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1. Key development issues and rationale for Bank involvement

There have been few studies of the importance of atmospheric deposition in the nutrients loading of lakes, but the few studies that have been conducted indicate that in many regions, the atmosphere can be an important source of nitrogen, phosphorus and other elements to lakes (e.g. Schindler et al. 1976; Scheider et al. 1979; Manny and Owens 1983; Cole et al. 1990). For example, in the North American Great Lakes, the concentration of dissolved inorganic nitrogen has risen steadily over the past century, probably due to increased atmospheric deposition of nitrogen (Bennett 1986). Despite these demonstrations that atmospheric deposition can increase nutrient concentrations in lakes, the role of atmospheric deposition as a potential cause of lake eutrophication has been largely ignored. From the perspective of limnology, phosphorus is most likely to limit productivity of most lakes and rivers. Urban point sources are generally the dominant source of P to many lakes in developed, temperate countries where most limnological scientists practice. Atmospheric sources of P are generally low in temperate latitudes where most studies on atmospheric chemistry and lake eutrophication have been performed.

In developed countries, most of the research on atmospheric deposition, has been driven by concerns about acidic deposition, which results primarily from emissions of gaseous nitrogen and sulphur compounds, or with the deposition of volatile and semivolatile contaminants such as organochlorines and some heavy metals e.g. mercury. These acidic and contaminant compounds largely arise from energy production, industrial sources and agricultural processes. Because phosphorus does not have a stable gaseous compound, combustion processes leave P in the ash and particulate fraction (Lewis 1981). In developed countries, internal combustion for energy production injects little ash into the atmosphere and in general open burning is discouraged with even wildfires being suppressed. Leenhouts (1998) has recently estimated that total particulate mass (TPM) release into the atmosphere is less than 10% of what it was in the USA before the industrial age when most population growth in US and other developed countries occurred. Internal combustion and changing cultural attitudes towards open burning have probably reduced P inputs into the atmosphere since the dawn of the industrial age. Consequently, atmospheric deposition of P is low in developed countries (Table 1) even when human populations are large, and therefore atmospheric P is only infrequently studied despite the fact that phosphorus is often the key nutrient controlling algal production in lakes. However, recent research (Goldman et al., 1990; Li et al. 2004) observed a dramatic increase in algal photosynthetic rates in Lake Tahoe, a large, remote oligotrophic following large forest fires in the region. They attributed this increase to the atmospheric deposition of phosphorus-containing ash produced by the forest fires. Also the potential for long range transport of particulate P sources has received attention in regards P loading of distant ecosystems, including tropical forests and coral reefs. The origin of this long range transport is arid and semi-arid regions of the globe and deflation of open, exposed soils.

1.1. Atmospheric Deposition in Tropical Africa

In contrast with temperate regions, open burning of biomass fuels are recognized as a major mechanism that influences the atmospheric transport of elements (Andreae et al. 1988; Crutzen and Andreae 1990) in the tropics. Biomass burning is especially pervasive within tropical Africa (Delmas 1982; Andreae 1993). However, as in the rest of the world, studies of atmospheric chemistry and atmospheric deposition have rarely been related to nutrient cycles in African lakes. Early studies within Africa include those by Visser (1961), who examined the chemical composition of rain near Kampala, Uganda, Ganf and Viner (1973), and Bromfield (1974; Bromfield et al. 1980) who measured the concentration of sulphur in rainwater in Ethiopia and Kenya. Prior to 1990, there were only two studies investigating the role of atmospheric deposition in lake element cycles in Africa (Gaudet and Melack 1981; Rodhe et al. 1981), but neither of these included phosphorus. Current knowledge of atmospheric deposition and its significance as a nutrient source to African lakes is based on several studies conducted since 1990. A small number of measurements made at Jinja, Uganda in 1991 (reported in Lindenschmidt et al) indicated that the atmospheric deposition rates of phosphorus and sulphur on Lake Victoria could be substantial and may have increased significantly over the previous three decades since the measurements of Visser (1961). While no data existed at the time to compare atmospheric deposition rates with other sources of nutrients to Lake Victoria, the coincidence of increased atmospheric deposition of P with the eutrophication of Lake Victoria hinted at a possible causal link. Recently, numerous measurements of both atmospheric P deposition and other nutrient sources have been made for Lake Victoria (e.g. Tamatamah 2005) in studies conducted as part of the GEF-supported Lake Victoria Environmental Management Program. The measurements of atmospheric deposition were confined to coastal locations, but when extrapolated over the large area of the lake and compared to river inputs of nutrients, they suggest that atmospheric deposition is responsible for more than 60% of phosphorus input to the lake.

In Lake Malawi, measurements of atmospheric nutrient deposition were first made in 1990/91 (Bootsma et al. 1996). A comparison of these measurements with estimates of nutrient loading from rivers provided the first indication that atmospheric deposition might be an important source of nutrients to the African Great Lakes. In this study, the measurement of other elements provided some insight into potential sources of nutrients and other rain components. Relatively high concentrations of nitrogen ions (nitrate and ammonium), as well as sulphate suggested that biomass burning was having a strong influence on atmospheric deposition. High concentrations of calcium indicated that soil exposure and deflation by wind were also important in the region. Phosphorus concentrations in rain were high, but the sources of this phosphorus were uncertain. Both biomass burning and soil suspension were suggested as possible sources, with biogenic emission of phosphorus-containing aerosols also being a possible source. Further research as part of the SADC/GEF Lake Malawi/Nyasa Biodiversity Conservation Project (1996-1999) resulted in additional measurements of atmospheric nutrient deposition near Lake Malawi/Nyasa. This study also measured other fluxes of nutrients for Lake Malawi/Nyasa, including river inputs, river outputs, sedimentation and burial, and vertical mixing within the lake. This allowed for the first accurate quantitative comparison of atmospheric deposition with other nutrient fluxes. The study showed that atmospheric inputs of nitrogen and phosphorus were similar in magnitude to inputs from rivers (Table 2). On a daily basis, wet deposition rates were found to be similar to dry deposition rates. Because the Lake Malawi region experiences more dry days than rainy days in a year, total annual deposition was dominated by dry deposition (Table 3).

Table 2. Fluxes of carbon, nitrogen and phosphorus in the Lake Malawi/Nyasa nutrient budget (from Bootsma and Hecky 1999).

	Source	**Nitrogen**	**Phosphorus**	**Silicon**
INPUTS	Atmosphere	149	7.9	51
	River Inflow	231	10.7	872
OUTPUTS	River Outflow	4.4	0.18	12.9
	Sedimentation	129	10.2	1011

Table 3. Wet and dry atmospheric deposition rates of carbon, nitrogen and phosphorus for Lake Malawi/Nyasa (Bootsma et al. 1999).

	Carbon	**Nitrogen**	**Phosphorus**
Wet (mmol m^{-2} yr^{-1})	139	19.4	1.3
Dry (mmol m^{-2} yr^{-1})	730	129	6.6

A comparison of atmospheric deposition rates of P near Lakes Malawi/Nyasa and Victoria with measurements made in other parts of the world reveals that deposition rates in the tropics tend to be higher than in temperate regions, and that deposition rates on these two lakes are among the highest recorded in the literature for any part of the world (Table 1).

1.2. Atmospheric Deposition and its Impact on African Great Lakes

The recent GEF-supported research on Lake Malawi/Nyasa and Lake Victoria has established two facts with regard to the atmospheric deposition of nutrients near these lakes: 1) Deposition rates of nutrients, particularly phosphorus, appear to have increased over the past several decades. While there is limited historical data with which to establish the timing and rate of increase, comparisons with the available historic data for equatorial Africa, as well as more recent data for other parts of the world indicates that current atmospheric deposition rates are high. 2) Atmospheric deposition represents an important mechanism by which nutrients enter the African Great Lakes. In Lake Malawi atmospheric input of P is similar to that from rivers, and in Lake Victoria atmospheric input of P appears to be significantly greater than river P input. The importance of atmospheric deposition as a P source to these lakes, along with the apparent increase in atmospheric deposition on these lakes in recent decades, suggests that this mechanism may be responsible at least in part for the eutrophication of Lake Victoria, and the observed recent increase in sediment P deposition rates in both Lake Victoria (Hecky 1993) and Lake Malawi/Nyasa (Hecky et al. 1999). Therefore, there is concern that atmospheric deposition of nutrients may be affecting other aquatic and terrestrial ecosystems in equatorial Africa. If, as the available data suggest, biomass burning and soil deflation are playing an important role in this process, then the issue of atmospheric nutrient transport is also of relevance to agriculture. Indeed, a number of studies have pointed to biomass burning as a factor promoting the declining fertility of soils in Africa (Wright and Bailey 1982; Roy 1991; Mills and Fey 2003). In this case, atmospheric transport and deposition of nutrients is a process of interest even in those parts of equatorial Africa without large water bodies.

Spatially limited data on atmospheric deposition inputs into the African Great Lakes generated by GEF International Waters Projects on Lakes Malawi, Tanganyika and Victoria have individually concluded that the atmospheric inputs of nitrogen and phosphorus are dominant components of the nutrient budgets of these lakes (Bootsma et al. 1996, 1999; Langenberg et al. 2003; Tamatamah et al. 2005) accounting for over 50% of external loading of fixed nitrogen species (TN) and total phosphorus (TP) in all three lakes when wet and dryfall are considered. Victoria, with 80% of its water input coming directly into the lake through rain and with its enormous surface area(69,000 km2) to collect dryfall, is the most influenced by atmospheric deposition with current estimates indicating that atmospheric deposition provides over 60% of external loading of TP and over 80% of TN (LVEMP 2005) . These estimates are comparable to the few other measurements of TN and TP in atmospheric deposition in tropical Africa and South America (Table 1) but are 8-10 times the reported deposition rates in North America away from urbanized areas.

Table 1. *Comparison of atmospheric deposition rates of phosphorus for various parts of the world, illustrating the high deposition rates in tropical Africa.*

Location	**P Deposition ($mmol\ m^{-2}\ yr^{-1}$)**	**Source**
Lake Victoria	5.7-8.5	Tamatamah 2001
Lake Malawi	7.9	Bootsma et al. 1999
Lake Valencia (Venezuela)	5.4	Lewis 1981
Hubbard Brook (New	0.23	Likens 1980

Hampshire)		
Colorado Mountains	0.9	Grant and Lewis 1979
Experimental Lakes Area (Canada)	1.1	Schindler et al. 1976

Biomass burning, soil dust and biogenic particles from exposed tilled, fields have been invoked as likely emission sources for gases and particulate loading rates to the atmosphere being higher in the tropics and resulting in elevated deposition rates (Echalar et al. 1998; Scholes and Andreae 2000; Eck et al 2003). Unfortunately direct estimates of P emission factors are rare. Currently estimates of P emissions must be inferred from total particulate emissions, as P is always associated with particulates, and has no known stable gaseous phase in the atmosphere. Lewis (1981) has shown that ash from biomass burning is a rich source of available P, and Okin et al. (2004) concluded that particulates in tropical air are enriched in P relative to P in the earth's crust because of P enrichment by biomass burning. Similarly airborne surveys in North America have shown that smoke plumes from forest fires are enriched 10x in P relative to P concentrations not influenced by fires (Zhang et al. 2002). Tropical Africa has the highest areal coverage of biomass fires of any area of the globe by a significant margin (Dwyer er al. 2000; Fig. 1), and African fires dominate the global biomass burning budget for many compounds (Scholes and Andreae 2000).

The initial studies on Lake Malawi/Nyasa and Lake Victoria have highlighted the significance of atmospheric deposition in the nutrient cycles of these lakes. Critical questions that must now be addressed include:

1. Are the high nutrient deposition rates observed in these two locations typical for much of equatorial Africa, or are there regional hot spots where emissions to the atmosphere are exceptionally high?
2. Where are the geographic sources of the nutrients that are being deposited to the African lakes?
3. What are the mechanisms by which nutrients are introduced to the atmosphere (e.g. biomass burning, soil deflation by wind, vegetation emissions of gases and aerosols, urban/industrial emissions)?
4. Is atmospheric nutrient emission, transport and deposition also affecting other aquatic and terrestrial/agricultural systems in Africa?
5. Are there other components of atmospheric deposition (e.g. metals, organochlorines, organophosphates) that may have an influence on the health of humans and terrestrial / aquatic ecosystems?

1.3. Rationale for GEF Involvement

<u>Previous GEF International Waters projects on African Great Lakes verified the early researcy-identified links between increasing eutrophication and atmospheric deposition of macronutrients.</u> Unfortunately, there are no estimates of the regional atmospheric transport of P within tropical Africa nor export of N and P from the continent in tropical latitudes.

Transport of macronutrients may be both a regional and global problem. Africa through deflation of dust from the Sahara and the Sahel is a major global source of dust and associated P (Okin et al. 2004). Long distance transport of African dust originating in northern Africa may sustain the productivity of tropical forests in the Amazon (Chadwick et al. 1999), but may also be degrading reefs in the Carribean (Garrison et al. 2003). Seasonally, winds in the troposphere will also distribute this Saharan dust over western and eastern Africa. Globally, atmospheric particulates have been estimated to contribute 50% of the total annual P load to the oceans (Duce et al. 1991), a percentage remarkably similar to that estimated for atmospheric P loading to the African Great Lakes.

There are still many questions about sources and areas of contribution to atmospheric loading of particulates and no historical or existing monitoring networks in equatorial Africa to provide data needed to answer these questions. Although the current understanding of the distribution of particulate emissions to the atmosphere and their chemical composition are consistent with a strong inference that the atmosphere may be a significant source of P and N (and other compounds and pollutants) to the African Great Lakes (and other aquatic ecosystems), substantial uncertainty remains about the quantitative and relative contribution of atmospheric loading to ecosystem nutrient budgets, especially in Africa where the highest rates have been measured but at few locations. Although African savannas have received close attention as emission sources (Scholes and Andreae 2000), deposition estimates are very few in Africa, largely generated through empirical measurements out of the GEF projects. The lakeside location of most of the few estimates may limit their extrapolation to over-lake deposition on one hand while on the other hand they may also not be representative of terrestrial ecosystems where vegetation is a much more efficient collector of aerosols than water surfaces. The high surface area of vegetation is highly efficient at intercepting dryfall, and its vegetation cover reduces aerodynamic turbulence near the groung and enhances particle settling Depending on the climatic aridity of a site, the relative importance of wet and dryfall varies from site to site although dryfall is broadly comparable to wet deposition of TN and TP in all studied sites (Tamatamah et al 2004, Bootsma et al. 1999). Similarly on Bootsma et al. (1999) has addressed interannual variability, and even then only over two years

2. Proposed objective(s)

2.1 Development Objective

The proposed Regional Atmospheric Deposition Monitoring Network Project (which will be referred to as the Equatorial Atmospheric Deposition Network or EADN) will establish and operate a regional, wet/dry deposition, monitoring network across equatorial Africa, and tie these data into atmospheric mass transport models of materials transfer helping to identify important sources of these materials. This Project has its origins in 3 large GEF-supported projects on African Great Lakes. These project on Lake Tanganyika, Lake Malawi/Nyassa, and Lake Victoria all yielded data strongly linking macronutrients (particularly phosphorous as the limiting element) to changes in trophic status. Surprisingly, the source of the macronutrients driving this process was overwhelmingly from atmospheric deposition directly onto the surface of these lakes. While data from these projects clearly identified the nature and scope of the problem, the data were not sufficient to establish the likely sources of the material and contribution ranking (either within or regionally, outside, the lake basins).

The objective of this proposed project is to provide regional input into government interventions targeting rural development, and particularly those targeting land use management, soil fertility, livestock and agricultural productivity, that would allow the estimation of their offsite impacts associated inflow of macronutrients (and particularly phosphorous) into African lakes.

2.2 Key Performance Indicators

Most Africans live in a rural setting and depend directly or indirectly on agrarian economic activities. Land use in rural Africa is dominated by small scale farmers and pastoralists. Since the contribution of the agricultural sector to national economies is significant, there is an increasing awareness that more government and donor attention is needed to promote sustainable and more economically viable exploitation of rural lands. Multilateral and bilateral donors are therefore allocating more of their resources to development in rural areas. But work funded by the GEF and other research agencies and universities suggest that these rural, land-based, projects may have significant "off-site" impacts on the natural resources of inland water bodies, which significantly reduce any benefits that accrue locally through these investments.

The EADN is an information gathering exercise. There are scientific and investment-oriented benefits to starting and operating the EADN. By linking the network to existing regional and global atmospheric monitoring networks, it is possible to obtain a more reliable and complete understanding of global circulation patterns of particulates and important polluting elements and compounds. But of more immediate benefit would be to provide input into development assistance programs of multilateral and bilateral donors and their African client governments that fund agricultural development activities. The EADN will help to provide estimates of potential reductions in expected economic/financial rates of return that a rural development project might produce locally because of offsite impacts on African Great Lakes and other lotic water bodies in the region. How successful the EADN will be at achieving this objective could be measured by:

- Input needed to modify the Africa region's rural development strategy regarding improving management of livestock production and enhancing management of natural resources (from: Action to Impact: the Africa Region's Rural Strategy, pp28-30);
- Information derived from the EADN to be considered in the development and/or modification of rural segments of Bank Country Assistance Strategies in equatorial African Countries;
- Bring geographically and politically diverse research institutions across Africa together to concentrate sufficient regional resources together to design, operate and advocate for any needed change national/regional rural development programs in the continent.
- Establishing an imperative and facilitating the creation of dialogue between equatorial African governments that relates to transboundry transport of polluting elements and compounds, particularly major macronutrients;

3. Preliminary description

3.1 The Approach

The method of passive collection onto a water surface used for dryfall estimates in GEF projects may not provide comparable data among sites because of micrometeorological differences at collection sites, e.g. winds and turbulence, and this reduces confidence in comparing or extrapolating an estimate of dryfall to different locations. The passive collectors also do not provide estimates of particle and gaseous fluxes past a point. For example, particles may be depositing at a higher rate at one site, yielding higher estimates of TN and TP deposition, but the same area may also be increasing atmospheric concentrations of particulates and exporting those materials to neighboring ecosystems. Active aerosol collectors are required to establish atmospheric concentrations of aerosols which when combined with meteorological data and appropriate transport models will permit calculation of export of materials from a site as well as more standardized estimates of deposition at the site based on standard transport-deposition models such as the Dust Emission and Deposition (DEAD) model (for coarse particles, Okin et al. 2004) or CALPUF for fine aerosols. Current data in Africa for deposition in rain are based on manual collectors deployed at the beginning of an event. Because the concentration of materials is highly time dependent as the atmosphere is washed out early in a rain event, large errors in mass deposition can occur if there are delays in the manual deployment. Current estimates of deposition based on these simple manual methods are subject to both high and low bias depending on site characteristics and operator error.

The monitoring network needs to be linked to and produce information needed by government land management agencies and donors that support their work. The network should also support regional collaboration in land management. Before recommending policies and practices to address widespread and traditional land management practices including burning, the estimates of elevated atmospheric deposition on African aquatic ecosystems including the Great Lakes, the following hypotheses must be tested:

1) Nutrient loading to the African Great Lakes is dominated by atmospheric deposition.
2) Atmospheric nutrient deposition rates over the great lakes are as high or similar to rates measured at coastal locations
3) The source for elevated atmospheric loading rates for N and P is western Africa is Sahelian dust while savanna burning is the dominant source in eastern and southern Africa
4) The sources of the atmospheric burden of particulates are regional and widespread and not just local or point sources.

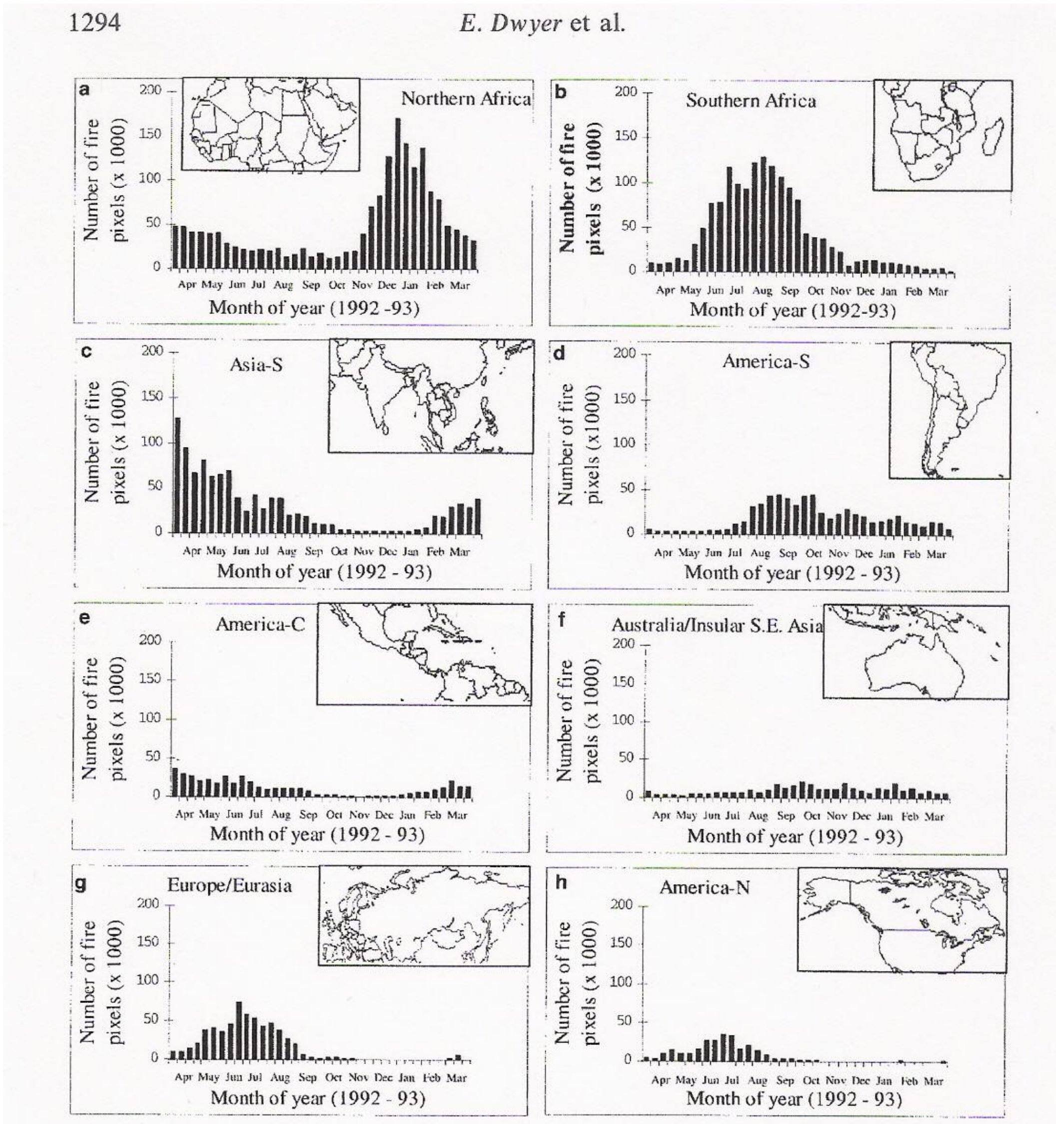

Fig. 1 (after Dwyer et al. 2000). The number of fire pixels from satellite imagery is plotted against time. Africa has the highest incidence regardless of season. Different timing of the fires season in western and southern Africa provides excellent opportunity to determine the affect o ffies on atmospheric loading of phosphours.

To test these hypotheses an Equatorial African Deposition Network (**EADN**) must be established with extensive spatial coverage and operating in all seasons to evaluate differences in regional sources (different vegetation covers, different land use practices, different burning practices, etc.) and to evaluate deposition over large water surfaces relative to land surfaces. If deposition rates are similar over wide areas and over lakes, then reducing these rates to provide protection to aquatic resources will require regional and possibly Pan-African management action and agreements. If certain source emissions dominate the loading of the African atmosphere, action may become more targetted but still regional coordination of policies will be necessary. If high deposition rates are a result of local sources and practices then addressing these issues at the catchment or lake basin scale will be successful.

3.2 What will be monitored and why?

It is proposed to establish an Equatorial Africa Atmospheric Deposition Network (EADN) initially with a minimum of 12 participating countries in western, eastern, central and southern Africa to test hypotheses about the importance of atmospheric nutrient deposition and transport to aquatic and terrestrial resources in inter-tropical Africa. The large geographic scope is necessary to address uncertainties about source areas, seasonality and cultural practices on atmospheric transport. The establishment of such a network will not only test hypotheses concerning nutrients but will demonstrate the feasibility of such a network to eventually address POP's and toxic metal atmospheric transport. It is anticipated the network will attract great interest (and research funding) from environmental agencies and academic in developed countries already operating networks to address these contaminant compounds.

The primary objective of the proposed monitoring network is to better quantify the atmospheric deposition of macronutrients – nitrogen and phosphorus – onto aquatic systems in Africa, and to determine how deposition of these nutrients varies in space and time. The only system for which more than one year of published data is available is Lake Malawi/Nyasa. The data collected in Malawi indicate that there can be large interannual variation of deposition rates (Bootsma et al. 1999). As a result, estimates of annual deposition rates onto the lakes still include a large degree of uncertainty. This uncertainty will decrease with continued measurements, allowing a more precise determination of long-term deposition rates. Comparison of interannual differences with other variables, such as meteorological conditions, biomass burning, and vegetation cover will also provide further insight into the factors that control atmospheric nutrient deposition.

Data currently available indicate that nutrient deposition rates are high near Lakes Malawi and Victoria. If, as suspected, biomass burning is partly responsible for these high rates, then it is expected that much larger areas of equatorial Africa will also be experiencing high deposition rates (and emission rates), since biomass burning is prevalent throughout much of Africa, especially in the regions 5 to 20^{o} north and south of the equator (Andreae 1993; Dwyer et al. 2000; Fig. 1). The establishment of a monitoring network will test this hypothesis. The proposed network will extend from west Africa where Sahelian dust might be expected to dominate P sources relative to biomass burning and will extend to central and southern Africa where biomass burning may dominate (Fig. 2 map). The network will extend over several biophysical regions with different climatic and vegetation characteristics as well as different seasonalities of burning (Fig. 1). Comparison of spatial patterns of deposition with patterns of meteorology, burning and vegetation will also help to determine the sources of atmospheric nutrients and the mechanisms of transfer – two pieces of information that are critical prerequisites to considering any management strategies. The primary atmospheric components of interest are initially nitrogen and phosphorus. Analyses of these nutrients will include the determination of several forms of each. For nitrogen, the forms of interest will be dissolved inorganic N (including nitrite + nitrate and ammonium), dissolved organic N (determined as total dissolved N minus dissolved inorganic N), and particulate N. Data on these individual forms is useful both for identifying sources and for determining the bioavailability of the nitrogen in lakes. For phosphorus the forms of interest are phosphate (operationally defined as soluble reactive phosphorus), dissolved organic phosphorus (determined as total dissolved P minus soluble reactive P), and particulate phosphorus. These are the analyses that will be conducted for all sites in the network. For most sites, dissolved N and P components, which are relatively simple to analyze[1], will be analyzed at local laboratories participating in the program. Particulate analyses will be carried out on the same filters that are used to determine total particulate concentrations. Because this analysis requires a high precision analytical balance capable of measuring weight increments as small as 0.1 μg, it is expected that these TPM samples will need to be send to a regional laboratory with this capacity (procuring this type of balance for each participating laboratory will be prohibitively expensive).

A second group of components to consider for analyses are the major ions – calcium, sodium, potassium, magnesium, sulphate, chloride, bicarbonate and carbonate, as well as pH. During the time period covered by this grant these parameters will be done to the extent that the volume of individual sample collections and the budget allows. Some of these compounds (e.g. sulphate and pH) of are interest on their own, but the primary application of these compounds is to help determine sources of N and P and mechanisms of N and P loading to the atmosphere. The usefulness of these compounds for this purpose has been illustrated in several previous studies (Echalar et al. 1998; Crutzen and Andreae 1990; Andreae et al. 1988; Bootsma et al. 1996). This will help to test the hypothesis that biomass burning is producing much of the N and P that is being atmospherically transported, and will also provide further insight into the importance of soils as a source of atmospheric N and P. This information will inform management strategies from the lake perspective, and will also be of interest to managers and researchers in the agricultural and forestry sectors. It is expected that not all laboratories directly involved in the atmospheric deposition monitoring program will have the capacity for analyses of all major ions. Some labs are atomic absorption spectroscopy (AAS), but in other cases samples will need to be sent to laboratories with this capacity, or with capacity for ion chromatography.

In addition to major ions, other components that are useful in determining sources of atmospheric sources and their production mechanisms include the following:

- Total organic carbon
- Al, Si, Fe, Cu
- Hg
- Stable isotopes (C, N, S)
- Levoglucosan
- Organophosphates
- Mercury
- Other heavy metals (Pb, Cd, As, Cr, Mn, Cu, Co, Ni, Va)
- Radioisotopes
- Persistent Organic Pollutants / Polycyclic Aromatic Hydrocarbons

[1] Although the analyses are simple relative to analysis of other compounds such as organic pollutants and mercury, a high degree of quality control / quality assurance is still required to produce accurate results.

Carbon dioxide is also a useful tracer. However, its measurement is done directly in situ at the sampling site, rather than on collected samples. Relatively low cost instruments are available for continuous in situ CO_2 monitoring. These analytes are expensive to do, and cannot be a priority in the initial setting up of the network despite their importance to public health and international concern. It is anticipated that, once the network is established, that international interest from environmental agencies and existing networks will be willing to support a range of these analyses for their own interests and purposes. Therefore, cost of these analyses are not included as part of the proposed program. Rather, the establishment of a monitoring network will provide a logistic platform that will greatly facilitate additional, separately funded studies that will focus on some of these atmospheric components. It is anticipated that international scientists and scientific programs will make use of the network and provide these more expensive analyses as the network demonstrates its performance capacity.

3.3 The EADN Infrastructure and Operational Program

To date the methods used to assess the atmospheric inputs to the lakes and affected land surfaces have indicated substantial inputs but the efforts have been on too small a scale and the methods too rudimentary to provide the needed quantitative estimates of deposition and to support quantitative inferences of likely emission sources. This proposal will greatly enlarge the geographic and temporal scale of past and ongoing studies and to use improved, standardized methods employed by other current regional networks to gain much better quantitative estimates of deposition for Intertropical Africa wide basis and to relate these measures to other global networks. A proposal for a network of sites and choice of appropriate and desirable methods was the subject of a workshop in Nairobi Kenya (23 to 26 of May 2005). A substantial side benefit of this proposal will be the transfer of technology and training required in order to establish capacity for sophisticated environmental monitoring on the African Continent. The network will establish a continental network of scientists and technicians expert in this field, particularly in the equatorial region. This network will harness and enhance the technical capacity to quantify atmospheric deposition and transport that will enable determining the impact of these atmospheric processes on receiving aquatic and terrestrial ecosystems in tropical Africa. Such a network does not now exist although there are networks (e.g. AERONET and FLUXNET) evaluating the contribution of biomass burning to global GHG and climate change.

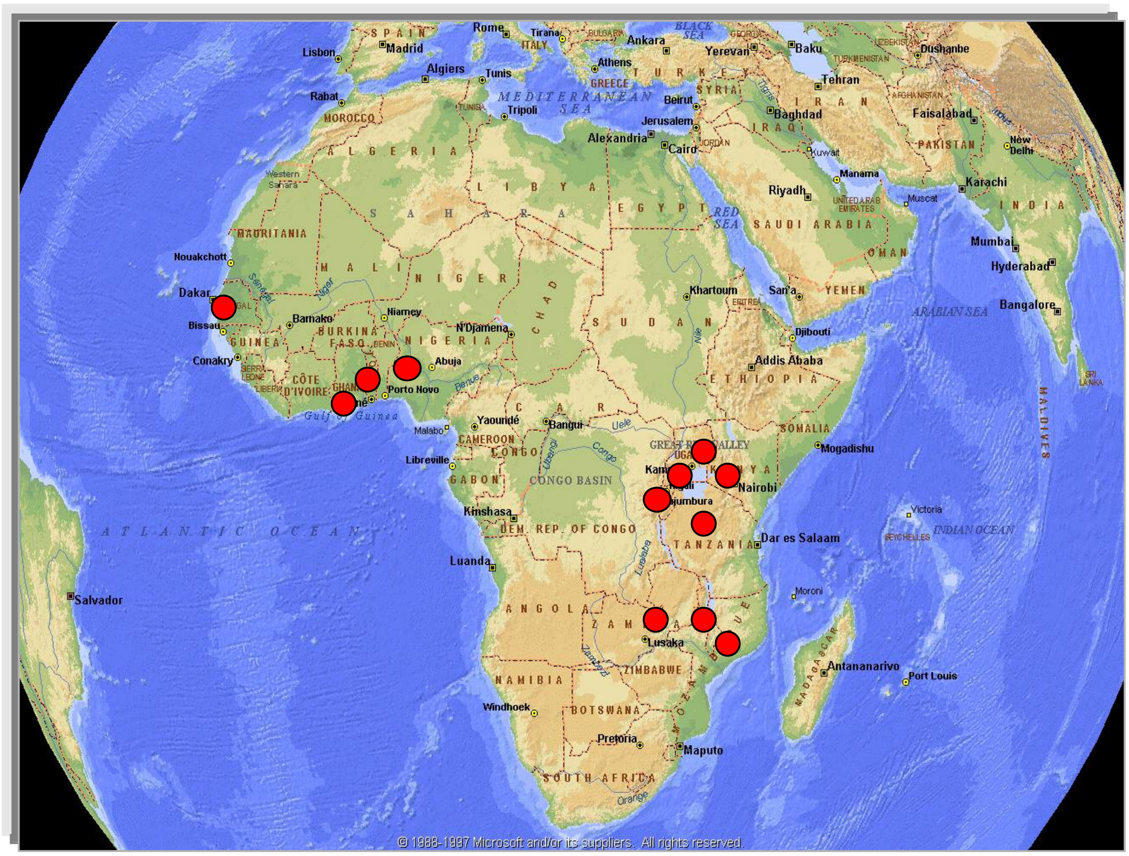

Figure 2. Initial network agreed to at Nairobi workshop. Twelve stations in 12 countries. Budget would allow expansion to as many as 15.

3.3.1 Results of the Initial PDF-A Workshop to Identify the EADN

The workshop recognized and endorsed the need for establishing a network in Equatorial Africa consistent with atmospheric deposition networks in other parts of the world namely, North America (Canada and the US) and Europe. To achieve this end and to establish the long-term data trends require a number of tasks that are the subject of this proposal. Among these are the critical tasks of training and establishing quality assurance and control (QA/QC) to provide qualified staff and support to ensure acquisition of data for the evaluation of nutrient deposition that is of known and certified quality. The training and quality manuals will address design and operational issues such as strategic site criteria to enable testing of hypotheses, logistical and QA/QC criteria for monitoring stations, operation of the stations for collection of airborne particles and possibly gases and precipitation, protocols for sample handling, storage, documentation and transport, analysis and data reporting and management of the information in widely available databases. Good quality data acquired from strategic station will allow application of sophisticated models to develop deposition patterns of the nutrients and possibly other compounds on a continent wide basis. The establishment of a well run, efficient network will provide the infrastructure for study of other environmental issues that are likely to arise, representing a substantial side benefit for this program. The necessary activities to establishing a successful, high quality network must include 1) QA/QC, 2) training, 3) establishing infrastructure and operation of the field component of the network (siting, establishing the equipment and instrumentation at each site, sample collection, storage, and transport to the analytical laboratory) as well as analysis, documentation and reporting and 4) creation of a regional database and application of existing transport and depositional models. A further QA/QC check on the validity of the model is the embedding the estimates of atmospheric inputs into a nutrient/ contaminant budget for selected watersheds. These “calibrated” watershed studies are the ultimate test of the validity of the estimates of atmospheric inputs into aquatic systems. Bootsma et al (1999) completed such an analysis for Lake Malawi with a closed nutrient budget in which inputs (including atmospheric) approximately equaled outputs, and a similar exercise is underway as part of the Regional Water Quality Synthesis for Lake Victoria by LVEMP. This proposal will enable a similar calibration exercise for Lake Bosumtwi in West Africa (Ghana) but the study is funded outside this proposal through collaboration with the National Science and Engineering Research Council of Canada.

3.3.2 Spatial Orientation of Sampling Sites

Movement of particulates from the African Continent towards the Caribbean and Central America are well known. Significant deposition of African-sourced soils are documented in these areas and impacts of African sediments on Caribbean coral reefs can also be found in the literature. It is very likely that macronutrient transport will following the same equatorial monsoonal pattern of transport/dispersal as sediment. But although we know there is transport of material across the Atlantic, we do not know what proportion of the material mobilized stays within the Africa region and what percentage is transported across the Atlantic and perhaps beyond.

Sampling sites are oriented to reflect monsoonal weather patterns and to be able to identify (through modeling) both sources of mobilization and regional transport of macronutrients. The EADN will link to global atmospheric monitoring networks to trace global movement of these nutrients, enabling a better understanding of both regional and global impacts of land use in Africa.

3.4 Draft Project Activities

The establishment of a successful network will require four interrelated activities (described below) before the hypotheses of this proposal can be answered and implications for environmental management can be determined with confidence.

Component 1: Quality Assurance and Quality Control-

The objective of quality assurance and quality control is to provide acceptable data with well-documented characteristics, particularly with respect to the data attributes of representativeness, accuracy, precision, and blank levels. A cornerstone of any quality assurance program is development of a quality assurance/quality control (QA/QC) plan and well-documented methods and protocols. The implementation of a quality control program requires independent auditing,

both internal and external, to ensure that procedures are being followed, that problems are tracked and dealt with in a timely fashion and that a QA/QC document is attached to the data before release to allow data users to qualify their assessments. Included in a QA/QC plan are details on training of field, laboratory and data processing staff to ensure uniformity of execution of tasks across the network and consistent documentation.
Why is the QA/QC component so important? Samples from the EADN will be collected and analyzed by different organizations, individuals and laboratories. If the sampling is not uniform and consistent from one location to the next, sampling errors (which are difficult, if not impossible to measure) will result in data thatcannot be compared across sites in the network. Even if sampling processes are standardized and rigidly monitored, laboratory assessments of these samples may also result in estimates of concentration that, while "accurate", are not representative and reproducible (i.e. will result in a standard error for a particular analyte on a particular standard sampling day across the network that is so large that no meaningful comparisons with other standard sampling days and sties are possible). It is very difficult to minimize internal sampling and analytical errors when a monitoring network is within a single country, but when a network crosses 12 countries and involves many institutions and laboratories, a strong QA/QC is absolutely essential to avoid producing a lot of "precise" numbers that are not statistically useful for location and time comparisons. As an example, initial QA/QC work done early in the Lake Victoria Environmental Management Project indicated differences of several hundred percent in reported results from laboratory assessment of standardized/known blanks by all laboratories used in the Project.

Sub-component One: Development of a QAQC Plan: A QA/QC plan will be developed that identifies of the aspects of QA/QC that need to be addressed as integral to the network's operation. This will include, siting considerations, instrument manuals, QA/QC manuals for field and laboratory operations, data documentation, sample collection and analysis procedures etc. A corollary benefit of the detailed QA plan will be that it will provide an index of all network documentation as well as a record of all changes made to documents (and procedures) as the network develops. Additionally, the QA plan will identify the basic proficiency levels of staff required for each of the fundamental tasks in the network (sample collection, analysis and database construction). The plan will provide an operational framework and document the management structure including responsibilities of staff positions in the network. This is especially important as the network will be operating in a number of countries and a clear understanding of roles and responsibilities will be essential to the smooth operation of the network.

Sub-component two: Documentation of Procedures: Clearly documented procedures for all aspects of network operation are essential to ensure consistent operation and comparable data. This is especially important because of the number of different countries involved, and the use of different languages in some of the countries (French, English and Portuguese). To minimize ambiguity, each procedure will need detailed documentation. The specific tasks or elements requiring documentation include:

- Specification of equipment and method characteristics and performance parameters.
- Site requirements, specifications and documentation.

- Instrumentation manuals and equipment maintenance procedures and schedules.
- Operational procedures for precipitation sample collection, storage, transport to the laboratory and documentation. (This will require input from each of the participants as transportation and laboratory arrangements in particular are likely to be country-specific).
- QA/QC procedures for precipitation sample collection.
- Operational procedures for air concentration sample collection (air concentration data will eventually be modeled using meteorological, orographic and vegetation information to provide deposition rates.
- Documentation requirements for all samples and the means of recording the data.
- Meteorological data collection specifications as a minimum wind speed and direction (frequency of measurement needs to be defined). Some sites may require this instrumentation since national meteorological stations may be too far away or there is insufficient meteorological data to eventually provide inputs for the model.
- Laboratory analysis procedures for wet and dry samples.
- QA/QC procedures for laboratory analysis.
- Documentation of laboratory data including raw data and calculation, and detailed QC data.
- Reporting requirements and details of where data will reside.
- Type and characteristics of the database and documentation of database features including the computer platform and software required for its operation.

Additionally, the procedures will include recommendations for collocation of some sites to assess measurement precision and nature and frequency of external audits at each site. As a minimum, one external audit per site will be needed to assist with identifying problems and to document the viability of each site's operation.

The QA/QC manager and ultimately the network manager will ultimately be responsible for the output of the network's operation and thus responsible for maintenance of this QA system and the documentation.

Note that the cost for this activity does not include travel costs since there should be no costs associated with travel for this assignment. In addition, the manual will be provided in English only at this cost. Translation into other languages is possible but the associated cost has not been determined.

Component 2: Training

Training will be required since the type of network and measurements being proposed are new to the region and thus it is unlikely that staff can be recruited with sufficient experience in the specific (and often novel to the staff) instrumentation and methods to be employed in the network. Moreover, the purpose and eventual outcome of the network and its organization need to be described to ensure that all participants understand the objectives. Detailed training on methods will ensure that all participants are operating on a common footing and that the operation in the field, laboratories and in data documentation will be as consistent and uniform as possible. The basis for the training will be the QA plan and the procedures developed as part of the previous activity. It may also be desirable, but not essential, to provide an introductory course on atmospheric chemistry and physics as basic nomenclature and atmospheric processes would form part of such a course and thus provide a common basis of understanding for the network staff. The subactivities and costs related to training are described below. All QA/QC and training activities assume that the venue costs will be covered by an in-country sponsoring agency and that audio-visual aids for computer displays will be provided on-site. It is also assumed that students and participants will have their own computer systems to work on and that internet access will be provided at the training site.

Sub-component 1: Field instruments and sample collection, including QA/QC and documentation: A course will be developed and materials provided (preferably distribution will be by internet to minimize distribution costs) and subsequently delivered based on the procedures documented in the previous activity, addressing siting, establishment of sites, instrumentation, operational procedures, storage and transport methods and documentation of sample collection. This will be for precipitation collection as well as sampling to determine airborne levels of particulate matter and nutrients. Measurement of meteorological parameters will also be described.

Sub-component 2: Laboratory analysis, QA/Qc, and database development. A course will be developed and materials provided (preferably distribution will be by internet to minimize distribution costs) and subsequently delivered based on the procedures documented in the previous activity, addressing laboratory analysis procedures and documentation data. This will include methods of analysis for gravimetric determination of suspended particulate matter and analysis of nitrogen and phosphorus species. QA/QC procedures will also be described. Since this activity will lead directly to data processing on a network basis, it is suggested that overall network QA/QC and the database will form a good complementary topic and should be covered in this course.

Sub-component 3: Auditing. Certification of network performance will require site and laboratory audits. It is recommended that the auditing system for ISO 17025 be used for this purpose and that a few auditors including the network QA/QC manager be trained in these procedures so that site and laboratory audits can be regularly undertaken. A training course developed using these principles will require about 3 days to deliver and because of the intensive training required should be limited to a maximum of 4 participants in addition to the instructor.

Sub-component 4: Introductory courses in atmospheric chemistry and physics. As indicated above, it may be useful but not essential to provide a core group of network scientific managers with a course on basic atmospheric physics and chemistry including basic methods of measurement. Such a course would require at least 26 course hours of training not including assignments and marking to provide a certificate. As a lot of material will be covered the course should be delivered over an 8 to 10 day period with a maximum of 3 hours of formal instruction per day. One-on-one assistance would form the balance of the day. To be more relevant to the students the material should seek as much as possible to use African examples.

Component 3: Air and Precipitation Monitoring

Past and current monitoring has indicated the need for regional monitoring of airborne particles and their composition respecting nutrients primarily, but not exclusively, nitrogen and phosphorus. The methods used also need to be upgraded to meet the data needs, including greater spatial and temporal coverage as well as greater accuracy in determination of these parameters. Experience in Europe and North America since the 1970s has provided viable and scientific based methods to address this issue for related species such as airborne particulate sulfates and nitrates and gaseous contaminants. The conceptual approach has been to undertake detail diagnostic studies at selected, well controlled locations to provide fundamental scientific data on mechanisms and detailed budgets for target compounds. With reference to the network proposed in this proposal, such budgeting exercises are being done or have been done for Lake Malawi, Lake Victoria and Lake Bosumtwi. Strategic network monitoring coupled with already available sophisticated models can enable estimates of transport from and deposition to areas due to precipitation and airborne concentrations of target species. Such networks, with defined spatial density and frequency of monitoring provide information on geographic and temporal trends (e.g., diurnal, daily, weekly, monthly, seasonal and annual trends) required for linkage with terrestial and acquatic phenomena.

Precipitation monitoring

To date the approach has been to collect rainfall using manual approaches. A clean container with known surface area is placed in an appropriate location at the start of every rain event and removed at the end of the event. Since precipitation is highly variable, and can occur suddenly at inconvenient times, this, in addition to being very labor intensive, can cause the loss of early parts of rain events. Since it has been shown that the rain efficiently causes washout of airborne particles and vapors, the early fraction of each rain event can contain significantly higher amounts of contaminants than the latter part of the event. Hence if collectors are not exposed promptly, significant loss of event deposition can occur leading to underestimation of deposited amounts. In addition, these types of rain collectors can bias the collection of rainfall amount as their collection efficiency differs from that of standard rain collectors.

Because of these deficiencies it is proposed that monitoring at network sites be undertaken with automated systems such as MIC collectors (or similar collectors). These collectors consist of a two-collector system, one for wet precipitation and one for dry fall. One side of the precipitation sampler, is fitted with a collector equipped with a plastic bag. This is normally covered. Upon detection of rainfall a sensor triggers operation of the cover to move it to the dry side thus protecting the dry side if this part of the system is in active collection mode, and exposing the rain collection side for the entire event. Upon termination of rainfall, the heated sensor dries and causes the cover to move back and cover the rainfall collector and exposing the dry side to fallout. The precipitation sample can be collected every 24 hours on a regular schedule and sent for analysis. Coupled to this system is a standard rain gauge that allows accurate measurement of rainfall amount during each sampling period. The laboratory-measured concentrations of nutrients, and the volume of rainfall from the rain gauge can be combined to determine the wet deposition of nutrients to the land or water surface accurately. For deployment at remote sites it is desirable to fit the collector with a solar power source and battery to avoid the requirement for location near habitation that can lead to sample bias.

Air sampling of dry constituents (particles and particle-bound compounds)

Past and current studies in Africa because of their focus on lake deposition have used passive dry collectors to acquire deposition samples of particles and particle-bound compounds over a defined period of time onto a water surface of known dimension. These collectors cannot mimic all the natural surfaces, e.g. vegetations types, that collect dry deposition. Passive collectors can be influenced by local aerodynamic effects and electrostatic effects that lead to biased collection of airborne particles of different size fractions, even for water surfaces let alone natural vegetation. Small particles in particular have been shown to adhere to external surfaces rather than the surfaces normally extracted and analyzed. Since the phenomenon leading to production of nutrients in airborne particles is suspected to be due to slash burning for preparation of land for agricultural purposes and burning generally produces small particles, use of this method can severely bias the estimates of dry fall amounts of particulate matter and nutrients.

Because of these factors it is recommended that active air sampling be undertaken at all network sites. As noted above, the precipitation collectors include a dry collection side that may be used if desired and if collocated with airborne particle concentration systems can be used to determine the feasibility of continuing with the dry-fall approach at minimal incremental cost. At sites chosen because of their proximity to lakes, the passive collectors will be run concurrently with the new standard method to evaluate the error possibly inherent in past studies. The recommended standard method is deployment of a particle collection system based on 47 mm filters (standard sizes for air sampling systems) operated be means of controlled suction delivered by a pumping system such as a diaphragm pump. A typical system consists of a filter holder loaded with appropriate filter media (for nutrients Teflon 1 or 2 μm pore size is adequate) deployed by means of a mast at the 10 m level. The filter requires protection from the rain. The system design should allow lowering of the mast for sample changes. The filter holder and filter are connected to a sampling valve to allow automatic changes of samples, a mass flow control meter (recording) to control and measure flow rates and a diaphragm pump operating at approximately 5 lpm by means of flexible tubing. The flow meter and pump will need to be sheltered. The flow rate is recommended since the electrical requirements of the pump operating at that flow rate are sufficiently low to allow powering with solar collectors and batteries. This may be required in areas where power sources are scarce. Also, 5 lpm of flow should provide sufficient sensitivity for laboratory analysis of samples for the target compounds. Moreover, sampling heads are already commercially available at this flow rate to allow adaptation of PM10 and PM2.5 sampling heads should this be desirable in the future and in addition the sampling system can be adapted for monitoring of other target compounds in the future should that be desirable.

In Europe and N. America these types of systems operate on 24 h, day/night or weekly sampling schedules. For purposes of data collection daily day and night samples would be highly desirable. However the costs of such operation would be prohibitive from a field operational perspective as well as from an analysis perspective for the intitial phase of establishing the network and evaluating its capacity and data quality. It is recommended that the sampling valve be arranged to provide for collection and integration of daytime samples over 7 days and equally over 7 nights, thus delivering two samples per week per site. Once every 4 weeks a filter should be deployed to determine passive deposition to the filter that does not receive pumped air flow for correction of active filter data.

Meteorological parameters

While not required at every site, there may be sites where meteorological data are sparse and insufficient to allow interpretation of the network results. When final selection of sites is completed, the proximity of met stations will need to be investigated and it will need to be determined if some of the sites should be fitted with traditional meteorological sensors (wind speed, wind direction, temperature, relative humidity, solar radiation and a recording system) on a 10 m tower. This requirement is still undefined at this point.

Security requirements

Depending on site selection and location security arrangements such as fencing and site supervision will be required. The degree to which this will be required is unknown at this time, but provision for some costs will need to be made by local participants in the network.

Identifying the size and distribution of the Network

Based on the precipitation and dry collectors systems it is recommended that a network of as many sites as possible be developed. Tentative initial estimates indicate, that with budgetary resources available initially from this proposal,12 to 14 sites may be feasible but all of the cost estimates for equipment and operation need to be confirmed, as will the estimates for direct operation since there is currently no experience with establishing such a network on the African continent. At the workshop in Nairobi it was agreed that the initial network would consist of a minimum of 12 stations in 12 African countries spanning the diversity of land cover, climates and land management practices (especially burning) in inter-tropical Africa (Fig.2).

Database and Modeling

The network as accomplished in this proposal will return data on concentrations of nitrogen and phosphorus concentrations in wet deposition, in dry deposition (by passive sampling at lake sites only) and in total particle mass in air for a minimum of 12 sites from nearly daily (for wet deposition) to weekly for particulates in air to biweekly time scales (for passive dry deposition sampling at lake sites. The data available will accumulate rapidly at all 12 sites and effective database management will be required at the national level as well as at a central database for EADN that would be web accessible by all participants, with secure access initially only to participating agencies but eventually to public access. These output data will be able to identify subregional differences in atmospheric chemical composition and to evaluate differences in wet deposition across the EADN. They will be adequate to In order to analyze the data it will be necessary to use a sophisticated meteorological model. On the regional scale up to 800 km Lagrangian or Eulerian models such as CALPUF for fine particulates or DEAD for coarse particulates can be used, on larger scales it may be necessary to use more sophisticated models such as those used in N. America (RADM) and Europe that deal with continental scale phenomena. Lagrangian models are generally easier to run and have lower computing requirements than Eulerian models. The current challenge is to establish an operating network delivering reliable data, but at the same time some resources should be devoted to investigate appropriate models to meet the objectives of the current program and to establish contacts that can assist in this evaluation. The modeling objectives are to use the network information to develop concentration and deposition fields for the target parameters. A means will need to be developed to collect or input emissions data, orographic information and vegetation information in addition to the precipitation, air concentration and meteorological information. The complexity and size of this task should not be underestimated especially since this will be a brand new exercise introduced to the continent on a scale that has not previously been envisioned.

Project Implementation Coordination

With so many countries and agencies involved in the EADN it is essential that there be strong, central coordination of national inputs, and that this central coordination be very cost effective. Since GEF funds are very limited, it is essential that it be concentrated on operating the monitoring network. The EADN will therefore be implemented at the national level, but coordinated by the Pan African START Secretariat (PASS) in the University of Nairobi, Kenya. PASS is an existing regional body of African scientists and institutios that is associated and housed in the University of Nairobi, but is financially independent from it. It also has rights granted from the Government of Kenya, to operate a USD account. EADN will not need to set up a separate, transitory, project implementation unit. Nor will the Project need to establish national Project implementation units, as national implementation will be through identified (based on mutually agreed terms) research institutions

<u>Regional Coordination of Project Implementation will be through a centralized agency representing all participating countries (the role of PASS)</u>*:* Implementation coordination at the regional level will involve two structures: a Regional Executive Secretariat (and the participating countries have designated PASS to fill this role) which will manage the operational aspects of the project, and a Regional Management Board, comprised of the technical heads of the agencies responsible for operating and maintaining the monitoring sites in participating countries. The Regional Management Board will provide technical oversight over the secretariat and the project.

The Regional Executive Secretariat will be managed by the Director of PASS and supported by two full-time professionals: 1) a Data and Information Technology Manager, 3) a Regional Procurement and Financial Manager. An appropriate level of support staff would also be hired in the Secretariat. The Project would support the operational travel and Project-related expenses of the Director of PASS in his role as Regional Coordinator of the EADN, but not salary. The RES will also manage the Grant Special Account, disburseing funds from it to participating organizations and submitting claims to the Bank for replenishment of the Special Account according to procedures of the World Bank.

<u>The Regional Management Board has the supreme power and authority over all matters relating to the overall technical operation of the EADN</u>. The Regional Management Board (RMB) will mainly operate in "electronic cessions" rather than physically meet. All decisions taken regarding the operation of the EADN by the Regional Management Board are binding on national implementing agencies. The Regional Secretariat (PASS) will regularly submit QA/QC, semi-annual tables of raw data generated from the EADN, and current status of disbursement of funds to the Regional Management Board for assessment, monitoring and evaluation. Recommendations sent to the Regional Secretariat by members of the Regional Management Board will be compiled and sent back as a set of recommendations to the RMB for consideration. The RMB will meet physically at least twice. Once, half-way through the Project implementation period, and at the end of the implementation period to agree on recommendations for continued operation of the EADN.

3.5 Implementation Arrangements

The project will be implemented both at the national and regional level, similarly project finances and cash flows will be managed at both levels**.** The Regional Executive Secretariat will act as overall project management unit which will provide regional financial, procurement, and harmonization services to the respective EADN operating units established in each. GEF financing, along with other donor finances will be routed through the Regional Executive Secretariat. By Effectiveness, the Secretariat will be staffed by a qualified Regional Finance and Procurement Manager who will be responsible for establishing a financial management system that will be adequate to account and report for project resources and expenditures. A financial management manual will be developed within 3 months of Effectiveness for the overall FM framework for the project and to facilitate the harmonization and uniformity of procedures used by each implementing country. At national/country level, reliance on existing countriy and/or EADN implementing agency's existing accounting and financial management systems will be applied as far as possible. In cases were there are critical weaknesses, an agreed action plan will be developed to address weaknesses before the project effectiveness or during the implementations as may deem necessary based on the individual country/implementing agency FM capacity assessment.

Flow of funds will occur from the Grant Account in Washington to the Project GEF Grant dollar Special Account to be opened and maintained in a reputable commercial bank acceptable to the WB by the Regional Secretariat to be established in Nairobi, Kenya. Funds for the EADN will be apportioned on a universally developed and approved basis to various EADN member countries, reflecting each country's contractual obligations entered with IDA/GEF through the individual Project Grant Agreements (one for each country participating in the EADN) to support project components and sub components. Funds to support the coordination activities of the regional executive secretariat and pay for harmonization activities between two or more countries will be retained by the Regional Secretariat and released to the respective country as needed.

The Funds will flow from the IDA/GEF main dollar Special Account to the respective project accounts to be opened and maintained by the various implementing agencies by project effectiveness. Upon submission of individual quarterly disbursement requests and based on a yearly work plan approved by the PMC, the Regional Secretariat will transfer funds to EADN implementing agencies in each country. These funds will be used to pay for national operational costs, small procurement, and any other local expenses associated with operating and maintaining the monitoring stations and to pay for analyses of samples in Project-approved national laboratories. Replenishment of funds to the project account maintained by each agency will be made on the basis of new quarterly disbursement forecasts /work plan and Statement of Expenditure (SOEs), with attached supporting documentation accounting for expenditures incurred in the previous quarter to be submitted to the Regional Secretariat in Kenya.

Disbursements from IDA would initially be made on the basis of incurred eligible expenditures (transaction based disbursements). IDA would then make advance disbursement from the proceeds of the Credit by depositing into a Regional Secretariat -operated Special Account (SA) to expedite project implementation. The advance to a SA would be used to finance GEF's share of project expenditures under the proposed Grant.

Upon credit effectiveness, the Regional Secretariat would be required to submit a withdrawal application for an initial deposit to the SA, drawn from the GEF Grant, in an amount to be agreed to in the Development Grant Agreement. Replenishment of funds from IDA to the SA will be made upon evidence of satisfactory utilization of the advance, reflected in SOEs and/or on full documentation for payments above SOE thresholds. Replenishment applications would be required to be submitted regularly. If ineligible expenditures are found to have been made from the SA, the Borrower will be obligated to refund the same. If the SA remains inactive for more than six months, the Borrower may be requested to refund to IDA amounts advanced to the SA.

<u>Most procurement under the EADN will be for acquisition of monitoring equipment</u>. The procurement of these goods will be undertaken in bulk for all monitoring stations by the Regional Executive Secretariat. The tender will specify delivery to and acceptance by the EADN implementing agency in each participating country. Procurement of simple works to secure the monitoring sites will be done by the implementing agencies with help from the Regional Executive Secretary in preparation of bid documents.

3.6 Funding

Baseline funding.

Under the baseline funding scenario, no significant increase over the existing very low base of basin and national monitoring of airborne pollutants (of any kind) is expected. Although there is some regional monitoring of meteorology and airborne pollutants in southern Africa and in west and east Africa, no historical cooperation exists amongst equatorial African countries for monitoring the atmosphere. There are three reasons for this, including: i) Lack of funding; ii) political instability; and importantly, iii) the countries do not realize the nature and magnitude of the impact that atmospheric deposition of macronutrients have on large, inland lakes and impoundments in the part of Africa and how their agricultural development support may be involved.

Incremental Cost Justification of the EADN

The EADN is designed to integrate with existing and proposed GEF International Waters projects on African Great Lakes. These projects (and particularly the second phase of the Lake Victoria Environmental Management Project) will include establishment of atmospheric deposition monitoring sites within the various lake basins. Although these are also regional activities, they do not include support for monitoring outside the target basins. Without input from the EADNs, it is unlikely these other regional activities specifically promoting sustainable and equitable use of shared water bodies would be able to properly identify and scope solutions to the problems posed by eutrophication.

The EADN will:

- Raise awareness amongst all African countries of the problems resulting from inappropriate land uses and associated degradation of the value of the resources of African Great Lakes

- Help identify types and locations of large scale land uses that are contributing to atmospheric loading of macronutrients that are subsequently deposited into African Great Lakes and other inland water bodies;

Link countries that are regional sources of problematic land uses that contribute the largest part of the macronutrient loading into the atmosphere with those countries that are impacted by subsequent deposition of these macronutrients.

3.7 Progress to Date

This Concept Note is the result of a regional workshop supported by a PDF-A grant. The institutions participating in this workshop prepared the general outline and substance of this proposal and will form the core of the EADN. These institutions and representatives of each follow.

Institution	Country	Person
University of Nairobi	Kenya	Shem Wandiga
University of Nairobi (PASS)	Kenya	Eric Odada
Lake Victoria Env. Mgt. Prj. (LVEMP)	Kenya	John Okungu
University of Nairobi (PASS)	Kenya	Daniel Olago
Maseno University	Kenya	Joseph Abuodha
University of Nairobi	Kenya	Vincent Madadi
University of Nairobi (PASS)	Kenya	Michael Marshall
Egerton Universtiy	Kenya	Millicent Oketch
LVEMP	Kenya	Samuel Gor
NEMA	Kenya	Rose Antipa
UNEP	Kenya	Mahendra Kumar
NEMA	Kenya	Joyce Onyango
Makerere University	Uganda	Bernard Kiremire
Heritage Oil & Gas Ltd	Uganda	Samuel Ochola
NARO-FIRI	Uganda	Christopher Kiiza
University of Dar es Salaam	Tanzania	Michael Kishimba
University of Dar es Salaam	Tanzania	Rashid Tamatamah
Centre de Recherches en Science Naturelles	Democratic Republic of the Congo	Jean Jacques Bagalwa
Institut Superieur D’ecologie	Rwanda	Bisimwa Mubwebwe Arthur
Blantyre Water Board	Malawi	Mangaliso Gondwe
University of Lagos	Nigeria	Kehinde Olayinka
Oceanography and Fisheries Department	Ghana	Adelina Mensah
Copperbelt University	Zambia	Misery Mulele

Universite de Lome	Togo	Ayite-Lo Ajavon
Scientific Council of the Scientific Research Association	Mozambique	Manuel Chenene
Norwegian Institute for Air Research	Norway	Henrik Kylin
University of Waterloo	Canada	Bob Hecky
University of Wisconsin	USA	Harvey Bootsma
Air Monitoring & Analysis	Canada	Phil Fellin (consultant)

4. Safeguard policies that might apply

[Guideline: Refer to section 5 of the PCN. Which safeguard policies might apply to the project and in what ways? What actions might be needed during project preparation to assess safeguard issues and prepare to mitigate them?]

5. Tentative financing

Source:		($m.)
BORROWER/RECIPIENT		2
GLOBAL ENVIRONMENT FACILITY		3.5
BILATERAL AGENCIES (UNIDENTIFIED)		1.5
	Total	7

6. Contact point

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