Project Summary

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Title: Biosphere-Atmosphere Stable Isotope Network (BASIN)

Duration: 60 months

Requested Budget: $325,901 total

Ecologists and atmospheric scientists from terrestrial ecosystem sites located on different continents have formed the **B**iosphere-**A**tmosphere **S**table **I**sotope **N**etwork (BASIN), with the goals of (a) developing and promoting common approaches for measurements of stable isotopes within ecosystem gas-exchange studies which allow cross-site data comparisons, (b) encouraging integrated efforts, such as production of global maps, describing the variations in the isotopic composition of CO_2 exchanging between terrestrial ecosystems and the atmosphere that can be used for better constraining predictions of global carbon cycle models, particularly at FLUXNET eddy covariance sites across the globe, (c) bringing investigators together for workshops exploring such topics as (i) the mechanistic basis and environmental factors determining changes in the isotopic composition of CO_2 exchanging between terrestrial ecosystems and the atmosphere, (ii) partitioning ecosystem CO_2 fluxes into their respiratory and assimilatory components for better understanding the basis of ecosystem-scale gas exchange, and (iii) experimental approaches for scaling CO_2 gas exchange from patch through regional scales, (d) promoting and coordinating regional cross-site studies which allow development of linkages between ecologists at the ecosystem scale and atmospheric scientists at the boundary layer mesoscale, (e) providing opportunities for cross-site training of both young and under-represented investigators in the latest methodologies and analytical approaches, and (f) development of web-accessed databases to be used in terrestrial ecosystem and global carbon cycle studies. BASIN is a Global Change and Terrestrial Ecosystem (GCTE) activity whose goals are to foster, promote, and encourage integration of stable isotope measurements into carbon cycle studies at ecosystem, regional, and global scales. The BASIN activities and products are relevant beyond ecological scales, since integrated data products serve as direct constraints on the possible interpretations of global

carbon cycle simulations and also provide a mechanistic basis for interpreting biosphere-atmosphere CO_2 fluxes within different ecosystems. Funds requested with this proposal will be combined with a similar proposal to be submitted to the European Science Foundation to ensure adequate opportunities at both national and international scales for network development, cross-site training, field campaign integration, and workshops.

Individuals participating in BASIN include Peter Bakwin (NOAA, Boulder), Joseph Berry (Carnegie Institution of Washington), Dave Bowling (University of Utah), J. Renee Brooks (EPA, Corvallis), Nina Buchmann (Max Planck Jena, Germany), Jeff Chanton (Florida State University), Peter Curtis (Ohio State University), Todd Dawson (UC Berkeley), Scott Denning (Colorado State University), Jim Ehleringer (University of Utah), Julianna Fessenden (University of Utah), Larry Flanagan (University of Lethbridge, Canada), Inez Fung (UC Berkeley), Dave Hollinger (USFS, Durham), Nigel Livingston (University of Victoria, Canada), Jon Lloyd (Max Planck Jena, Germany), Luiz Martinelli (University of Sao Paulo, Brazil), Jim Randerson (Cal Tech), Rolf Siegwolf (Paul Sherrer Institute, Switzerland), Chris Still (Carnegie Institution of Washington), Neil Suits (Colorado State University), Peter Tans (University of Colorado), Margaret Torn (UC Berkeley), Reynaldo Victoria (University of Sao Paulo, Brazil), Jeff Welker (University of Wyoming), Lisa Wingate (University of Edinburgh, UK), and Dan Yakir (Weizmann Institute, Israel).

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Project Description

Biosphere-**A**tmosphere **S**table **I**sotope **N**etwork (BASIN)

Stable isotope ratios (δ) of CO_2 are recognized as a key element for improving our interpretations of the carbon cycle at the ecosystem, regional, and global scales. The $\delta^{13}C$ and $\delta^{18}O$ analyses of CO_2 have been an element of the international global flask network for over a decade, where these data are essential in partitioning fluxes within the global carbon cycle. At the physiological and biochemical scales, the basis for $\delta^{13}C$ and $\delta^{18}O$ variations in plants are reasonably well understood. Bridging between these physiological and global scales by now also focusing at the ecosystem scale is critical and likely to lead to new breakthroughs in our understanding of the terrestrial carbon sinks and distinguishing between the fluxes of photosynthesis and respiration in ecosystems. In this regard, the Global Change and Terrestrial Ecosystems (GCTE) Project of the International Geosphere Biosphere Programme (IGBP) recently formed the **B**iosphere-**A**tmosphere **S**table **I**sotope **N**etwork (BASIN) to focus on coordinating and promoting ecosystem research on the isotopic fluxes that bear on improving our understanding of ecosystem processes and of the global carbon cycle. The U.S. Carbon Cycle Science Plan (1999) recognizes the need to now expand atmospheric monitoring over terrestrial surfaces and the need to have a stronger characterization of the isotopic composition of CO_2 in terrestrial biosphere-atmosphere exchange. In that regard, the NSF, DOE, NASA, NOAA, and USDA are initiating new research programs to better understand the global carbon cycle and the role that the terrestrial surface will play in moderating anthropogenic CO_2 inputs and in determining the isotopic composition of the atmosphere. The BASIN effort is already underway with initial workshop funding from DOE and NASA to form a network for integrating this ecosystem-scale isotopic research.

Also at the ecosystem scale, eddy covariance methods are a powerful approach for determining the seasonal and long-term ecosystem carbon balances (Baldocchi et al., 1996; Valentini et al., 2000). These site-based studies are particularly useful for understanding functioning of individual ecosystems, but cross-site integration is a key element in any continental or global integration. FLUXNET is the IGBP international network for integrating eddy flux sites. The BASIN effort complements existing flux network efforts evaluating mechanistic explanations of observed net ecosystem exchange patterns (e.g., FLUXNET), provides a bridge between ecosystem and regional flux efforts, and develops a network for more realistic and dynamic ecological inputs into carbon balance modeling (http://GCTE-Focus1.org/BASIN.html).

Why should investigators come together to form a network?

Isotopes as tracers of regional and global carbon fluxes. The concentration and isotopic composition ($\delta^{13}C$, $\delta^{18}O$) of atmospheric CO_2 are key variables used in the analysis of the global carbon cycle by inversion of atmospheric transport models (Tans et al., 1990, 1993, 1996; Enting et al., 1995; Ciais et al., 1995; Keeling et al., 1995, 1996; Fung et al., 1997; Lloyd et al., 1996).

This is a direct link between biological and physical sciences. Carbon isotopes are used in inverse calculations to distinguish oceanic from terrestrial exchange processes and in evaluating the magnitude of the terrestrial carbon sink (Tans et al., 1993; Enting et al., 1995; Keeling et al., 1995, 1996; Fung et al., 1997; Ciais et al., 1999). These tracers have tremendous potential to improve our understanding of the terrestrial carbon cycle. However, there are limited integrated data sets available regarding the isotope effects on CO_2 exchange between terrestrial ecosystems and the atmosphere. Most ^{13}C data available are for leaves of individual species and not canopy-scale CO_2-exchange measures (Lloyd and Farquhar 1994). Establishing the ^{13}C variations in ecosystem-level responses is critical. Assuming a terrestrial biosphere with fixed versus dynamic ^{13}C signal will necessarily influence the magnitude of any regional terrestrial carbon sink (Fung et al., 1997). The biology matters and it is only through network efforts that we can link to provide the basic data sets needed to understand how the biospheric ^{13}C signal varies in time and space.

We know that carbon isotope discrimination by C_3 and C_4 plants varies with physiological and meteorological factors (Farquhar et al., 1989; Ehleringer et al., 1993), leading to both spatial and temporal changes on a regional basis. Furthermore, C_4 species account for a significant fraction of terrestrial productivity, some 16 - 30 % of total terrestrial photosynthesis (Lloyd and Farquhar 1994; Fung et al., 1997; Collatz et al., 1998). Many natural grassland ecosystems contain a mixture of C_3 and C_4 species, and the proportion can vary seasonally and interannually with climatic fluctuations. The quality of atmospheric inversions to estimate locations and magnitudes of terrestrial carbon sinks would be improved if terrestrial $^{13}CO_2$ exchange data were available to constrain our understanding of these variations.

Introduction to the Science Topics Addressed and Integrated with the Network

Interpreting the carbon isotope ratio signal of terrestrial photosynthesis. Photosynthesis discriminates against $^{13}CO_2$, resulting in organic matter ($\delta^{13}C_p$) that is ^{13}C depleted relative to the atmosphere. For C_3 plants, the overall relation is

$$\Delta = a + (b - a)(c_i/c_a) \qquad (1)$$

where c_a and c_i are the atmospheric and intercellular partial pressures of CO_2, respectively, a = 4.4 ‰ (diffusional fractionation against $^{13}CO_2$), and b =27 ‰ (net fractionation during carboxylation) (Farquhar et al., 1989; Ehleringer et al., 1993; Lloyd and Farquhar, 1994). For C_4 plants, CO_2 is concentrated by a biochemical mechanism so that b is substantially lower in value. In C_3 plants, c_i is subject to change (0.5 - 0.8), mostly as a function of changes in the stomatal conductance relative to CO_2 assimilation capacity. Discrimination during photosynthesis has been viewed at three scales: leaf, canopy, and ecosystem. While the Δ describes carbon isotope discrimination at the leaf level (Farquhar et al., 1989), Δ_{canopy} is the integrated photosynthetic discrimination of all leaves within the canopy. Δ_{canopy} should be mostly influenced by upper canopy leaves, since this is typically where most canopy-level photosynthesis takes place. Yet lower canopy and/or understory leaves with higher Δ values due to exposure to shady conditions would also be expected to influence Δ_{canopy}.

The carbon isotope ratio of ecosystem respiration is not a constant. In the same manner that weather is a critical and variable input for modeling, the same applies to the biological processes that impact biosphere-atmosphere gas exchange. Measurements of $[CO_2]$ and isotope ratios are important observations in our efforts to bridge the gap between global inversions and ecosystem-scale CO_2 exchange studies. Integration of these individual efforts into a research network will go a long way towards improving global carbon cycle modeling efforts. Keeling (1958) determined that the carbon isotope ratio of CO_2 respired from ecosystems ($\delta^{13}C_R$) could be measured based on changes in the concentration ($[CO_2]_{a-i}$) and isotope ratio of atmospheric CO_2 ($\delta^{13}C_{a-i}$) within the footprint of interest. Keeling (1958) showed that by plotting the mixing relationship between $\delta^{13}C_{a-i}$ and $1/[CO_2]_{a-i}$ of atmospheric CO_2, a linear relationship was obtained and the intercept of this relationship was the isotope ratio of the respired CO_2 input into the canopy air space (Fig. 1):

$$\delta^{13}C_{a-i} = \frac{[CO_2]_{a-o}}{[CO_2]_{a-i}} \bullet (\delta^{13}C_{a-o} - \delta^{13}C_R) + \delta^{13}C_R \quad , \qquad (2)$$

where the subscripts *a-i* and *a-o* represent the atmosphere inside a canopy and the atmosphere above (outside) the forest, respectively. We see from Equation 2 that a plot of $1/[CO_2]_{a-i}$ versus $\delta^{13}C_{a-i}$ gives a straight line relationship with an intercept, $\delta^{13}C_R$. At the ecosystem or forest canopy scale, $\delta^{13}C_R$ represents a spatially integrated measure of the $\delta^{13}C$ of CO_2 respired from both vegetation and soil components. Buchmann et al. (1998) defined $\Delta_{ecosystem}$ as the difference in the $\delta^{13}C$ values of CO_2 in the free troposphere ($\delta^{13}C_t$) and that released by ecosystems ($\delta^{13}C_R$). Thus, while Δ_{canopy} is defined as a spatially integrated measure of the fractionation during photosynthesis, $\Delta_{ecosystem}$ integrates all photosynthetic and respiratory aspects of both vegetative and soil elements.

The $\delta^{13}C_R$ values within an ecosystem do not remain constant, but reflect the consequences of changes in weather on photosynthetic processes. Biology matters and the linkage of efforts among sites is critical to obtaining the regional and global perspectives, needed for carbon cycle models. Consider recent observations collected at the Wind River Canopy Crane ecosystem in southern Washington (an AmeriFlux site) during dry and wet years by Julianna Fessenden and Jim Ehleringer (DOE-WESTGEC project). The $\delta^{13}C_R$ values responded to seasonal and interannual differences in climate, changing by more than 5 ‰ in response to El Niño and La Niña years. In part, the changes in $\delta^{13}C_R$ reflected shifts in Δ_{canopy} in response to changes in soil moisture availability. Despite the tremendous progress in understanding at the leaf-level, scaling to the whole canopy is still poorly documented and integrated at the moment. Shifts in $\delta^{13}C_R$ are not only responsive to changes in climate, but land-use history also plays a significant role. Aspects of ^{13}C exchange between the biosphere and atmosphere exhibit changes with stand

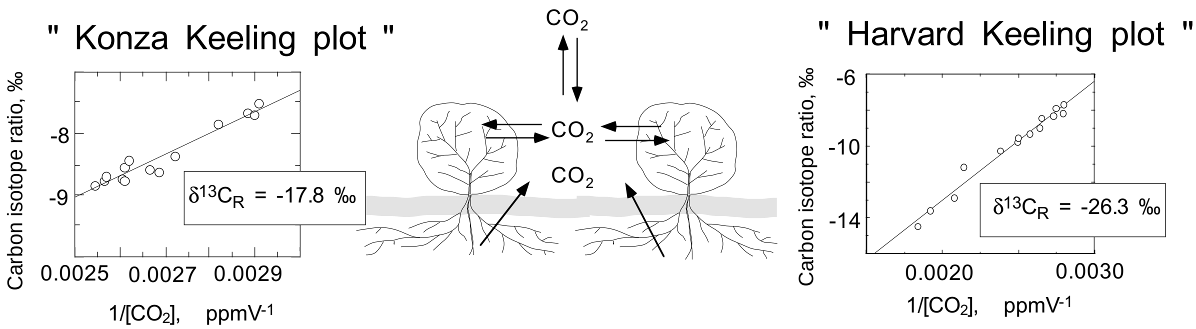

Figure 1. Keeling plots. Respired carbon dioxide from canopies and soils is mixed by turbulent motion in the air spaces within a canopy. This ecosystem-respired carbon dioxide increases the atmospheric carbon dioxide concentration. If we sample air within the canopy and analyze the carbon dioxide for both concentration and isotope ratio, we create a "Keeling" plot as shown.

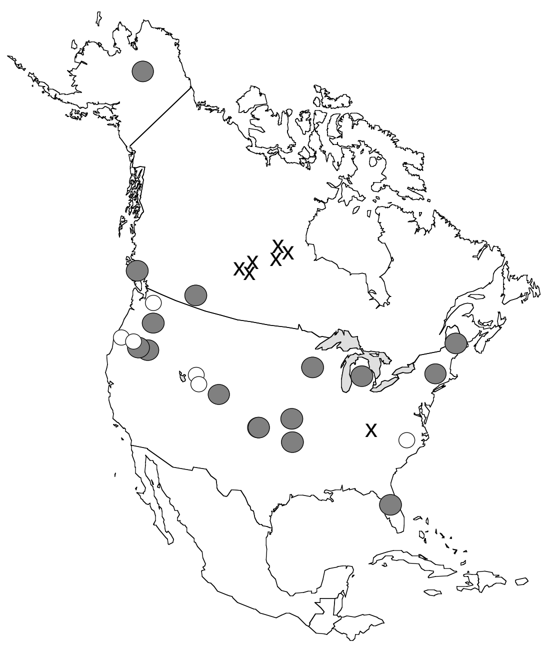

Fig. 2. North American AmeriFlux sites with isotope ratio sampling initiating or underway with sampling at least once per year or conducted in the past but not ongoing at the moment (x). For further information, visit the BASIN homepage (http://GCTE-Focus1.org/BASIN.html). Other non-AmeriFlux sites with extensive sampling in the past or underway now are shown with open circles.

development, which mimic leaf-level patterns observed by physiologists (Panek, 1996; Ryan et al., 1997; Hubbard et al., 1998). These changes may reflect aspects of canopy development, such as shifts from a forest with a single dominant tree species to a forest stand with significant overstory and understory components, differing in their ^{13}C values. BASIN activities will include coordination of synthesis efforts focusing on how $\delta^{13}C_R$ and Δ_{canopy} change across different ecosystem types in response to climatic variation.

The $\delta^{13}C_R$ values for deciduous forests, such as Harvard Forest, and grasslands, such as Konza Prairie, illustrate the pronounced $\delta^{13}C_R$ differences between C_3- and C_4-dominated ecosystems (Fig. 1). Moreover, there can be significant seasonal variations associated with hydrological changes in forest water balance (Buchmann et al., 1997) or with changing C_3/C_4 dynamics (Buchmann and Ehleringer, 1998). The $\delta^{13}C_R$ also represents a temporal integration, including contributions from different aged carbon pools that have different turnover times and $\delta^{13}C$ values. This network will pull together efforts to directly examine changes in $\delta^{13}C_R$ over seasonal and interannual time scales and across continental and global geographic scales.

Partitioning of NEE into photosynthesis and respiration components. The eddy covariance measurement approach can continuously monitor and provide precise measurements of net ecosystem exchange (NEE). Through AmeriFlux and FLUXNET, considerable effort is devoted to the precise measurement of NEE across a range of ecosystems and land-use types. The eddy covariance measurement alone does not allow the independent partitioning of the component processes of NEE, which consists of the small difference in two major flux components:

$$NEE = F_A + F_R \quad , \qquad (3)$$

where F_A and F_R represent the total assimilatory and respiratory fluxes, respectively. These important processes are subject to different environmental constraints and show differences based on land-use history. A recent study of European forests (EUROFLUX) by Valentini et al.

(2000) suggests that changes in ecosystem respiration and not photosynthesis are the main determinant of increases in the carbon balance of European forests. Bowling and Monson (2000) proposed a novel approach for BASIN efforts that combined isotopic analyses of CO_2 and NEE fluxes to separate NEE into its photosynthetic (F_A) and respiratory (F_R) components:

$$^{13}NEE = (\delta^{13}C_R)(F_R) + (\delta^{13}C_{a-o} - \Delta_{canopy})(F_A) \qquad (4)$$

where ^{13}NEE represents the net ecosystem exchange for $^{13}CO_2$. Conceptually, Bowling and Monson (2000) have simply identified that the net ecosystem exchange for $^{13}CO_2$ has two basic components: the total $^{13}CO_2$ added to atmosphere $(\delta^{13}C_R)(F_R)$ and the total $^{13}CO_2$ removed from the atmosphere by photosynthesis $(\delta^{13}C_{a-o} - \Delta_{canopy})(F_A)$. Δ_{canopy} is the mean canopy isotope discrimination, in contrast to Δ, which is the carbon isotope discrimination value for any individual leaf within the canopy. One exciting BASIN interest is to understand how different ecosystems balance photosynthetic carbon gain relative to the respiratory losses. Only a coordinated effort can pull together an intensive field campaign to simultaneously measure these patterns across large geographical scales.

BASIN Activities and Objectives

BASIN is a Global Change and Terrestrial Ecosystem (GCTE) network activity whose goals are to foster, promote, and encourage integration of stable isotope measurements into carbon cycle studies at ecosystem, regional, and global scales. The 6 objectives of this network are:

(a) developing and promoting common analytical approaches for measurements of stable isotopes within ecosystem gas-exchange studies which allow cross-site data comparisons,

(b) encouraging integrated efforts, such as production of global maps, describing the variations in the isotopic composition of CO_2 exchanging between terrestrial ecosystems and the atmosphere that can be used for better constraining predictions of global carbon cycle models,

(c) bringing investigators together for workshops that integrate and cross disciplinary boundaries

(d) promoting and coordinating regional cross-site studies which provide linkages between physiologists, ecologists, and atmospheric scientists at the boundary layer mesoscale,

(e) providing opportunities for cross-site training of both young and under-represented investigators in the latest methodologies, analytical approaches, and modeling studies,

(f) development of web-accessed databases to be used in terrestrial carbon cycle studies.

Common measurement approaches across ecosystems. If BASIN is to help promote development of a network that will provide data to better constrain global carbon models and improve our understanding of ecosystem component fluxes, we must invest time in ensuring development and promotion of common approaches for measurements of stable isotopes which will allow cross-site data comparisons. This was a conclusion of the initial workshop (ftp://ecophys.biology.utah.edu/BASIN/BASIN98.pdf). Perhaps the best way to achieve this goal is through a combination of interlaboratory comparisons, establishment of uniform sampling strategies, and exchanging graduate students and postdocs among different labs for opportunities to learn experimental and modeling techniques. BASIN will coordinate this activity among the current and emerging sites measuring biosphere-atmosphere isotope fluxes (e.g., Fig. 2).

Synthesis efforts - expansion of the existing $\delta^{13}C_R$ data base to form a global database. To really understand the magnitude and distribution of any terrestrial carbon sink, we need a better understanding of how $\delta^{13}C_R$ and Δ_{canopy} vary in response to climatic factors, geographical gradients, and land-use history. Some ecosystems may exhibit limited variations in $\delta^{13}C_R$, whereas others are likely to be dynamic and responsive. Fung et al. (1997) stressed the importance of constraining the degrees of freedom in global carbon cycle inversions by improving our understanding of the ^{13}C exchanges between the biosphere and the atmosphere. Our proposed network efforts will address this concern through both our workshops and through the annual post-AGU meeting and planning sessions.

A number of BASIN-member research efforts are already beginning to address measurements of the ^{13}C exchanges between the biosphere and the atmosphere (Fig. 2). Most sites have limited sampling history, but this is a start and more studies are being initiated each year, especially at FLUXNET sites in North America, South America, Asia, and Europe. One BASIN objective is to use the winter post-AGU workshops as opportunities to synthesize the spatial and temporal data sets to develop the global database of ecosystem respiration over time at different latitudes to constrain inverse models and to plan for simultaneous field campaign measurement periods.

There is additional information to be gained at every AmeriFlux eddy-covariance site by including $^{13}CO_2$ measurements (Flanagan and Ehleringer, 1997; Fung et al., 1997). At the international scale where AmeriFlux is but one continental effort within a global FLUXNET framework, the same logic applies. There is also significant value to be added by capitalizing on an existing network which spans isotope measurements across AmeriFlux sites. BASIN was initiated as a GCTE effort at integrating isotope and flux studies and to bridging the gap between ecosystem-scale and global-scale carbon cycle studies (http://GCTE-Focus1.org/BASIN.html).

Workshops to identify research frontiers and establish cross-disciplinary linkages. Workshops serve a critical need to bring together scientific communities with different expertise or geographic experiences to address and coordinate BASIN efforts. These are also an important opportunity to bring together new investigators (graduate students and postdocs) to interact with more established investigators in a common setting.

We propose having one international workshop per year (alternately in the US and in Europe). The primary reason for these workshops is to bring investigators together to address the critical challenges limiting progress in the field and to brainstorm over possible solutions to improve our understanding of the fundamental ecological processes and of how to bridge across disciplines, ranging from biology to atmospheric science. No specific workshop titles are identified in this proposal, because we feel that it is incumbent on the community to identify these issues. However, description of past and planned (for 2000) workshop efforts will provide a flavor of the intents of the BASIN.

Workshop history. (a) **The initial BASIN workshop** focused on identifying what ecosystem-scale information could be obtained by sampling the CO_2 and H2O isotopes within the atmosphere. While it is clear from atmospheric studies that there are large seasonal and interannual cycles, the role of biology and of particular ecosystem types was poorly appreciated. Conclusions of that workshop included the need to develop common sampling efforts, joint intensive field sampling periods to provide coherent data sets, an initial intersite data-collection effort, and the need to consider global integration as opposed to simply site-specific data sets with limited interactions among investigators. Efforts from these initial recommendations are currently being written for publication. (b) **In April 2000** several BASIN members met with ecologists at the Max Plank Biogeochemistry (Jena) (organized by Dave Schimel) to discuss what new approaches are needed in soil carbon studies to better predict fluxes and isotopic composition of CO_2 emerging from soils, especially with respect to land-use and other global changes. Key conclusions included development of new soil-carbon modeling efforts to replace CENTURY, consideration of multi-investigator efforts to measure the carbon pools most relevant to carbon-flux studies rather than historical categorizations which have no process-based relevance, and a pilot cross-disciplinary study bringing geochemists, ecologists, and carbon cycle modelers. (c) **In October 2000** GCTE-BASIN will co-sponsor (along with BAHC) a workshop addressing regional scale carbon balance. The intent is to focus on the CO_2 concentration and isotope information contained within the convective and nocturnal boundary layers as a measure of the terrestrial ecosystems processes across the landscape. This workshop brings the quite different perspectives of ecologists, environmental physiologists, atmospheric chemists, and modelers at different scales together to focus on how we can best integrate aircraft sampling and atmospheric sampling to understand carbon-flux contributions of different landscape elements.

Future BASIN workshops would explore such topics as (i) the mechanistic basis and environmental factors determining changes in the $^{13}CO_2$ exchanging between the terrestrial biosphere and the atmosphere, (ii) partitioning ecosystem CO_2 fluxes into their respiratory and assimilatory components for better understanding the basis of ecosystem scale gas exchange, and (iii) experimental approaches for scaling CO_2 gas exchange from patch through regional scales. A workshop-planning committee, consisting of the current BASIN steering committee, two at-large BASIN members, and one FLUXNET member would communicate through e-mail and teleconference to make suggestions for the annual workshop. An organizational committee, which could include some of the above members, would be responsible for planning all aspects of the workshop and, if necessary, securing any additional funding needed to carry out the workshop and produce public products. Expected products of any workshop would include 1-2 synthesis papers, one of which would be completed after the workshop and reflecting decisions derived there. Both web and hard-copy publications are expected.

Coordinating research to achieve simultaneous sampling at regional and global scales. We propose to provide travel funds to bring together BASIN participants immediately before the annual AGU meeting (December, San Francisco). The focus of these workshops will be to see what principles and common trends are emerging from ^{13}C/flux studies and to design experiments or intensive-field-campaign studies that can be carried out at our respective sites. Data exchange and developing linkages with larger-scale modeling efforts will be a focus of the initial meeting. In December 2000, we plan to have a 2-day workshop promoting and coordinating regional cross-site studies which allow development of linkages between ecologists at the ecosystem scale. This initial workshop will focus on details on exactly what information can be extracted from Keeling plots and on footprint and temporal considerations in data collection. At this and future post-AGU meetings, we will focus on coordinating our independently-funded research efforts to ensure simultaneously collected data across sites which will be useful data sets for constraining global carbon cycle models. Critical to these discussions is to ensure that global carbon modelers and atmospheric scientists are participants, not just the terrestrial ecologists. Identifying periods for common campaign-style measurements and the most critical periods within the year for sampling are BASIN activities that must emerge at these post-AGU workshops.

As a group, one possibility is to work with existing models (e.g., SiB2, BGC) which incorporate both physiological and stand parameters to see if we can model the responses of $\delta^{13}C_R$ to seasonal and interannual changes in climate across AmeriFlux and EUROFLUX sites. To the extent possible, we will collaborate on model development and testing. By initiating these modeling efforts soon after the initial data come in, members of the BASIN group should to be able to quickly understand which parameters particularly influence $\delta^{13}C_R$ and to ensure that future studies include adequate sampling of those parameters. The funds requested are for coordination of these independently funded efforts, not for conducting the research.

Laboratory exchange opportunities for learning sampling and analysis methodologies. Providing opportunities for cross-site training of both young and under-represented investigators in the latest methodologies and analytical approaches. We request funds that will allow graduate students and postdocs from different BASIN sites to go visit appropriate labs where they can learn such things as the latest details in isotope sampling, automated sample collection, learning modeling techniques. Clear communications among experimentalist and across disciplines is important. We will use a procedure where graduate students and postdocs apply to the BASIN steering committee with a brief proposal request for funds to cover these training expenses.

Management plan

Steering Committee. BASIN is overseen by a 6-person Steering Committee consisting of Joseph Berry (Carnegie Institution of Washington), Nina Buchmann (Max Planck Institute, Jena Germany), Jim Ehleringer (Chair, University of Utah), Larry Flanagan (University of Lethbridge, Canada), Diane Pataki (GCTE Science Officer, Salt Lake City), and Dan Yakir (Weizmann Institute of Science, Israel). Rotation of new members onto the committee will take place in year 3 after we have the network and interactions working to allow smooth transitions. The function of the Steering Committee is to decide on resource allocations, develop agendas for workshops, provide guidance for database developments, encourage participation by young investigators, encourage cross-disciplinary activity, and encourage incorporation of new BASIN sites.

Resource allocations. Resource allocations for (a) annual workshops, (b) post-AGU workshop, and (c) graduate student and postdoc exchange visits will be decided upon by a Resource Allocation Committee. Guidelines for fund allocations are provided in the table detailed in the Budget Justification Section of this proposal. This committee will consist of the 6 members of the Steering Committee and two other BASIN members decided at large annually. Decisions will be based on e-mail and teleconference meetings.

BASIN Membership. Participation in BASIN is open to all scientists interested in biosphere-atmosphere interactions. We will use national meetings (AGU, ESA) and web sites as means to further spread the word and increase participation outside of the currently listed members. Of special interest this past year has been communication with under represented areas (e.g., South America and Africa) to increase their awareness of this network and of their participation. We are finding that training opportunities and agreement to jointly share experiences and data are key elements attracting new participants.

Web page development and data sharing. We plan enhancement of web-accessed databases to be used in terrestrial ecosystem and global carbon cycle studies. Funds are requested for a 0.25 FTE technician to assist investigators with putting their data sets online and facilitating data exchanges. These efforts have already been initiated (http://GCTE-Focus1.org/BASIN.html) and several dozen data sets are already online and available for synthesis and cross-site studies. We expect the following products to emerge from our network:

- continental-scale and global-scale maps of $\delta^{13}C_R$ and $\Delta_{ecosystem}$ and their variation with environment; a time series of these parameters that can be used in testing continental scale carbon modeling efforts and intersite comparisons
- a time series of $\delta^{13}C_R$ and $\Delta_{ecosystem}$ and their variation with land-use history

Coordinating Efforts Within the Network. Our network coordination activities include (a) annual post-AGU meeting for synthesis and planning future data collection activities, (b) annual workshop focusing on future areas for development and integration, (c) an e-mail list server with archiving and search-engine capacities, and (d) web-based data and information dissemination (http://GCTE-Focus1.org/BASIN.html).

Efforts to Increase Participation of Under-Represented Groups. Geography is perhaps the best way of describing the under-represented elements in this international network. Much of the initial focus has been in the United States (see Fig. 2), with recent efforts in Europe. Through LBA-Ecology, efforts in South America are expanding (6-8 sites now). At the IGBP Congress last year, initial contacts were made with Japanese and Chinese investigators to expand coverage in those areas. Last month contacts were made with the SAFARI 2000 Program to expand BASIN coverage into sites in South Africa and Botswana. We will use international meetings and international efforts, such as IAI and START, to increase participation by investigators in Africa and the Americas. Together with European BASIN Steering Committee members, we will use ESF funds to also encourage participation by these under-represented groups.

We have set aside specific workshop and travel funds to support participation by the under-represented international groups (see table in Budget Justification Section). It is only through training opportunities and participation in workshops that we will be able to attract representation from all of the groups (both established investigators and young scientists) critical to establishing a true global picture of the biosphere-atmosphere signal.

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