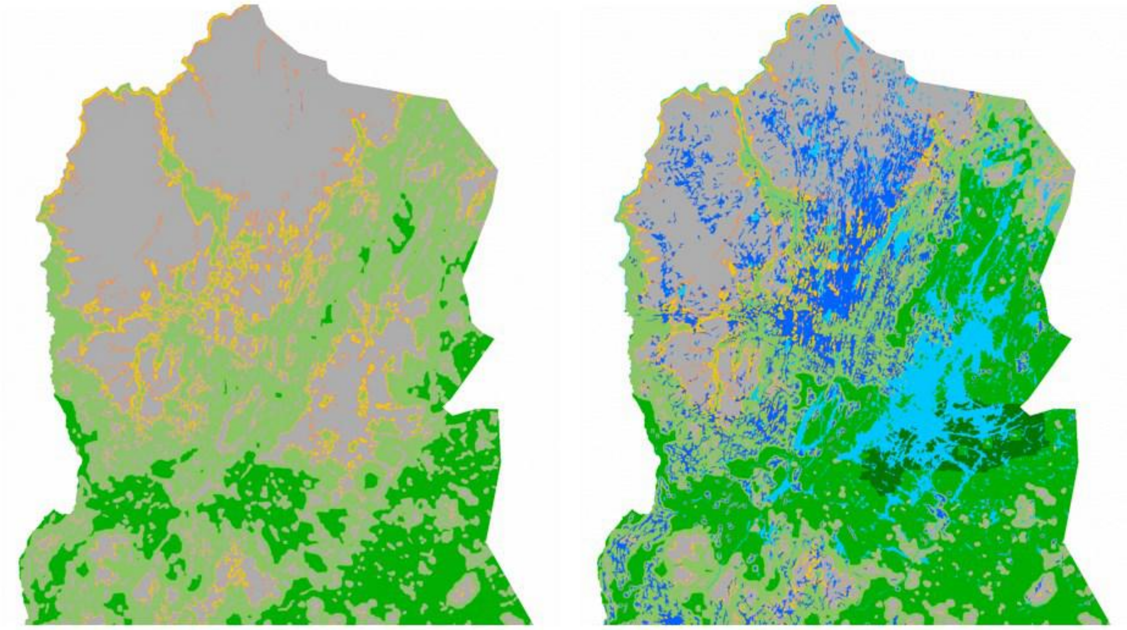


Figure 5: Multi-scale forest fragmentation map from Option A (left) and from Option C (right) with *specific background* (wetlands) highlighted in dark blue and *non-fragmenting background* (water bodies) highlighted in light blue. In the image on the right, note the difference in forest fragmentation in the vicinity of water bodies that were set to have a non-fragmenting effect on forest cover.

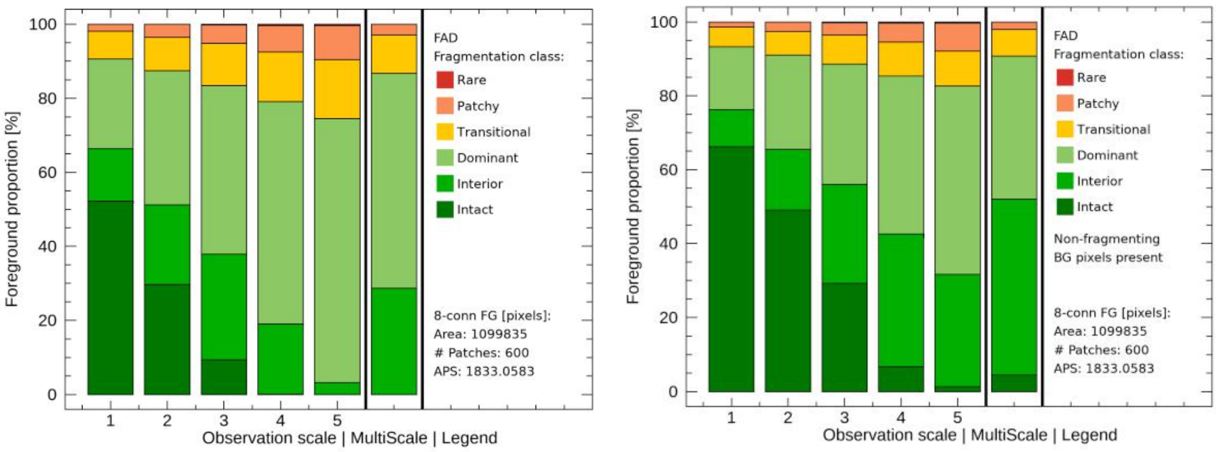


Figure 6: Fragmentation class bar plot summary from Option A (left) and from Option C (right), where the presence of non-fragmenting background changes the statistics of the forest fragmentation classes.

4. Fragmentation change analysis

A dedicated fragmentation change analysis scheme will compare two data sets of FAD. The input data sets must have the same geographic meta-data and cover the same area. All changes are summarized in a bar-plot image and further detailed in observation-scale specific summary statistics provided in txt and csv-format. The features of the fragmentation change analysis are illustrated on a sample forest mask of Slovakia derived from CORINE 2000 and CORINE 2012.

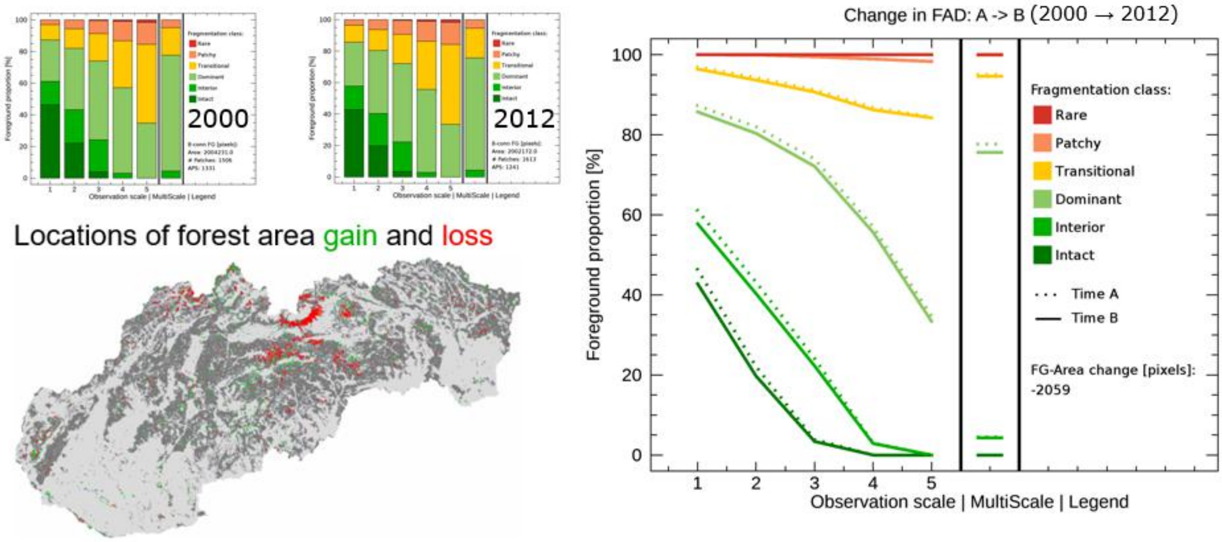


Figure 7: Top left: Fragmentation classes bar plot summary for Slovakia in the year 2000 and 2012. Bottom left: Morphological change analysis showing locations of forest area gain and loss. Right: Changes in the proportions of forest fragmentation classes for the year 2000 and 2012 for each observation scale and the multi-scale assessment.

# pixels	B0-Background	B1-Rare	B2-Patchy	B3-Transitional	B4-Dominant	B5-Interior	B6-Intact
A0-Background	2769270	232	22492	41064	61309	2500	0
A1-Rare	18	131	98	0	0	0	0
A2-Patchy	6819	29	76506	14764	217	0	0
A3-Transitional	22052	0	7069	272923	47079	13	0
A4-Dominant	97084	1	2038	50132	1292332	24524	0
A5-Interior	3683	0	0	270	28145	58304	0
A6-Intact	0	0	0	0	0	0	0
Gross area gain (Class A0 -> Class B1-B6): 127597 pixels							
Gross area loss (Class A1-A6 -> B0): 129656 pixels							
Net area change (A->B): -2059 pixels							

Table 5: Transition matrix of forest area changes in fragmentation classes in the year 2000 (A) to the year 2012 (B) for the multi-scale summary image. The bottom part shows a summary of forest area gain, loss and net change. Fragmentation increase is found within the triangle outlined with the full orange line and fragmentation decrease within the triangle outlined with the dotted orange line.

The first table in the summary statistics (Table 5) shows the number of pixels being in one of the six FAD-classes or in the background at time A and at time B. Missing pixels at time A and/or time B are excluded from the change analysis. If the area of a pixel is known and constant throughout the image (equal-area projection) then the number of pixels multiplied by the pixel-area corresponds to actual area measures. For example, in the case of using CORINE data 1 pixel = 1 hectare. The gross area gain equals to the number of pixels changing from background at time A to any foreground class at time B. Similarly, gross area loss equals the number of pixels changing from any foreground class at time A to background at time B. The net area change is the sum of gross area gain and gross area loss. Entries along the diagonal of the transition matrix show the amount of forest which is in the same fragmentation class at both times. Matrix entries below the diagonal (full orange line triangle) correspond to an increase in fragmentation where the original fragmentation class of a given forest pixel in the year 2000 has changed to a higher fragmentation class in the year 2012. Similarly, entries within the dotted orange line triangle correspond to a decrease in fragmentation.

Table 5 allows making statements on area changes in fragmentation classes and forest cover changes. For example, 50132 hectare of forest changed from the fragmentation class *Dominant* in 2000 → *Transitional* in 2012; 217 hectare of *Patchy* forest turned into *Dominant* forest in 2012. Or, in the period from 2000 to 2012 we found a gross area gain of 127597 hectare and a gross area loss of 129656 hectare leading to a net forest area change of -2059 hectare.

% change A->B	B1-Rare	B2-Patchy	B3-Transitional	B4-Dominant	B5-Interior	B6-Intact
A1-Rare	0	-0.11304	0	0	0	0
A2-Patchy	0.033073309	0	-17.029817	-0.25030279	0	0
A3-Transitional	0	8.0619041	0	-54.30417	-0.0149951	0
A4-Dominant	0.001140459	2.3242553	57.173487	0	-28.287675	0
A5-Interior	0	0	0.30792391	32.098216	0	0
A6-Intact	0	0	0	0	0	0

Table 6: Transition matrix of relative changes in forest fragmentation classes in the year 2000 (A) to the year 2012 (B). Fragmentation increase is found within the triangle outlined with the full orange line and fragmentation decrease within the triangle outlined with the dotted orange line.

The second table in the summary statistics (Table 6) shows the *relative* changes within the foreground only and normalized to each, fragmentation increase and decrease. Entries along the diagonal of the matrix are zero because these entries correspond to pixels being in the same class at time A and B, equivalent to no change. Matrix entries below the diagonal represent fragmentation increase expressed with positive percentages. Fragmentation decrease is expressed with negative percentages and found above the matrix diagonal. With this setup, the second table shows the relative contribution of each possible fragmentation class change separate for each fraction change type, fragmentation increase and fragmentation decrease.

Table 6 allows making statements on relative changes in fragmentation classes. For example, 32% of all fragmentation increase is found for *Interior* to *Dominant*. Or, 17% of all fragmentation decrease is found for the transition of *Patchy* forest in 2000 into the less fragmented class *Transitional* in 2012.

Note: The example above showed results for the multi-scale analysis only. Fragmentation change analysis consists of six files: the multi-scale change analysis shown above plus a corresponding set for each of the five individual observation scales.

5. FOS: Fragmentation analysis at a fixed observation scale

The Fixed Observation Scale (FOS) analysis calculates fragmentation as a function of the foreground area density, equivalent to FAD but at a user-selected observation scale, a setup chosen by UN-FAO (chapter 2) to measure *Forest Intactness and Fragmentation* (see also Vogt et al., 2019a).
In this mode, the user can define the observation scale by specifying the pixel resolution (in meters) and the edge length of the square moving window (observation scale) in a GUI:

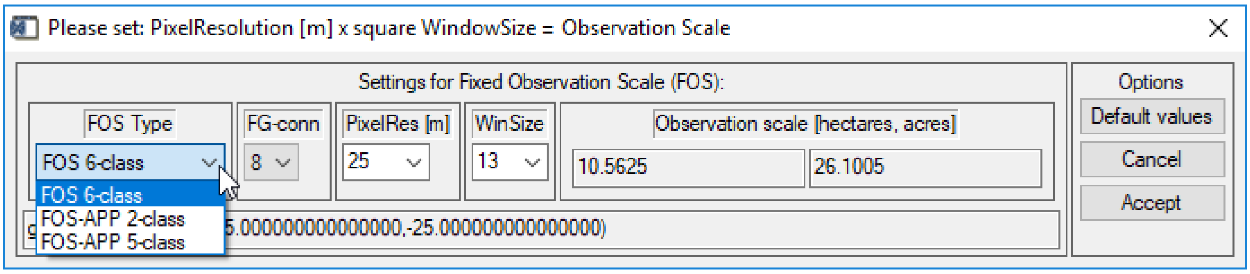


Figure 8: FOS GUI: Via the three entry fields on the left the user can set the analysis type, the spatial pixel resolution and the moving window size to define a specific observation scale (here 10 hectare) for the Fixed Observation Scale (FOS) fragmentation analysis.

The user-selected settings are then used to calculate the area of the moving window (observation scale), which is displayed in hectares and acres. The bottom panel of the GUI provides information on the pixel size retrieved via the *gdalinfo* command. The image above shows a combination of pixel resolution and window size resulting in an observation scale of ~10 hectares. The user can choose settings from the drop-down menu or insert custom values, followed by the Enter key. After the definition of the user-selected observation scale, click on *Accept* to apply this scale for the fragmentation analysis.
A FOS change analysis can be conducted in the same way as outlined for FAD in section 4 above.

6. FAD/FOS-APP

The previous section described measuring foreground area density over each foreground pixel using a specific square neighborhood window. As a result, the map product shows a variable density distribution within a given patch. This feature may be of interest to differentiate intact areas from less intact areas inside larger patches. In general, and by definition, a per-pixel moving window assessment scheme will assign low density values to pixels along the patch boundary. Users preferring to see a single and constant density value for each patch may select the option APP (Figure 1, 8). Here, the density values of all pixels of a given patch are used to calculate the *Average density Per Patch* (APP), which is then re-assigned to all pixel values of the given patch. In addition, and with APP being designed as a more simplified version of the original FAD/FOS, the number of color-classes is reduced to either five or two, using a threshold of 40% in density to distinguish *Separated* (fragmented, dark-green) from *Continuous* (non-fragmented, light-green) foreground cover, a setup chosen by Forest Europe for the definition of indicator 4.7 *Forest Fragmentation* (Vogt et al., 2019a).
Compared to the original FAD/FOS the classifier APP applies the average per patch density and uses a different color-table only. As with FAD/FOS, the APP option provides actual density

values in [1, 100] %, just averaged by patch. Figure 8 illustrates this fact when switching from the 2-class *FAD APP* color-table to the default *FAD* color-table.

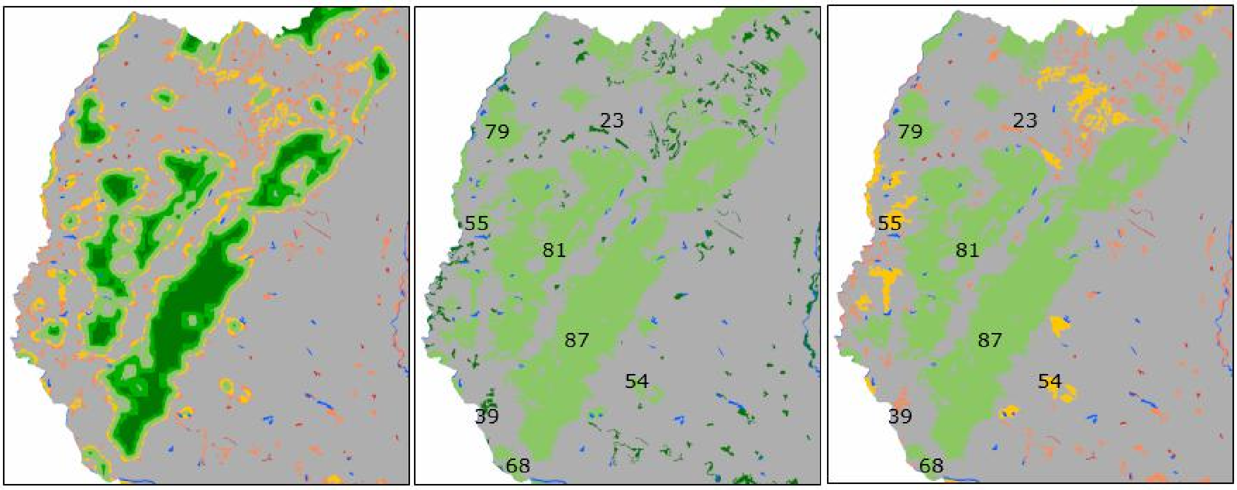


Figure 8: Forest density in the western part of Slovakia, CORINE 2012, and observation scale 23x23 pixels ~ 529 ha.
Left: FOS 6-class showing per-pixel density and the default 6-class FAD color-table (Figure 1).
Center: FOS-APP 2-class showing per-patch average density and 2-class FAD-APP color-table.
Right: Same as center panel but applying the FAD-APP 5-class color-table. The center and right panel include average per patch (APP) density values for some selected patches.

7. Discussion

This document describes a methodology for reporting state and trends of forest fragmentation. The approach is based on measuring forest area density (FAD) at five different observation scales and a multi-scale summary. The FAD/FOS concept assures to simultaneously measure key aspects of fragmentation including, the amount of forest, the area of continuous forest cover, perforations inside forest patches, patch shape and linear features, and the distance between individual forest patches.
An optional subsequent fragmentation change analysis provides details and a statistical summary on forest gain, loss and fragmentation class changes over time.

The FAD/FOS forest fragmentation assessment and change analysis scheme provides:

- **Generic concept:** The methodology is based on geometric principles only. As such, it can be applied to any kind of forest raster maps, independent of the definition of forest and the spatial resolution of the forest map. In contrast to many existing fragmentation schemes, the outlined methodology provides quantitative measures and is not necessarily a descriptive measure for a specific faunal species.

- **Fragmentation at different scales:** Fragmentation is perceived different at different scales, or a given landscape has a different degree of fragmentation for any given species living in that landscape. For example, the same forested landscape may be highly fragmented for a bear but not fragmented for a small bird. With reporting fragmentation at multiple scales, foresters can make their own choice and decide which scale best suits their field of application.

- **Fragmentation classes:** The intuitive naming scheme (see Figure 1) can be easily communicated and has a direct relation to habitat and biodiversity related studies. Reporting *Interior* for illustration in tables and maps may be of interest because the literature indicates FAD above 90% is a reasonable threshold for core habitat. Reporting *Dominant* may be interesting because it describes transitions from mostly forested to patchy forest landscapes. Fragmentation classes show the degree of forest fragmentation derived from a *measured* range of forest area density within [0, 100] %. Researchers will probably consult the more detailed per-pixel density distribution map while policy makers may prefer the simplified 2-class version with a clearer focus on fragmented versus continuous land cover.

- **Fragmentation statistics and change:** The bar plot graph and the text/csv-file provide summary statistics in a tabular format. These statistics provide a concise summary on the state of forest fragmentation as well as details on changes of forest area and fragmentation classes over time.

- **Fragmentation maps:** The map product provides additional spatial information, which cannot be retrieved from indices and statistics: A geographic map of fragmentation classes is not only visually appealing but it permits localizing hotspots of fragmentation, which is a crucial information for planning and risk assessment. Moreover, comparing maps over time can show where and how much fragmentation has decreased/increased or where it has not changed. This information is an essential requisite to localize and measure temporal changes in fragmentation. It can also be used to measure progress or the overall effectiveness of political directives; for example, and in the case of afforestation, where the forest cover has changed from the fragmentation class *Transitional* to *Dominant*.

- **Communication:** The intuitive class names can be easily communicated and provide a clear message on a complex topic. The assessment of fragmentation is of key interest in a variety of land cover planning measures, impacting biodiversity and other environmental indicators and contributes to answering questions like:
  - **State Analysis:** How high is the degree of fragmentation in different administrative units/counties or ecological regions of the country?
  - **Trend Analysis:** Where and how much has fragmentation changed over the past decades? How are the trends? What can be expected for the future?
  - **Monitoring & Assessment:** How strong was the impact of a specific political directive or planning program in the targeted area? How big is the change outside of the monitored region? Does the result of the program merit the money spent? With these findings, what are the implications for future planning and which areas should be targeted next?

7. Conclusions

The outlined fragmentation change analysis and FAD/FOS itself is available in the free JRC software *GuidosToolbox* as one option for forest fragmentation analysis.

With the outlined setup, and the availability in a free software, each user can test the FAD/FOS methodology and its settings on their own data. Additional comments:

- A *forest - nonforest raster map* as described in this document is of generic nature. It can be derived from any source such as airborne or satellite or National Forest Inventory data, rasterizing a vector map, or plot data.
- The definition of *Forest* can be based on land *use* or actual land *cover.* For example, non-stocked forested land can still be defined as Forest even if it appears as non-forest in satellite scenes.
- The user can customize the analysis by assigning dedicated non-forest land cover to *not* have a fragmenting effect on forests, e.g., lakes or small rock formations within forests.
- The user can switch between a detailed per-pixel 6-class analysis, or a per-patch averaged 2- or 5- class analysis.

The software can be downloaded and used by anybody and for any kind of analysis. All data analysis schemes in GuidosToolbox are based on geometric principles, which permits processing forest maps of any kind, independent of the definition of forest and/or the spatial resolution. In addition to fragmentation, GuidosToolbox provides dedicated routines for spatial mapping and quantification of pattern, object analysis, distance and other aspects derived from land cover maps.
Further information is available in related product sheets available on the GuidosToolbox homepage.

References:

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