FunDivEUROPE

Functional significance of forest biodiversity in Europe

Project number: 265171

Soil water content

FunDivEUROPE (FP7) field protocol

V1.0

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Content

1 Introduction

This protocol deals with the measurements necessary to estimate quantity and quality of drinking water production with the help of hydrological models. Due to the high work load to obtain the necessary parameters 10 plots per focal region of the Exploratory Platform will be selected, creating a total of 60 highly instrumented plots (HIPs). Table 1 gives an overview of the surveys conducted on each selected HIP. The surveys can be divided in four subgroups:

- Survey on seasonal variability (chapter 2);
- Survey on spatial variability (chapter 3);
- Survey on precipitation and deposition with precipitation (chapter 4);
- Soil survey (chapter 5).

Measurements of seasonal variability entail high costs since the measurements have to be repeated in short intervals. Automatic probes and data loggers are necessary for those measurements, whose high costs make sufficient repetitions to represent the within plot variability inefficient. It is therefore necessary to complete the surveys on seasonal variability with surveys on spatial variability, to account for the high variability in space of hydrological properties. The second set of surveys (Survey on spatial viabilities (chapter 3) will just be conducted once. Those surveys will give sufficient information to calibrate the seasonal measurements to gain plot representative estimates.

For parameterisation of hydrological models additional information on precipitation and soil properties are necessary. It is indispensable to measure precipitation on a resolution of at least 30 min. To get the necessary information on soil properties a soil profile will be examined and soil cores sampled for analysis in the laboratory.

To evaluate the influence of the ecosystem on the quality of the ground water it is also necessary to know the element input with precipitation.

Table 1: Surveys included in the task "Freshwater provisioning and water quality".

Survey	see Chapter
Seasonal variability of soil moisture at the depths of 15 and 50 cm	2
Spatial variability of soil moisture at the depths of 15, 30 and 50 cm	3
Seasonal variability of element concentrations in the soil solution at a depth of 50 cm	2
Spatial variability of element concentrations in the soil solution at a depth of 50 cm	3
Open space precipitation	4
Element deposition with precipitation in open space	4
Crown cover at all sample points	3
Soil texture at all sample points	3
Skeletal fraction at all sample points	3
Ground vegetation cover at all sample points	3
Soil survey including the organic layer and the first 60 cm of mineral soil at sample points were seasonal variability are measured	5
Hydrological properties of the soil	5

2 Survey on seasonal variability

2.1 Introduction

This part of the protocol deals with the survey on the seasonal variability of soil moisture and element concentration in the soil solution. For this purpose a permanent station will be installed on each HIP. The permanent station will include two automatic probes in 15 and 50 cm and one data logger for the survey on soil moisture and a suction cup unit sampling soil solution in 50 cm.

2.2 Objectives

Objective of this protocol is the measurement of the seasonal variability of the soil moisture and the element concentration of the soil solution.

2.3 Sampling scheme

The permanent station will occupy approximately 1.5 x 2 m (see fig 1). It is crucial that it is placed in a crown gap because the crown cover is a major force influencing the spatial

variability of both parameters. By placing the permanent station in a crown gap the comparability between the HIPs can be ensured.

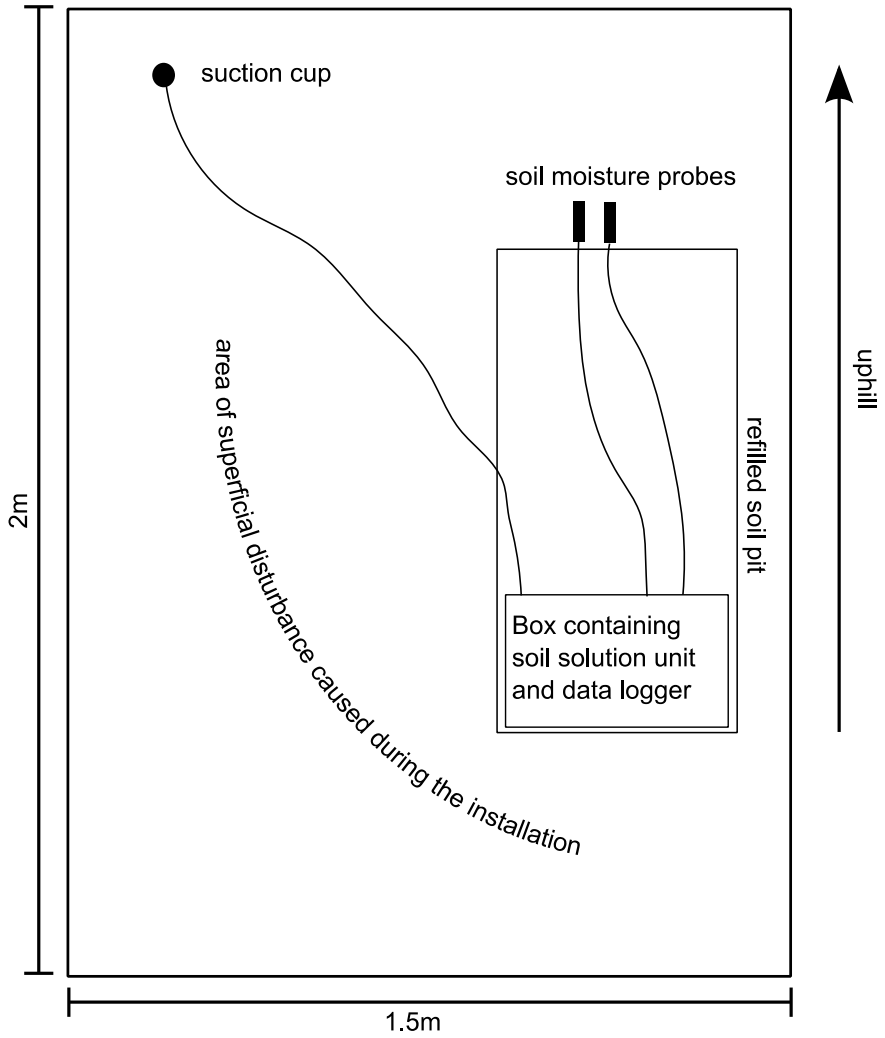

Figure 1: Design of the permanent station.

2.4 Equipment

Table 2: Equipment

Amount	Description	Supplied by
1/plot	Soil solution unit	FVA
2/plot	soil moisture probes	FVA
1/plot	data logger	FVA
3m/plot	corrugated pipe	FVA
1/ecoregion	digging tools	local team
1/ecoregion	plastic tarpaulin (≈ 2x2m)	local team

Installation of the soil solution unit and the soil water content probes

A soil profile will be dug approximately 50 cm wide 100 cm long and 70 cm deep. At the beginning the organic layer with the herb layer will be carefully removed so that the layer can be put back after refilling the pit. All the material dug out will placed on a plastic tarpaulin, this reduces the damage done to the spot where the soil will be placed temporally.

When the soil profile is dug the soil moisture probes will be inserted in the ground (detailed instructions will be delivered by the FVA together with the probes). The whole cable of the probes will be inserted in the corrugated pipe to protect it from rodents. Close to the connectors the cables will be marked with coloured tape to enable the technicians to identify the probes after the soil pit is closed.

Then the soil pit will be closed and the box containing the logger and the soil solution unit dug in so that 2/3 of the box is in the soil. This is important to ensure that the soil solution will not overheat during the sampling. Finally the organic layer with the herb layer will be placed on top of the soil pit. The suction cup will be installed the same way as the mobile suction cup device (see chapter 3). The tube of the suction cup has also to be protected with corrugated pipe.

Finally the area were no further disturbance can be tolerated has to be marked with rods and barrier tape. This area includes the face of the soil pit were the probes are installed and the place where the place of the permanent suction cup.

2.5 Frequency of sampling

2.6.1 Soil solution

The soil solution will be sampled every second week. In case there is less than 50 ml soil solution in the collecting bottle the soil solution will not be collected. In this case just the approximate amount is noted in the field protocol.

2.6.2 Soil moisture

Each soil moisture probe will log one measurement every 30 min. Every second week the logger will be read out.

2.6.3 Sampling of soil solution

The amount of soil solution in the sampling bottle will be noted at an accuracy of +/- 50 ml. If there is less than 50 ml the soil solution will not be collected. The soil solution will be filled from the sampling bottle in a clean polyethylene bottle and placed in a cooling box immediately. Attention has to be paid that no surfaces getting in contact with the soil solution will be touched with the finger to avoid contamination of the sample (Tiny amounts of sweat are changing the samples considerably). The samples in the polyethylene bottles will be stored in a refrigerator until the samples of all 10 plots in a region are collected. Every second week the samples will be shipped by mail in a cooling box to the laboratory of the FVA.

3 Survey on spatial variability

3.1 Introduction

This protocol deals with the surveys on spatial variability of soil moisture and element concentration of the soil solution (see also chapter 2.1). Since both parameters are strongly influenced by the crown cover, the soil texture, the skeletal fraction and the ground vegetation cover, it is crucial to assess these parameters as well to be able to estimate their influence and deduce the remaining variability which is caused by other parameters.

3.2 Objectives

Objective of this part of the protocol is the measurement of the spatial variability of the following parameters:

- Soil moisture;
- Element concentration in soil solution;
- Additional explaining parameters:
    - Crown cover;
    - Soil texture;
    - Skeletal fraction;

- Cover of ground vegetation.

3.3 Sampling scheme

Figure 2 shows the sample scheme. Table 3 shows at which depths the surveys are conducted.

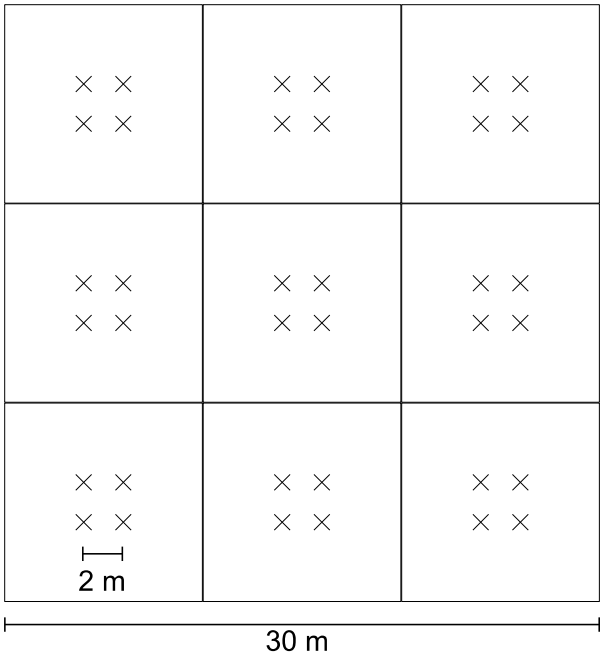

Figure 2: Sampling scheme.

Table 3: Depths at which the surveys are conducted.

survey	**depth of survey**	**point of origin**
soil moisture	15, 30, 50 cm	mineral soil
soil solution	50 cm	mineral soil
crown cover	>1,5 m	organic soil
soil texture	15, 30, 50 cm	mineral soil
skeletal fraction	0-15 cm	mineral soil
cover of ground vegetation	<1,5 m	organic soil

3.4 Equipment

Table 4: Equipment.

Amount	Description	Supplied by
1	Mobile soil moisture probe	FVA
1	soil auger and hammer	FVA
1/plot	Mobile suction cup device (MSCD)	FVA
1/ecoregion	auger, pipe, stick, hand pump	FVA
1/ecoregion	hammer	local team
1/plot /sample interval	polyethylene bottles	FVA
1/ecoregion/sample interval	cooling box with cooling element (mailing)	FVA
1/ecoregion	cooling box with cooling element (transportation)	FVA
1/ecoregion	refrigerator	local team
	deionised water	local team
1	digital camera with tripod and bubble level	FVA
1	Hand auger and hammer	FVA
1	spade	FVA
	soil sample paper bags	FVA

3.5 Frequency of measurements

3.5.1 Soil moisture

The measurements will be conducted once on each plot. To carry out all measurements one or two day will be needed. The time of the field campaign will be in the main rain season since most ground water will be produced during this period. Spatial variability of soil moisture is of minor importance.

3.5.2 Soil solution

Since sampling of soil solution needs expensive equipment and the extraction needs several days it is not possible to conduct this survey in a single campaign, but sampling will continue over a whole year. Sampling starts in 3rd quarter of 2011 after the introduction by the FVA technician and proceeds till end of 2012. Every second week the mobile suction cup device (MSCD) will be relocated to a new sampling point in each plot. The soil solution will be collected 3 – 5 days after relocating the MSCD.

3.5.3 Additional explaining parameters

All measurements will be conducted once. The soil texture will be estimated when the soil moisture is measured. The other additional measurements will be conducted the day after.

3.6 Measurements and sample collections

3.6.1 Soil moisture

At each sample point a 50 cm deep hole will be drilled with the help of a soil auger. The hole will be placed approximately 20 cm from the marking rod and has a diameter of approximately 3.5 cm. The distance and direction from the marking rod to the hole will be noted in the field protocol at an accuracy of 5° and 5 cm. After the hole is drilled the probe will be inserted and the soil moisture measurement conducted. The soil extracted by the soil auger will be used to estimate the soil texture see chapter 5.

3.6.2 Soil solution

Every second week the MSCDs will be moved to another point according to the delivered random chart (please note that not the spatial distribution of the points is random but the order in which the points will be sampled). The suction cup will be placed approximately 20 cm from the sampling point marking rod and other rods marking previous measurements. The direction and distance from the marking rod to the sample point will be measured at an accuracy of 5° and 5 cm.

At the selected plot the organic soil will be cleaned in an approximate diameter of 10 cm. It is very important that during the installation process no organic matter is displaced into the subsoil. If this happens, the soil solution will be altered considerably.

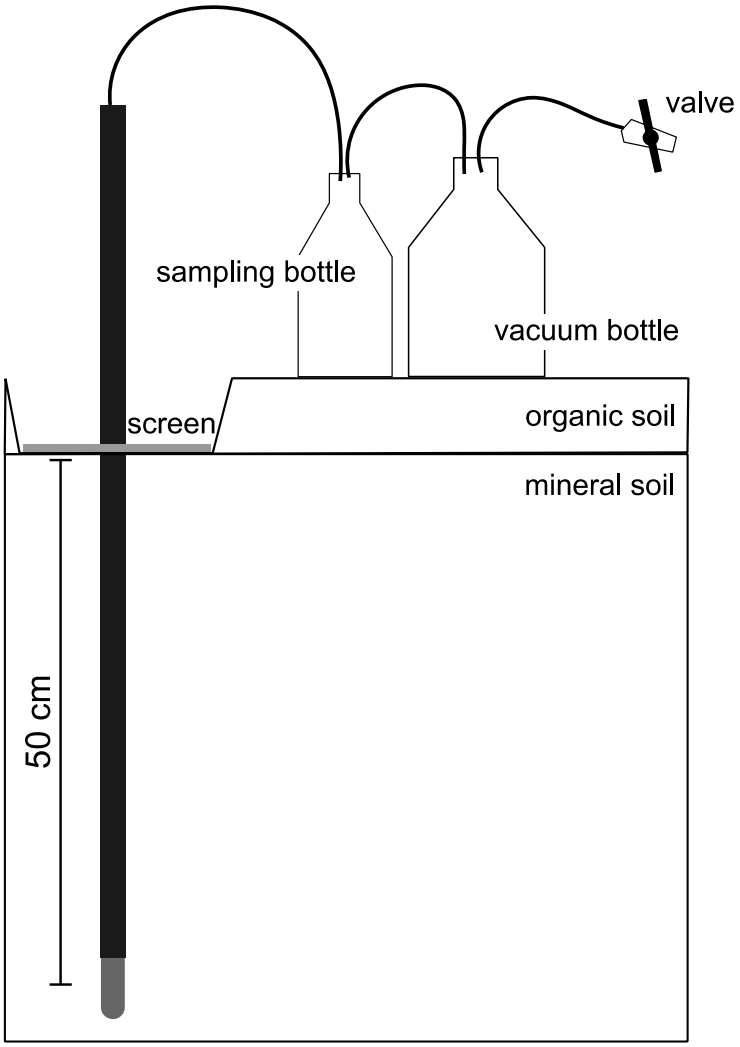

Figure 3: Design of mobile suction cup device (MSCD)

With the help of an auger a hole will be drilled. Then the pipe will be inserted. From the auger a bit of soil from the depth of 50 cm will be extracted and stones removed from the soil. The soil will then be put into the pipe and flushed with some deionised water. A stick will inserted into the pipe and while holding the stick in position, the pipe will be pulled out of the hole. Then the stick will be removed. Now the suction cup will be inserted into the hole. The screen at the suction cup will be placed to the surface of the mineral soil to avoid that rain water will run down the suction cup and thus changes the soil solution. After the suction cup is installed the vacuum bottle will be deflated to a pressure of 0.5 bar with the help of a hand pump.

3 – 5 days later the sample will be collected. If there is less than 50 ml, the soil solution will be discarded. The amount of soil solution in the sampling bottle will be noted at an accuracy of +/- 50 ml. The soil solution will be filled from the sampling bottle in a clean polyethylene bottle and placed in a cooling box immediately. Attention has to be paid that no surfaces getting in contact with the soil solution will be touched with the finger. The samples in the

polyethylene bottles will be stored in a refrigerator until the samples of all 10 plots in a region are collected. Every second week the samples will be shipped by mail in a cooling box to the laboratory of the FVA. The sample bottle will be taken to the station to be rinsed with deionised water; the rest of the MSCD can be left in the field until the next sample interval.

When removing the suction cup from the soil to relocate it, it has to be done very gentile to avoid that the head of the suction cup is breaking of and is lost in the soil.

Immediately after removing the suction cup from the soil a rod will be inserted in the hole to mark the spot of disturbance to avoid that other measurements will be conducted on the same spot leading to biased results. The rod should be colour-coded or have flag attached to identify the spot as being part of the soil solution measurement under this task.

3.6.3 Additional explaining parameters

The crown cover will be mapped with a common digital camera. The camera will be mounted on a tripod and assure the correct adjustment. The photos have to be taken in the morning or in the evening. As long as there are no extreme weather events the photos can be taken any time. The digital photos will be analysed automatically with R scripts written exclusively for this purpose.

The ground vegetation will be mapped with a digital camera perpendicular from above if possible. If the vegetation is too high the photos will be made from the side. The photos will be classified manually in degrees of cover. The area of interest consists of a circle with a radius of 20 cm.

The soil texture will be estimated in the field by the technician with the finger test. Just rough estimates will be given due to the nature of this technique (sand, silt and clay will be estimated in classes of 33%). At least three samples will be collected. In case the technician identifies different texture classes within the plot, from each texture class three samples will be collected. Those samples will be analysed in the laboratory of the FVA to calibrate the estimates of the technician.

The skeletal fraction will be estimated by the field technician for the first 15 cm of mineral soil. For this purpose a cube of soil will be extracted with a spade. The cube will have a dimension of approximately 30 x 30 x 15 cm. The skeletal fraction will be estimated visually. Finally the extracted soil will be refilled.

4 Survey on precipitation and deposition with precipitation

4.1 Introduction

To calculate water budgets and element flows for the plots it is essential to have detailed meteorological data. The precipitation data will also be used to calculate exact amounts of

element input with precipitation in combination with the deposition data and the influence on the element concentrations of the soil solution.

4.2 Objectives

The objective of this survey is the bulk precipitation in a temporal resolution of 30 min. The results will form a crucial input parameter to calculate total deposition of elements and water balance models. Table 5 gives an overview of the parameters for deposition.

Table 5: Parameters for deposition sampling.

Variable	Reporting unit
pH	pH unit
Conductivity	µS/cm
Ca	mg/L
Mg	mg/L
Na	mg/L
K	mg/L
NH4-N	mg N/L
SO4-S	mg S/L
NO3-N	mg N/L
Cl	mg/L
Alkalinity	µeq/L
Total N	mg/L
DOC	mg/L

4.3 Sampling scheme

As close as possible to each HIP, especially in hilly terrain, an open space spot will be selected, for placing the rain gauge and deposition collectors. The open space should be selected in such a manner that no obstacle is closer to the samplers than twice the obstacles height. In areas where snowfall is expected the deposition samplers should be installed sheltered from the wind. The best sites are often found in forest clearings (WMO 2008). It is important that this spot is representative for the HIP, concerning altitude, slope and aspect. As soon as the plots are selected a suggestion, concerning the tolerable distance between HIP and the spot for the rain gauge and deposition collectors, can be given using digital elevation models and aerial photos. The final decision is up to the experts installing the samplers.

4.3.1 Precipitation

The rain gauge will be installed with the rim of the funnel at a height of 1.5 m; the rim of the funnel has to be horizontal.

4.3.2 Deposition

Three sampling bottles will be installed per plot. They will be situated approximately 1m apart from each other. The contents from all three samplers will be united to one composite sample.

The samplers will be installed with the rim of the funnel at a height of 1.5 m; the rim has to be horizontal (ICP Forest 2010).

4.4 Sampling equipment

Table 6: Equipment

Amount	Description	Supplied by
1/plot	tipping bucket rain gauge	FVA
1/plot	combined air temperature/air moisture probe	FVA
1/plot	data logger	FVA
1/ecoregion	calibration equipment	local team
6/plot	plastic samplers with attached funnel	FVA
6/plot	watch glasses	FVA
3/plot	wooden poles 1.5 m length, approximately 5 cm in diameter	local team
3/plot	metal mounting	FVA
3/plot	bird protection	FVA
12/plot	wood screws	local team
1/ecoregion	beaker (1.5 l)	local team
1/ecoregion	plastic receptacle (4.5 l)	local team
1/plot and sample interval	polyethylene bottles	FVA
1/ecoregion and sample interval	cooling box with cooling element (mailing)	FVA
1/ecoregion	cooling box with cooling element (transportation)	FVA
1/ecoregion	refrigerator	local team
	deionised water	local team

4.5 Installation

Detailed installation and calibration instructions will be delivered with the equipment by the FVA.

4.6 Frequency of sampling

4.6.1 Precipitation

The logger will record the readings for each 30 minute interval. The data will be read out every second week when the rain water from the deposition samplers is collected.

4.6.2 Deposition

As soon as samplers are installed in the field the sampling campaign starts. Installation should be conducted in 3rd quarter 2011. The samples will be collected bi-weekly till the end of 2012.

4.7 Measurements and sample collection

4.7.1 Precipitation

Before reading out the data the funnel of the rain gauge will be removed and checked if any debris prevents the rain gauge from running correctly. If necessary, the rain gauge will be cleaned. The funnel will be freed from any debris as well. If the bucket tips during the maintenance, this should be noted in the field protocol.

Then the data will be read out and checked for any obviously incorrect values (e.g. no readings during the whole time when it is known that raining events occurred).

The data file will be send via email to the FVA after the field work. One copy of the data file will be stored by the local team during the whole project.

4.7.2 Deposition

The amount of rainwater will be measured in the beaker for each sampler separately. The water will be filled in the plastic receptacle as long as no pollution of the sampler can be seen (e.g. bird droppings or dead animals in the funnel or sampler). Any obvious or suspected pollution will be noted in the protocol. If the sampler is polluted the water will be discarded. From the receptacle a composite sample of 100 ml will be filled in a polyethylene bottle the rest will be discarded. The polyethylene bottle will be labelled with the plot number and the date. For transportation the polyethylene bottle will be placed in the cooling box. During the whole process attention has to be paid that the water will not be polluted. A single touch with the finger of the rim of the bottle or the inner cap will significantly change the sample. Any incident and suspected contaminations must be recorded.

The three plastic samplers with attached funnels and the watch glass will be replaced by clean ones. In case during the transport the watch glass turned with the hump downwards, it has to be turned to the right position. This will be performed by thrusting the funnel with the sampling bottle upwards so the watch glass jumps some centimetres and turns when falling

down. It is crucial not to turn it with the fingers or some instrument to avoid any contamination of the sampler.

5 Soil survey

5.1 Introduction

For the calibration of hydrological models many soil parameters are required. Thus it is indispensable to conduct once a soil description. Additional soil cores will be taken to derive the hydrological parameter of the soil to be able to set the soil moisture measurements into context.

5.2 Sampling Scheme

The soil survey will be conducted during the installation of the permanent station. Soil cores will be taken at the depths of 15 cm and 50 cm with three replicates each.

5.3 Field assessments

The soil horizons will be designated and for each horizon the following parameters will be surveyed:

- Texture;
- Structure;
- Skeletal fraction;
- Rooting intensity;
- Colour;
- Carbonate content.

5.4 Laboratory measurements

In the laboratory the hydrological characteristics of the soil will be analysed with the multiple step outflow method. Additionally the texture and the bulk density will be analysed.

6 References

WMO (2008). WMO Guide to Meterological Instruments and Methods of Observation, No.8, 7th edition.