IMPACT OF WATER HARVESTING ON KABIRANYUMA SWAMP, MGAHINGA GORILLA NATIONAL PARK, SOUTHWEST UGANDA

A preliminary report

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Cover Photograph

Local communities from Gitenderi Parish (near MGNP) scramble to fetch water from a broken water pipe on the road (a case of water shortage)

(Photo by Robert Bitariho June 1999)

i. ACKNOWLEDGEMENTS

This report has been produced with various inputs from CARE-DTC (hydrological monitoring), Chicago Zoological Society and MacArthur Foundation (small mammal inventory) and Bob Drewes of California College of Sciences (amphibian inventory).

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ii. ACRONYMS USED

CARE-DTC	Development Through Conservation
cm	Centimeters
DGIS	The Royal Netherlands Government
EIA	Environmental Impact Assessment
GPS	Global Positioning System
ITFC-EMP	Institute of Tropical Forest Conservation-Ecological Monitoring Programme
km	Kilometers
m	Meters
mm	Millimeters
Pers comm.	Personal Communication

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iv. SUMMARY

Kabiranyuma swamp is one of the rarest afromontane swamp habitats in Uganda. The swamp is a major source of water for the Kabiranyuma Gravity Water Scheme that supplies water to over 21,000 people around Mgahinga Gorilla National Park. The Institute of Tropical forest Conservation-Ecological Monitoring Programme together with the Development Through Conservation of CARE are monitoring the impact of the water scheme on the ecology of the swamp and sustainability of water extraction from the swamp respectively.

Monitoring methods used are vegetation cover monitoring, fauna monitoring and hydrological monitoring. The vegetation cover monitoring was established by putting up a series of Permanent Sample Plots in the swamp to monitor changes in swamp vegetation over time and taking fixed-point photographs from the summit of Mt Gahinga for monitoring changes in swamp area cover. The fauna monitoring was established by carrying out a small mammal inventory within the swamp although successive inventories has not been possible due to insecurity in the park. Hydrological monitoring was established by CARE-DTC putting up a network of hydrological instruments to measure changes in water flows, water depth and rainfall.

A probable negative impact of the water scheme on the plant ecology was manifested in a slight increase in *Hypericum revolutum* seedlings in the swamp. This is an indication that the typical "dryland" plant species may be invading the central swamp area, as is also seen in the fixed-point photographs. The major swamp vegetation is *Carex spp* that constitutes over 50% vegetation cover and has been constant over a three-year study period (1999-2001). There is a decline in the number of the endemic *Alchemilla johnstonii* and *Lobelia wollastonii* plant species in the swamp, probably as a result of swamp drainage.

Successive fauna inventories within the park have not been possible due to the insecurity in Mgahinga. However work carried out by Kerbis and Austin in 1997 shows that there

was no evidence of any endemic Albertine rift rodent species like the *Delanymys brooksi* in the channels that drain the swamp, and yet these occurred in the upper swamp and adjoining sedges. This implies that there is a decline in the number of the sensitive endemic species due swamp drainage by the water scheme.

Hydrological monitoring data is still being analysed by CARE-DTC. However work done my Mulders (1998) indicates that there is a close relationship between rainfall and water flows in the channels, implying that water extraction during the dry season will have the most negative impact on the swamp ecology.

A major constraint to the monitoring has been insecurity within the park that precludes sampling of nocturnal animals (amphibians and rodents) and fixed points photography from the top of Mt Gahinga. It is hoped that with the improvement of the security situation in Mgahinga Gorilla National Park, more monitoring work will be done that will provide useful information on the impact of the Kabiranyuma Gravity Water scheme on the ecology of the swamp.

1. INTRODUCTION

The Kabiranyuma Swamp straddles Mt Muhavura and Mt Gahinga of Mgahinga Gorilla National Park (MGNP) in the furthest corner of southwestern Uganda. The swamp is an example of one of the rare swamp habitats in Uganda. It is known to contain some endemic plants like *Lobelia wollastonii* and *Alchemilla johnstonii* (Spinage, 1972; Hedberg, 1995; ITFC, 1996) as well as endemic and rare animals such as the Grauers rush warbler (*Bradypterus graueri*) (Mwambu, 2000) and the Delany's swamp mouse (*Delanymys brooksi*) (Kerbis and Austin, 1996). The major vegetation types within the swamp are *Carex spp* interspersed with a few plant species of *Helichrysum formosissum*, *Eriocaulon schimperii*, *Alchemilla johnstonii* and *Lobelia wollastonii* (Spinage, 1972; Hedberg, 1995; ITFC, 1996).

The swamp consists of an upper and a lower swamp which can be distinguished as follows: The upper swamp extends from the watershed divide, approximated by the international boundary between Rwanda and Uganda, to the end of the saddle between Mts Muhavura and Gahinga, which is marked by a relatively well defined drop in altitude of about 5m (ITFC, 1996). Below the upper swamp lies the lower swamp that is made up of smaller patches of open bog vegetated by sedges interspersed with *Hypericum* woodland.

Although the number of species in an area declines with increasing altitude (Hamilton, 1974), accounting for the low species diversity, rates of endemism are high in montane wetlands (Langdale-Brown *et al*. 1964; Hedberg, 1995; ITFC, 1996). It is the upper portion of the swamp that is the most fragile as it has the greatest percentage of endemic species like *Lobelia wollastonii* and *Alchemilla johnstonii* that are extremely sensitive to disturbance (Hedberg, 1995; ITFC, 1996). This area is bordered by *Hypericum revolutum* that extends down from the sides of the two volcanoes and in some areas occurs in the central part of the swamp. The lower and northeastern margin of the swamp towards Mt. Muhavura is covered with a shrub type vegetation of *Helichrysum* spp and *Carduus* *kikyorum*. This area contains most of the existing drainage channels for the water scheme. The water table is just below the surface of the swamp which results in a saturated marsh with frequent areas of open standing water, interspersed with clumps of vegetation. An expedition by Burtt in the 1930s described the swamp area as an "exceedingly spongy marsh, over a quarter of a mile wide" (Burtt, 1934).

The Kabiranyuma swamp is a major source of water supply for the local people living around MGNP in Kisoro district. Kisoro district experiences a serious water shortage especially during the dry seasons and water is thought to be the most critical resource in the area (Yeoman, 1989; Cunningham, 1995). There are two major water sources in Kisoro district: the Kabiranyuma gravity water scheme and the Chuho water scheme further north. The Kabiranyuma gravity water scheme draws water from the high altitude swamp (Kabiranyuma swamp) and was designed to supply water to a population of about 21,000 people in Kisoro district but has been under immense pressure to increase water supply to more local people around the park. The Chuho water scheme is the major source of water supply for people living in Kisoro town and surrounding communities and is located further north within a distance of about 20 Km from MGNP.

1.1 The Kabiranyuma Gravity Water scheme

Water extraction for community use from the Kabiranyuma swamp has been ongoing since the late 1940 (ITFC, 1996). Originally, the local community dug a channel from the swamp following an existing gully. However, most of the water soaked into the deep ash soils of the lower slopes before reaching the plains (ITFC, 1996).

The Kabiranyuma Gravity Water Scheme was upgraded from the previous water scheme in 1997 to increase efficiency of water extraction and storage after an Environmental Impact Assessment (EIA) carried out by ITFC in 1996. The Scheme consists of a 45 km pipeline that draws water from the swamp. There are drainage channels both in the upper and lower swamp that convey water into a dug out reservoir found near the lower swamp. From the reservoir, water is conveyed through a pipeline by gravity into a storage tank of 400,000-litre capacity located on the park boundary. From the storage tank, water is distributed to the surrounding local communities through pipelines and 51 tapstands. The length of the pipeline running through the park is 3.5 km long. CARE-DTC hydrological data of 1997 shows that during the 1994 dry season, water flow rate in the pipeline was 3.2 litre/sec. This declined to 0.6 litres/sec in the 1997 dry season. In the 1997 wet season, a flow rate of 5-10 litres/sec was recorded and this has remained constant. Historically drainage channels in the swamp have been cleared once a month, ensuring continuous water flow from the swamp down the conduit.

1.2 Why monitor the Kabiranyuma swamp?

We have pointed out above that the Kabiranyuma swamp is one of the rarest swamp habitats in Uganda, with its rare and endemic plants and animals. It is an afromontane swamp that is sensitive to extreme changes in water levels. Any water drainage systems that are likely to increase the natural drainage systems of the swamp will affect the swamp ecosystems. The swamp is a source of water for the Kabiranyuma gravity water scheme that supplies water to over 21,000 people in Kisoro district. There is need to monitor the impact of the Kabiranyuma Gravity Water Scheme on the swamp ecosystem in order protect the swamp biodiversity while at the same time ensuring sustainable water extraction by the local people living around the park. This can only be achieved through establishing a monitoring system for the swamp. A number of monitoring systems exist within the swamp, and these are: vegetation cover monitoring, fauna monitoring and hydrological monitoring. These were those suggested by Cunningham (1995), ITFC (1996), Davenport (1996) and Mulders (1998).

The objective of this report is to formulate methods that are replicable and repetitive that will be used for a long term monitoring of the Kabiranyuma swamp. The report also spells out preliminary results of the impact of the Kabiranyuma Gravity Water Scheme that will act as a baseline for future monitoring work. Below is a description of the monitoring methods that are being used to assess the impact of water harvesting in the Kabiranyuma swamp.

2.0 MONITORING METHODS

2.1 Changes in vegetation cover

We have mapped out some *Hypericum* shrubs along the swamp/*Hypericum* woodland boundary of the upper swamp. The *Hypericum* shrubs were tagged and marked with aluminium tags and flagging tapes, and a Global Positioning System (GPS) reading taken for each marked tree. After marking each tree, a compass bearing was taken to the middle of the swamp and the distance measured along this direction to the closest standing water (over 10cm in depth). The bearing and the distance were recorded. This process will be repeated every 24 months to give an indication of changes in the surface ground water and *Hypericum revolutum* woodland invasion of the swamp over time.

We have also established a series of permanent sample plots across the swamp as suggested by Cunningham, (1995). Two line-transects each bearing Permanent Sample Plots (PSPs) of 2 x 2m separated from each other by 15m and alternating on the right and left hand side of the transects were established in June 1999. One of the transect starts on the part of the swamp towards Mt Muhabura and ends towards Mt Gahinga while the other transect starts on the swamp inside Uganda and ends on the Rwanda-Uganda border. A total of 12 PSPs were set up and marked with white painted iron bars on the two corners of the plots. Plant species found within the plots are recorded every six months. *Carex spp* are recorded as estimations of percentage vegetation cover while *Hypericum revolutum, Alchemilla johnstonii* and *Lobelia wollastonii* are counted as individual stems. The above methods are a long-term process that will be repeated over years until trends are observed.

2.1.1 Fixed Point Photography

A great deal of information can be stored by photographic monitoring using time sequential photography from a fixed point in a fixed direction and with an adequate description. Photographs taken in the late 1940s by Hedberg show a view of the swamp taken from Mt. Muhavura. It has been suggested that similar photographs should be taken in a given month every 5 years as a quick assessment of whether the *Hypericum* is invading the central swamp area, reflecting a change in the water table (Cunningham, 1995; Davenport, 1996; ITFC, 1996).

Hedberg's photographs however, were taken along a trail that is no longer accessible and we have determined that although a partial view of the swamp could be obtained from a point towards the summit of Mt. Muhavura, it is not possible to obtain a clear view of Kabiranyuma swamp from the summit. A clear view of the swamp is now possible from the summit of Mt Gahinga that shows the whole swamp and its boundary of *Hypericum revolutum* woodland.

We took fixed-point photographs of Kabiranyuma swamp from a point on the summit of Mt. Gahinga in March 1999 using an Olympus om88 camera and Fuji 200ASA print film. The point from which the photograph was taken was marked with paint. The Photographs are accompanied with reference notes of: date, time and weather the photograph was taken, locality, type of camera, type of film, camera lens, exposure settings and compass direction of view. Taking of successive photographs has not been possible due to the unpredictable security situation and persistent mist/fog that engulfed the swamp during the field visits in the year 2000 and 2001. We have made four unsuccessful field visits this year. However, protocols have been developed for taking the fixed-point photographs to ensure consistency of methods as and when opportunities arise to take photographs.

2.2 Fauna

2.2.1 Mammals

In 1996, the Chicago Zoological Society and MacArthur Foundation carried out a small mammal inventory of Kabiranyuma swamp in collaboration with ITFC. The Inventory sampled the upper and lower swamps and the drainage channels. No further small mammal inventory work has been undertaken in Kabiranyuma swamp since then. ITFC-Ecological Monitoring Programme has the capacity to carry out the small mammal monitoring in the swamp but this activity has been greatly affected by the insecurity within the park especially since the small mammals have to be trapped at night. We will carry out further successive inventory of the small mammals in the swamp as a follow up of Kerbis and Austin (1996) as and when the security situation improves. We will use live traps (Sharman type) and Pitfall traps to trap the small mammals and identify them. The identification will be based on those prescribed by Delany (1975) and Skinner and Smithers (1990).

2.2.2 Amphibians

Amphibians are sensitive indicators of habitat changes. It has been suggested that an estimation of their relative abundance in both wet and dry seasons be carried out to give an indication as to whether the swamp habitat is changing or not (ITFC, 1996). An EIA carried out in the swamp by ITFC in 1996 recommend that relative changes be monitored by recording frog sounds at night twice a year (dry and wet seasons), before and after channel clearance. The difference in noise levels (decibels) will indicate increasing or decreasing numbers. While the recommendation to record frog sounds and monitor changes in the population by decreasing/increasing decibels is an interesting idea, it may not be practicable. Changes in decibel levels will indicate broad changes in frog numbers but will give no indication of which species are present. There may be a decline in a vulnerable species that is masked by an increase in a more robust noisy species. If all existing species in the area were known by their calls, then an estimate of the population could be obtained by collecting data during the day and recording at night. However, not enough is currently known about the population to undertake this kind of monitoring (Bob Drewes, pers comm.).

The ideal way to monitor the amphibian populations would be to work at night and catch and identify all species present. The current security situation on the Rwanda/Uganda border at the swamp precludes working at night and collecting specimens. If the security situation improves then the Ecological Monitoring Programme will enrol the services of a herpetologist to carry out an initial amphibian inventory to be used as a baseline.

2.3 Hydrology

Hydrological monitoring of the Kabiranyuma swamp started in July 1997 following recommendations of an Environmental Impact Assessment (EIA) commissioned by CARE-DTC and carried out by ITFC in June 1996. The hydrological monitoring is primarily done by CARE-DTC, who hired two field assistants who collect and record daily data on water outflow, water depth and rainfall. CARE-DTC continues to supervise this but has agreed in principle to handover the hydrological monitoring to ITFC-Ecological Monitoring Programme.

A small network of hydrological monitoring equipment was set up in the Kabiranyuma swamp by a consultant hired by CARE-DTC (Mulders, 1998). It consists of three peizometers (water depth), two raingauges (rainfall) and two V-notch weirs (water outflow rates). The upper swamp has one peizometer and one raingauge while the middle swamp has only one peizometer and the lower swamp one peizometer and one raingauge. The V-notch weirs are located 30m below the boundary between the upper and middle swamp, and 100m upstream of the intake of the Gravity Scheme.

3.0 RESULTS AND DISCUSSIONS

3.1 Flora monitoring

Figure 1 shows the changes in the number of the endemic plants species of *Lobelia wollastonii* and *Alchemilla johnstonii* and *Hypericum revolutum* plants within the sample plots. The figure shows a steady increase in *Lobelia wollastonii* plants and *Hypericum revolutum* from June 1999 to January 2000 but a loss of *Alchemilla johnstonii* plants from about 10 individuals to zero. The figure also shows that from January 2000 to January 2001 there was a reduction in the number of *Lobelia wollastoni* individuals and *Hypericum revolutum* plants. Figure 2 shows percentage coverage of *Carex spp*. (the most dominant in the swamp) in the sample plots. Generally the percentage coverage of *Carex spp* in the sample plots has been constant over the three-year study period (above 50 %). The observed slight differences could be related to errors as a result of estimating the percentages within the sample plots. It should be noted however, that these results are not conclusive as data collection is still ongoing and these results are based on a small sample size for any statistical conclusions to be made.

Critical key indicator species for monitoring changes in the groundwater levels in the swamp have been identified as *Carex spp.* and *Hypericum revolutum* that respond to changes in the swamp water level. *Carex spp.* like other sedges are dependent on swamps with high water retention capacity (Hedberg, 1995), while *Hypericum revolutum* is a typical "dryland" plant. The hypothesis here is that as the water level of the swamp drops, the *Hypericum revolutum* will encroach and overtake the major swamp vegetation of *Carex spp*.

Figure 1 & 2

Figure 1. Hypericum, Lobelia and Alchemilla plants abundance In Kabiranyuma Swamp

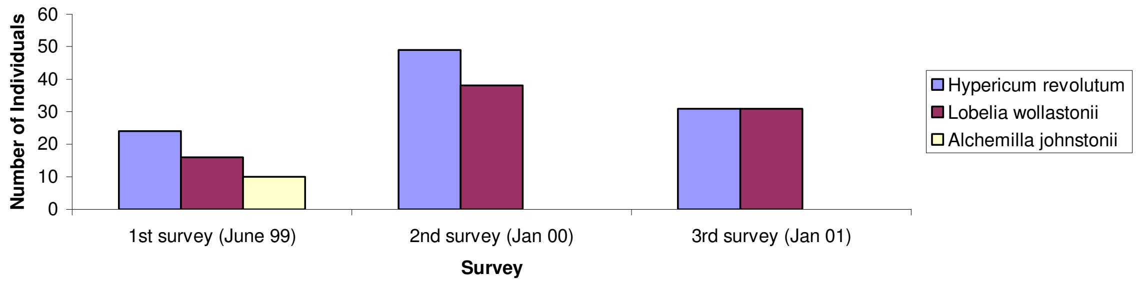
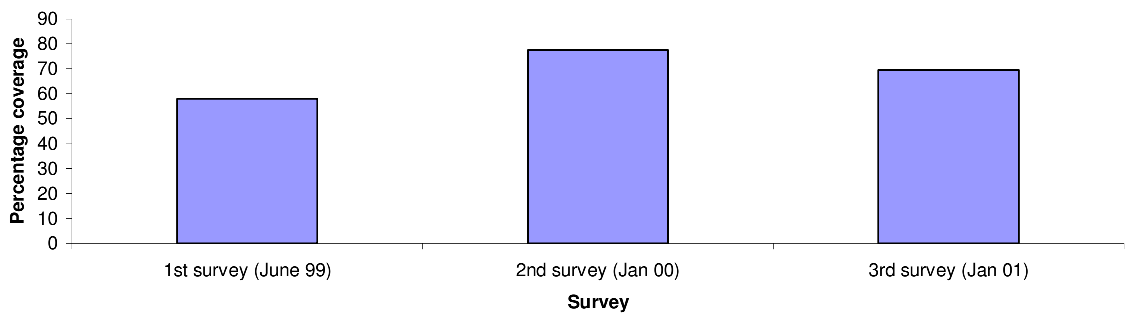


Figure 2. Percentange Coverage of Carex Spp. in Kabiranyuma Swamp



3.1.1 Fixed Point Photographs

The central swamp area can easily be distinguished from the surrounding *Hypericum* woodland and some *Hypericum revolutum* tree encroachment of the central swamp area in the photograph (Plate 1). The photograph serves as a baseline to track changes in the area of the swamp with the implementation of the current gravity water scheme over years. The hypothesis here is that as the swamp water level drops, the swamp area seen will shrink and will be tracked with various successive photographs taken over years.

Plate 1: The Kabiranyuma swamp fixed-point photograph taken from the summit of Mt Gahinga. Note the *Hypericum revolutum* shrub invading the middle of the swamp (shown by arrows) and the *Hypericum revolutum* shrub/swamp boundary.

(Photo by Robert Bitariho, June 1999)

3.2 Fauna monitoring

3.3.1 Small mammals

Results from a study by Kerbis and Austin (1996) indicate that the small mammals found in the Kabiranyuma swamp, and adjoining sedge meadows are 10 Albertine rift endemic species including the Delany's swamp rodent (genus, *Delanymys brooksi)*. In contrast, in the channels that drain the swamp, no evidence was found of the small Albertine rift endemic swamp specialists that might be expected to occur, and this was attributed to accelerated water flow probably caused by the Kabiranyuma Gravity Water Scheme (Kerbis and Austin, 1996).

Recording populations of the Albertine rift endemic swamp specialists over time will provide information about the status of the swamp. Details of these results can be found in Kerbis and Austin (1996).

3.1 Hydrological monitoring

Data collected over an 11-month period have been analysed by a consultant hired by CARE-DTC. Total rainfall was 3749 mm in the lower swamp and 3703 mm in the upper swamp (Mulders, 1998). The rainfall data indicate that this period was exceptionally wet, compared to an average year and is attributed to the effect of El Nino that caused excessive rainfall all over Uganda (Mulders, 1998).

Due to damage of the weirs, data on surface outflow were not available for Weir 1 (upstream of the intake), which is the flow that contributes most to the gravity water scheme. There is a close relationship between the rainfall and the runoff, in particular the rainfall of the upper swamp and the runoff (Mulders, 1998).

The response of the shallow ground water level to rainfall was most direct in the middle swamp, with the lowest groundwater level at the end of the driest month and the highest groundwater level in the wet season. There appeared to be an immediate response of the

surface outflow to the amount of rainfall. During the wet season of 1988, the surface outflow exceeded the design flow of the gravity scheme and the observed low flow rate at the first break pressure tank were the result of insufficient use of swamp outflow (Mulders, 1998).
Details of the results of hydrological monitoring can be found in Mulder (1998)

4.0 CONCLUSIONS

It is vital to continue monitoring both the ecology and hydrology of Kabiranyuma swamp in order to safeguard against excessive drainage of the swamp that might not only lead to a loss in biodiversity but also unsustainable harvest of water from the swamp. Kabiranyuma swamp supports plant and animal communities of high national and international conservation importance and at this stage it can certainly be stated that the richness of the small mammal community and the endemic plants in the swamp can easily be jeopardised if water extraction changed the integrity of the swamp ecosystem.

Hydrological monitoring has indicated that in the dry season water outflow is the lowest. Yet during the dry season that is when water is in great need by the local communities. It would thus imply that during the dry season the hydrology and ecology of the swamp is most negatively affected by loss in water levels and natural habitats of the sensitive endemic plants and animals.

Trends of changes in the swamp ecology can only become apparent after long-term data collections have been made and data analysed according to past and present situations. The study period from 1999 to2001 is too short to make any firm conclusions and recommendations; moreover some of the data set has not been possible due to the security situation in the area. With the improvement of the security situation in MGNP and years of more data collection, we hope to synchronise both ecological and hydrological data and be able to come up with firm conclusions and recommendations.

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Personal Communications

Bob Drewes of California College of Sciences, San Francisco (Department of Herpetology) to Maryke Gray former EMP Coordinator (June 1997-June 1999)

6.0 APPENDIX

6.1 Notes on fixed point photography

Fixed-point photography can be used as a systematic approach to monitor specific sites where degradation appears likely, or there is some cause for concern. There is potential with fixed-point photography, for a systematic approach to detect long-term changes that are rarely apparent without reference to older observations. It is relatively easy to take photographs (with careful notes about each image) and store these images with careful documentation providing a precise but cheap future reference.

The use of images such as photographs is not aimed at quantitative analysis. The observation and description of changes is the main objective. This is a particularly flexible system, as the changes do not need to be anticipated in advance. Images should be taken on an overcast day with small aperture (to reduce shadows and ensure good depth of field) and with relatively long exposures.

Notes to record for each image include: image number, date, time, weather, photographer, locality, camera, film, lens, aperture and exposure settings. Others include: height of tripod, direction of view (compass bearing) and notes on what is seen in each part of the picture (with a sketch). These details must be copied onto two sets of prints (kept in two locations) and the original notes kept with the negatives (cool dry storage).

6.2 Data sheets

6.2.1 Changes in vegetation cover monitoring

Date--

Transect No----------------------------Plot No-------------

GPS------------------------ (easting)---------------------------------(northing)

Plant species	**% Cover**	**Number of individuals**

Notes--

The % cover column = the dominant swamp plant species e.g. *Carex*.

Number of plants column = *Hypericum* it also includes the endemic plant species like *Alchemilla* and *Lobelia*.

6.2.2. Fixed Point photography

Date/ Time/ Weather	
Photographer	
Locality (GPS reading and details)	
Camera	
Film (brand and speed)	
Lens	
Image number (s)	
Aperture	
Exposure settings	
Height of tripod	
Compass direction of view	
Notes on what is seen in each part of the picture (with a sketch)	