



SAN DIEGO STATE
UNIVERSITY

Research Foundation

May 1, 2009

Eileen Maher
Environmental Services Department
Port of San Diego
3165 Pacific Highway
San Diego, CA 92101

Re: RFP - Environmental Projects Benefiting San Diego Bay
Chun-Ta Lai, PI
"Is San Diego Prepared for the EPA's New Greenhouse Gas Rules? A Study to Investigate Local Sources of CO2 Emission from the Past into the Future in San Diego Bay."

Enclosed please find the original application plus two copies and (1) CD ROM for the above referenced proposal.

This proposal is being submitted by the San Diego State University Research Foundation (SDSURF) on behalf of Dr. Chun-Ta Lai. SDSURF is a non-profit corporation under the laws of California, whose officers and members are administrators and faculty of San Diego State University. The Foundation handles the administration of grants and contracts for research and educational projects and will serve as the fiscal agent for this project. If awarded, funds should be drawn in favor of SDSURF.

SDSU Research Foundation takes exception to Item 16 (Ownership of Records) in the agreement template. As a state agency, SDSU is not allowed to give away ownership of the intellectual property its faculty develops while working on funded projects. Item 16 should be deleted from the agreement if Dr. Lai's project is awarded.

Please direct communications regarding this application to:

Programmatic

Chun-Ta Lai, PI
Biology Department
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-4614
TEL: (619) 594-0957
tgaroma@mail.sdsu.edu

Administrative

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Sincerely,

Eugene Stein, Director
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Sponsored Research Development
awards@foundation.sdsu.edu

Attachment(s)

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FURTHERING THE EDUCATIONAL,
RESEARCH AND COMMUNITY-SERVICE
MISSION OF SAN DIEGO STATE UNIVERSITY



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Eileen Maher
Environmental Services Department
Port of San Diego
3165 Pacific Highway
San Diego, CA 92101

April 28, 2009

Dear Environmental Advisory Committee

Attached please find a copy of our proposal titled, “**Is San Diego prepared for the EPA’s new greenhouse gas rules? A study to investigate local sources of CO₂ emission from the past into the future in San Diego Bay**”, to be considered for the environmental projects benefiting San Diego Bay.

Project Manager’s Contact information:

Dr. Chun-Ta Lai, Assistant Professor
Department of Biology, San Diego State University, 5500 Campanile Drive, San Diego, CA 92182-4614, USA, Phone: 619.594.0678, Fax: 619.594.5676
Email: lai@sciences.sdsu.edu

Project description: The Environmental Protection Agency (EPA) formally declared carbon dioxide and five other greenhouse gases to be pollutants that endanger public health and welfare on April 17, 2009, likely lead to the regulation of the gases for the first time in the U.S. (The New York Times report). We anticipate that efforts to identify areas of high carbon emission and impacts will increasingly become critical in urban planning. We propose to investigate a method of tracking historic local sources of CO₂ emission in the San Diego Bay area using radiocarbon measurements in tree rings.

Grant Funding Request: \$71,290

Total Cost of Proposal: \$89,285

Timeline of Project: September 2009 - October 2010, 14 months

Source of Matching Funds: San Diego State University

Benefit to San Diego Bay: The aim of the project is to use the procedure of calculating the amount of carbon dioxide produced by fossil fuel combustion on a local scale (San Diego Bay), using records of radiocarbon concentration in annual tree rings (pine tree) to estimate carbon dioxide emission from potential sources (airport, navy base, port, traffic, etc.) that surround the Bay. The results from our study can potentially be used to create a ‘zoning index’ that indicates high to low carbon footprints for the San Diego Bay. This work will evaluate



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whether the radiocarbon/tree ring approach can be used to as a complementary measure of local-scale CO₂ emission for future urban planning purposes.

Please let me know if I can provide other information.

Sincerely,

Chun-Ta Lai
Assistant Professor of Biology

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Title Is San Diego prepared for the EPA's new greenhouse gas rules? A study to investigate local sources of CO₂ emission from the past into the future in San Diego Bay

Primary investigators

Dr. Chun-Ta Lai, Assistant Professor, San Diego State University, Biology Department

Dr. Andrzej Rakowski, Research Associate, San Diego State University, Biology Department

Project summary

The Environmental Protection Agency (EPA) formally declared carbon dioxide and five other greenhouse gases to be pollutants that endanger public health and welfare on April 17, 2009, likely lead to the regulation of the gases for the first time in the U.S. (The New York Times report). We anticipate that efforts to identify areas of high carbon emission and impacts will increasingly become critical in urban planning. We propose to investigate a method of tracking historic local sources of CO₂ emission in the San Diego Bay area using radiocarbon measurements in tree rings.

The aim of the project is to use the procedure of calculating the amount of carbon dioxide produced by fossil fuel combustion on a local scale (San Diego Bay), using records of radiocarbon concentration in annual tree rings (pine tree) to estimate carbon dioxide emission from potential sources (airport, navy base, port, traffic, etc.) that surround the Bay. The results from our study can potentially be used to create a 'zoning index' that indicates high to low carbon footprints for the San Diego Bay. This work will evaluate whether the radiocarbon/tree ring approach can be used to as a complementary measure of local-scale CO₂ emission for future urban planning purposes.

I. Introduction

The US Environmental Protection Agency (EPA) recently declared that greenhouse gases endanger public health and welfare. This announcement represents a major shift in environmental policy and is expected to have significant socioeconomic impacts at many levels. How this declaration and likely new regulation of carbon dioxide emission affects the environmental policy, business and recreation activities of San Diego Bay requires careful and timely assessment.

The goal of this project is to create a historic record of CO₂ emission in the vicinity of San Diego Bay using radiocarbon measurements in tree rings. San Diego Bay is surrounded by a number of potentially large anthropogenic CO₂ sources (airport, navy base, port, traffic, etc.). To prepare for EPA's new regulation of CO₂ emission, it is important to estimate the annual emission rates from those sources. Tree ring analysis provides a historic perspective of anthropogenic influence on local organisms. By analyzing radiocarbon contents of wood cellulose extracted from tree rings, a time series of anthropogenic CO₂ record can be created. Tree rings are natural archives of environmental changes; anomalies observed in tree rings may signify milestone events (e.g. new installment of power plants, or implementation of a new, clean energy policy).

This project complements many local climate change projects (e.g. San Diego Foundation Regional Focus 2050 Study, San Diego Foundation) by designing a coordinated, Bay-wide approach for a historic view of anthropogenic CO₂ footprint in the San Diego Bay area. We will

incorporate our research findings into classroom materials, providing an educational opportunity for SDSU students.

II. Project Narrative

The traditional radiocarbon method, widely used in archaeology and geology for chronological purposes can also be used in environmental study. Isotopic composition of fossil carbon is slightly different from modern carbon, mostly because the former does not contain radiocarbon, whose half-life is much shorter than the formation period of fossil fuels. The addition of fossil carbon caused changes of carbon isotopic composition, in particular, a definite decrease of ^{14}C concentration in atmospheric CO_2 and other carbon reservoirs (ocean and terrestrial biosphere), known as the Suess effect (Suess 1955). Data of carbon dioxide and radiocarbon concentration levels have constantly been collected in clean and polluted areas, either directly by measuring atmospheric air (Keeling et al. 1989; Levin and Kromer, 1997, 2004; GLOBALVIEW-CO₂, 2003; Kuc *et al.*, 2003), or plants (McNeely, 1994; Krajcar-Bronić *et al.*, 1998; Muraki *et al.*, 1998, 2001; Rakowski *et al.*, 2001, 2004a, b, 2005, 2008).

Methods

The radiocarbon method is widely known as a method for chronological study but can also be useful for environmental purpose. Due to emission of dead CO_2 from fossil fuel use radiocarbon concentration in atmosphere has decreased over time. It can be observed not only in the atmosphere but also in other reservoirs of carbon (biosphere and ocean). Tree rings, leaves as well as other annual growing plants reflected the changes of radiocarbon concentration in the atmosphere due to processes of photosynthesis, assimilation and respiration of carbon dioxide from the air. By measuring the radiocarbon concentration in biospheric material (e.g. tree rings) found in the industrial and/or high urbanized area, it is possible to estimate the total emission of dead CO_2 (Levin Hesshaimer 2000; Levin et al. 2003). The calculation of this emission is possible by comparing radiocarbon concentration in industrial area with those in clean air, given by:

$$C_{\text{foss}} = C_{\text{BG}}(\Delta^{14}\text{C}_{\text{BG}} - \Delta^{14}\text{C})/(\Delta^{14}\text{C}_{\text{BG}} + 1000) \text{ [ppm]}, \quad (1)$$

where C is the concentration of CO_2 (parts per million), $\Delta^{14}\text{C}$ represents radiocarbon concentration (per mil), subscripts BG , foss represent biogenic and fossil fuel factors, respectively. Eq. 1 will be used to estimate the CO_2 concentration from fossil emission.

Radiocarbon concentration in tree rings ($\Delta^{14}\text{C}$) will provide information of any anthropogenic sources of CO_2 emission located in the area of the investigation. Small sample (<1mg of carbon content) will be prepared. An accelerated mass spectrometer (AMS) will be used for $\Delta^{14}\text{C}$ measurement. The procedure for sample preparation has been described in Rakowski *et al.* (2004a, b, 2005, and 2008). $\delta^{13}\text{C}$ value will also be measured to correct for $\Delta^{14}\text{C}$. The radiocarbon concentration will be reported as $\Delta^{14}\text{C}$ in per mil (‰) and/or pMC (%) deviations from the standard sample of NBS oxalic acid (Stuiver and Polach, 1977).

Sampling location

Tree ring (pine trees) samples will be collected to estimate carbon dioxide emission from potential sources (airport, navy base, port, traffic, etc.) that surround the Bay. We subdivide the San Diego Bay neighborhood into 5 zones, representing major sources of fossil CO₂ emission near the Bay: 1) industry, 2) a reference site of clean air, 3) Traffic (Downtown), 4) Naval Base (North Island), and 5) airport (Point Loma). Within each zone, 3 locations will be selected and cores of tree ring samples will be taken for radiocarbon and stable carbon ratio analyses.

Figure 1. Sampling locations. We subdivide the San Diego Bay neighborhood into 5 zones. Each study zone represents a major source of CO₂ emission:

- Zone 1 – Chula Vista (industry)
- Zone 2 – Coronado bay front (a reference site of clean air),
- Zone 3 – San Diego downtown (traffic),
- Zone 4 – North Island (naval base),
- Zone 5 – Point Loma (airport)



Previous studies suggest that radiocarbon signals observed in tree ring samples reflect localized sources ($< 1 \text{ km}^2$) (Rakowski et al. 2004 a,b; 2008). This allows us to use tree rings as a recorder to integrate local anthropogenic influences on the environment. We expect that zone 2 has the lowest anthropogenic impact because during the day when plants photosynthesize air comes from the ocean. However, if any decrease of radiocarbon concentration in tree rings from this location is noted, we will use global background values as the reference for clean air (Hua and Barbetti 2004).

Tree ring and $\Delta^{14}\text{C}$ analysis

Samples of annual tree rings (last 10-15 years) will be taken using a hollow drill from living trees from the selected area. From each tree five cores will be taken. Three of them will be used

for dendrochronology measurement and two for isotopic analysis. Three samples for dendrochronology will be taken from the trunk from three directions (every 120°), and two from the direction of the rings are the widest, to have enough material for carbon isotopes analysis. To measure width of each annual ring and early wood/late wood ratio a scanner with dendrochronological software will be use. The correlation coefficients between climate conditions and tree ring can be obtained using correlation functions from DendroClim2002, a statistical tool for analysis of climate/tree growth relationships.

Samples of annual growth rings of the pine tree will be taken for radiocarbon and stable carbon isotope analyses. To obtain sufficient amount of material for AMS analysis, three core samples will be used and the annual growth rings will be separated. From each annual ring early wood and late wood will be separated for $\Delta^{14}\text{C}$ analysis. Cellulose will be extracted from each wood samples using a standard protocol of α -cellulose extraction (Figure 2; Loader *et al.* 1997). This process removes all materials (mostly lignin) which can move from one annual ring to another, decreasing significantly the precision of time resolution of the measuring $\delta^{13}\text{C}$ value. α -cellulose samples will be prepared in Lai laboratory before being sent to Gliwice Radiocarbon Laboratory, Poland for graphite preparation and radiocarbon analysis.

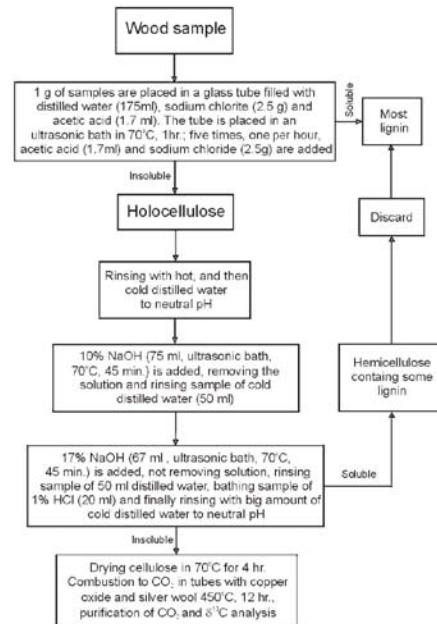


Figure 2. Cellulose extraction procedure

Project Deliverables

We expect to publish at least one paper from our results in internationally recognized journals. The products from the project will include:

- Detailed report of all protocols and findings
- Time series (10-15 years) of anthropogenic CO₂ emissions in San Diego Bay
- A GIS map of localized carbon footprint in San Diego Bay
- 1-2 peer-reviewed papers submitted to internationally recognized journals

Significance & Expected Results

The results of the purposed project will provide spatial and temporal distribution of carbon footprint in the San Diego Bay area. Local anthropogenic influences will be quantified from the dilution of radiocarbon signals by fossil CO₂ outputs in five investigated zones surrounding the Bay. A map of anthropogenic carbon footprint will be created (annually for the last 10-15 years if necessary) for the Bay. This information is useful to identify areas of high carbon emission and impacts that will increasingly become critical in future urban planning. The results will be presented in the national conferences and published in internationally recognized journals.

III. Qualifying Experience

Dr. Lai is a current investigator for the Unified District of San Diego Bay. Lai is leading the investigation “Using isotopes and element analysis to understand the impact of trophic structure and contaminants on threatened and endangered species in San Diego Bay” (PI: Lewison). Together with my co-investigators, we have completed collections of samples in the Bay (eelgrass, a variety of invertebrates, fish, turtle and least tern samples) and are continuing to prepare and analyze these samples in the laboratory. Lai has more than 10 years of experience in ecosystem carbon research. He is the PI for a DOE National Institute of Climate Change Research project, and a co-PI for a DOE Terrestrial Carbon Processes project. Additional information and references for his work can be obtained from Dr. James R. Ehleringer, 801-581-4665.

Dr. Rakowski has extensive experience in preparing samples for radiocarbon measurements using GPC method (Gas Proportional Counter), LSC method (Liquid Scintillation Counter) and AMS method (Accelerator Mass Spectrometry). He also has experience in using GP, LSC and AMS method to determinate radiocarbon concentration in samples. He is familiar with preparation of samples for stable isotopes measurement using mass spectrometry. Dr. Rakowski has more than ten years of experience using radiocarbon/tree rings method to study fossil CO₂ emissions in urban environment (Rakowski et al. 2001; 2004a,b; 2005; 2008).

IV. Objectives of Grant Proposal

The objective of the project is to use the procedure of calculating the amount of carbon dioxide produced by fossil fuel combustion on a local scale (San Diego Bay), using records of radiocarbon concentration in annual tree rings (pine tree) to estimate carbon dioxide emission from potential sources (airport, navy base, port, traffic, etc.) that surround the Bay. The results from our study can potentially be used to create a ‘zoning index’ that indicates high to low carbon footprints for the San Diego Bay. This work will evaluate whether the radiocarbon/tree ring approach can be used as a complementary measure of local-scale CO₂ emission for future urban planning.

V. Cost Proposal

Funds requested for the project are \$71,290. Total costs for the proposal are \$89,285. Dr. Lai will dedicate 11.5% FTE during academic year to the project. This is a 25.2% matching (\$17,995) to the fund request. Dr. Rakowski, a visiting scholar at Lai’s laboratory, is responsible for radiocarbon analysis. Samples of α -cellulose extracted from tree rings will be prepared in Rakowski’s home institute, Silesian University of Technology, Gliwice, Poland, for radiocarbon analysis. Costs for this analysis are estimated at \$195/sample, a 35% discount compared to the pricing published by the W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory at University of California, Irvine. Breakdown of the total costs is shown in the itemized budget.

The timeline for the proposal is 14 months. Field sampling and laboratory analyses will extend from September 2009 to March 2010. We will focus on data analysis and synthesis from April 2010 to October 2010.

VI. Personnel

Dr. Chun-Ta Lai is the PI on this project. Lai will oversee the progress of the project. Dr. Andrzej Rakowski, the Co-PI on the project, has extensive experience of studying fossil CO₂ emissions in urban environment. Rakowski will be responsible for the collection, preparation and analysis of tree ring samples. Lai supervises a number of graduate and undergraduate students at SDSU. We will engage students in field sample collection and laboratory preparation of tree ring samples. A GIS student project will be developed in the Geography Department's Center for Earth Systems Analysis Research (CESAR) at SDSU.

VII. Subconsultants

N/A

VIII. Non-Profit Status

San Diego State Research Foundation has been granted tax-exempt status under section 501(c)(3) under the Internal Revenue Code. A letter with relevant information regarding this status is attached (Appendix F).

IX Applicant Disclosure

All applicants and parties involved in this project have received no environmental violations from any regulatory agency within the last five years.

X. Agreement

The insurance clause as written in the attached sample agreement is acceptable. The indemnification clause as written in the attached sample agreement is acceptable

XI. Conflict of Interest

There are no conflicts of interests from project participants.

XII. Additional Information

For more than 30 years Gliwice Radiocarbon Laboratory provides radiocarbon analysis for scientists and researchers from around the world. A system for the preparation of samples for AMS dating has been developed in the Gliwice Radiocarbon Laboratory in 1999. As yet, the system has been used to produce graphite targets from plant macrofossils, wood, charcoal, peat, bones, shells and pollen extracts. Prepared graphite targets are sent to an AMS laboratory for the measurement (at present to Poznań Radiocarbon Laboratory, Poland or to Leibniz Laboratory for Radiometric Dating and Isotope Research in Kiel, Germany). Each batch of samples is accompanied by at least two modern standard (Oxalic Acid) and two background (coal or marble containing no radioactive carbon) samples, prepared in the same way as samples of unknown radiocarbon concentration.

References

- GLOBALVIEW-CO2: Cooperative Atmospheric Data Integration Project – Carbon Dioxide. CD-ROM, NOAA CMDL, Boulder, Colorado (Also available on Internet via anonymous FTP to ftp.cmdl.noaa.gov, Path: ccg/co2/GLOBALVIEW), 2003.
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- Levin I, Kromer B, Schmidt M, Sartorius H. 2003. A novel approach for independent budgeting of fossil fuel CO_2 over Europe by $^{14}\text{CO}_2$ observation. *Geophysical Research Letters* 30, No 23, 2194
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- Rakowski AZ, Pawelczyk S, Pazdur A. 2001. Changes of ^{14}C concentration in modern trees from Upper Silesia region, Poland. *Radiocarbon* 43(2B):679-689.
- Rakowski AZ, Nakamura T, Pazdur A, 2004a. Changes of radiocarbon concentration in modern wood from Nagoya, central Japan. *Nuclear Instruments and Methods in Physics Research Section B* 223-224: 507-510.
- Rakowski A., Kuc T.; Nakamura T., Pazdur A., 2004b. Radiocarbon Concentration in the Atmosphere and Modern Tree Rings in the Kraków Area, Southern Poland, *Radiocarbon* 46(2): 911 – 916
- Rakowski AZ, Kuc T, Nakamura T, Pazdur A, 2005. Radiocarbon concentration in urban area. *Journal of Methods and Applications of Absolute Chronology*, Vol. 24. 63-68.
- Rakowski AZ, Nakamura T, Pazdur A. 2008. Variations of anthropogenic CO_2 in urban area deduced by radiocarbon concentration in modern tree rings. *Journal of Environmental Radioactivity*. doi:10.1016/j.jenvrad.2007.12.007.
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Itemized Budget

SD Unified Port District - BUDGET

Annual Escalation: 1

Chun-Ta Lai, PI

September 01, 2009 through February 28, 2011

						PROPOSED COSTS YEAR 1	MATCHING COSTS YEAR 1	TOTAL	
A & B. PERSONNEL									
<i>Salaries</i>									
		FTE	Mo Salary	# of Mos	Person Mos				
1	Chunta Lai, PI	SU	100.0%	8,313	0.5	0.50	4,157	-	4,157
		AY	11.5%	8,313	9	1.04	-	8,604	8,604
2	Andrzej Rakowski, Postdoc	SU	100.0%	3,734	2	2.00	7,468	-	7,468
						<i>Total Salaries</i>	11,625	8,604	20,229
<i>Fringe Benefits</i>									
			%						
1	Lai - SU		21.00%				873	-	873
	Lai - AY		39.90%				-	3,433	3,433
2	Rakowski - SU		22.00%				1,643	-	1,643
						<i>Total Fringe Benefits</i>	2,516	3,433	5,949
						TOTAL PERSONNEL	14,141	12,037	26,178
C. EQUIPMENT									
1							-	-	-
2							-	-	-
						TOTAL EQUIPMENT	-	-	-
D. TRAVEL									
		Trip Cost	# of Trips						
1	Field Sampling Trips	300	2				600	-	600
2	Professional Conference - w/in State of CA	1450	1				1,450	-	1,450
						TOTAL TRAVEL	2,050	-	2,050
E. Supplies									
		Rate/Item	Quantity						
1	Tree Ring Collection Tools	1000	1				1,000	-	1,000
2	Chemicals for a-Cellulose Extraction	10	200				2,000	-	2,000
3	Glassware & Other Lab Supplies	20	40				800	-	800
						TOTAL PARTICIPANT COSTS	3,800	-	3,800
F. Other Direct Costs									
		Rate/Item	Quantity						
1	Radiocarbon Analysis	150	200				30,000	-	30,000
2	Graphite Preparation	45	200				9,000	-	9,000
3	Publication Costs	1500	1				1,500	-	1,500
4	Duplicating Costs	0.25	500				125	-	125
5	Telephone/Internet	175	1				175	-	175
6	Shipping Costs	1200	1				1,200	-	1,200
						TOTAL OTHER DIRECT COSTS	42,000	-	42,000
TOTAL DIRECT COSTS						61,991	12,037	74,028	
F&A @ TDCO 15.00%						9,299	-	9,299	
F&A @ MTDC 49.50%						-	5,958	5,958	
TOTAL PROJECT COSTS						71,290	17,995	89,285	

Percentage of Costs Matched: 25.2

Curriculum Vitae for Chun-Ta Lai

Lai, Chun-Ta

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Professional preparation

2001 Ph.D. Nicholas School of the Environment, Duke University, Durham, NC
1993 B.S. Marine Environment and Engineering, Sun Yat-sen University, Taiwan

Appointments

Jan 2007 – Assistant Professor, San Diego State University
2004 – 2006 Research Assistant Professor, University of Utah
2001 – 2004 Postdoctoral Associate, Department of Biology, University of Utah
1997 – 2001 Graduate Research Assistant, Duke University

Professional Affiliations

1996 – American Geophysical Union (AGU); 2007 – Ecological Society of America (ESA)

Honors

Jun 2006 Taiwan Outstanding Scholar Fellowship, Ministry of Education, Taiwan.
May 2001 Paul A. Humphrey/AMS chapter's Academic Achievement Award, Central North Carolina Chapter of the American Meteorological Society.

Publications

- Lai, C.-T., J. Ometto, J. Berry, L. Martinelli, T. Domingues, and J. Ehleringer (2008) Life form-specific variations in leaf water ^{18}O enrichment in Amazonian vegetation, *Oecologia*, 157, 197-210.
- Lai, C.-T., J. Ehleringer, B. Bond, and K.T. Paw U (2006), Contributions of evaporation, isotopic non-steady state transpiration, and atmospheric mixing on the $\delta^{18}\text{O}$ of water vapor in Pacific Northwest coniferous forests, *Plant, Cell and Environment*, 29(1), 77-94, doi: 10.1111/j.1365-3040.2005.01402.x.
- Lai, C.-T., W. Riley, C. Owensby, J. Ham, A. Schauer, and J. Ehleringer (2006), Seasonal and interannual variations of carbon and oxygen isotopes of respired CO_2 in a tallgrass prairie: Measurements and modeling results from three years with contrasting water availability, *Journal of Geophysical Research-atmosphere*, 111, D08S06, doi:10.1029/2005JD006436.
- Lai, C.-T., J. Ehleringer, A. Schauer, P. Tans., D. Hollinger, K.T. Paw U, J. Munger, and S. Wofsy (2005), Canopy-scale $\delta^{13}\text{C}$ of photosynthetic and respiratory CO_2 fluxes: observations in forest biomes across the United States, *Global Change Biology*, 11, 633-643, doi: 10.1111/j.1365-2486.2005.00931.x.
- Lai, C.-T., J. Ehleringer, P. Tans, S. Wofsy, S. Urbanski, and D. Hollinger (2004), Estimating photosynthetic ^{13}C discrimination in terrestrial CO_2 exchange from canopy to regional scales, *Global Biogeochemical Cycles*, 18, GB1041, doi:10.1029/2003GB002148.

- Lai, C.-T., A. Schauer, C. Owensby, J.M. Ham, B.R. Helliker, P.P. Tans, and J.R. Ehleringer (2006) Regional CO₂ fluxes inferred from mixing ratio measurements: estimates from flask air samples in central Kansas, USA, *Tellus* 58B, 523-536.
- Lai, C.-T., G. Katul, J. Butnor, M. Siqueira, D. Ellsworth, C. Maier, K. Johnson, S. McKeand, and R. Oren (2002), Limits on the net carbon exchange response to fertilization in a southeastern pine forest, *Plant, Cell and Environment*, 25(9), 1095-1119.
- Lai, C.-T., G. Katul, J. Butnor, D. Ellsworth, and R. Oren (2002), Modeling nighttime ecosystem respiration by a constrained source optimization method, *Global Change Biology*, 8, 124-141.
- Lai, C.-T., G. Katul, D. Ellsworth, and R. Oren (2000), Modeling vegetation-atmosphere CO₂ exchange by a coupled Eulerian-Lagrangian approach, *Boundary-Layer Meteorology*, 95, 91-122.
- Lai, C.-T., and G. Katul (2000), The dynamic role of root-water uptake in coupling potential to actual transpiration, *Advances in Water Resources*, 23, 427-439.

Synergistic activities

- 2006 – Principal Investigator, DOE-NICCR, “Understanding Seasonality and Interannual Variability of Biosphere-Atmosphere ¹³CO₂ Exchange in the Southeastern Region of the United States”
- 2006 – Co-lead Investigator, DOE-TCP, “Understanding the Influences of Seasonality and Interannual Variability on Biosphere-Atmosphere ¹³CO₂ Exchange in a Network of 8 AmeriFlux Sites”
- 2006 – Proposal review for NSF *Ecosystem Studies Program*, DOE-NICCR
- 2003 – Manuscript review for *Agricultural and Forest Meteorology*, *Crop Science*, *Ecography*, *Ecosystems*, *Environmental Science and Technology*, *European Journal of Soil Science*, *Geochimica et Cosmochimica Acta*, *Global Change Biology*, *Global and Planetary Change*, *Journal of Geophysical Research – Atmosphere*, *Journal of Geophysical Research – Biogeosciences*, *Plant, Cell and Environment*, *Oecologia*, and *Water Resources Research*

Graduate Students Mentored

(* - thesis chair, † - Master student, ‡ - Doctoral student)

Brian Brigham*‡, Marguerite Mauritz‡, Francis Bozzolo‡, Joelle Fournier†, Raghuram Narasimhan†, Marc Gregerson‡, Xuerui Dang*‡

Invited Seminars/Conferences

1st China Workshop on Stable Isotope Ecology, Beijing, China, 2008; Institute of Geographic Sciences and Natural Resources Research, Chinese Academic of Sciences, Beijing, 2008; BEACHON Workshop, NCAR, Boulder, 2007; Section of Integrative Biology, University of Texas at Austin, 2007; AsiaFlux Workshop 2007, Taoyuan, Taiwan, 2007; Youth AsiaFlux meet the Forefront 2007. Taoyuan, Taiwan, 2007; BASIN-SIBAE joint meeting, Portugal, 2006; BASIN-AGU workshop, San Francisco, 2005; SIBAE-BASIN conference, Switzerland, 2004; AmeriFlux Science Meeting. Boulder, 2002

Curriculum Vitae for Andrzej Rakowski

Rakowski, Andrzej Z.

Department of Biology
San Diego State University
5500 Campanile Drive
San Diego, CA 92182-4614
Tel: 619-594-1434
Fax: 619-594-5676

Professional preparation

2006 Ph.D. Department of Environmental Sciences, Nagoya University, Japan.
1999 Ph.D. Faculty of Mathematic and Physics, Silesian University of Technology, Gliwice, Poland.
1994 B.S. Faculty of Mathematic and Physics, Silesian University of Technology, Gliwice, Poland.

Appointments

March 2009 – present, Postdoctoral Associate, San Diego State University.
2004 – 2006 Postdoctoral Associate, Universidad Complutense de Madrid, Spain.
2000 – present, Assistant Professor, Silesian University of Technology, Poland.
1993 – 2000 Research assistant, Silesian University of Technology, Poland.

Honors

2000, 2001, 2006, 2007, 2008 Silesian University of Technology Annual Award
2004 - 2006 Fellowship in Spain. Archaeomagnetic Applications for the Rescue of Cultural Heritage, AARCH. Complutense University of Madrid, Madrid, Spain.
2004 – 2005 Sasagawa Foundation Grant: “Archives of annual post-bomb changes of radiocarbon concentration in the North and South Hemisphere”
2003 - 2006 Scholarship in Japan, funded by Ministry of Education, Sport and Culture of Japan. Ph.D. course □ Nagoya University, Faculty of Environmental Science. Nagoya, Japan.
2001 - 2003 Scholarship in Japan, funded by Ministry of Education, Sport and Culture of Japan. Research project. “AMS in environmental monitoring”. Center for Chronological Research, Nagoya University. Nagoya, Japan.
1999 Proyecto Arqueológico Condesuyos by Andean Archaeological Mission, Warsaw University Specialist in radiocarbon dating method (invited). Arequipa, Peru
1995-1997 Polish State Committee for Scientific Research Grant: “Anthropogenic changes of radiocarbon concentration in tree rings”

Five publications most relevant to the proposed project:

Rakowski AZ, Nakamura T, Pazdur A. 2008. Variations of anthropogenic CO₂ in urban area deduced by radiocarbon concentration in modern tree rings. *Journal of Environmental Radioactivity*. doi:10.1016/j.jenvrad.2007.12.007
Nakamura T, Miyahara H, Masuda K, Menjo H, Kuwana K, Kimura K, Okuno M, Minami M, Oda H, Rakowski A, Ohta T, Ikeda A, Niu E. 2007. High precision C-14 measurements and wiggle-match dating of tree rings at Nagoya University. *Nuclear Instruments and Methods In Physics Research Section B-Beam Interactions with Materials and Atoms* 259 (1): 408-413
Rakowski AZ, Kuc T, Nakamura T, Pazdur A, 2005. Radiocarbon concentration in urban area. *Geochronometria* Vol. 24. *Journal of Methods and Applications of Absolute Chronology*, 63-68.
Rakowski AZ, Nakamura T, Pazdur A, 2004. Changes of radiocarbon concentration in modern wood from Nagoya, central Japan. *Nuclear Instruments and Methods in Physics Research Section B -Beam Interactions with Materials and Atoms* 223-224: 507-510.
Rakowski A, Kuc T, Nakamura T, Pazdur A. 2004. Radiocarbon Concentration in the Atmosphere and Modern Tree Rings in the Kraków Area, Southern Poland, *Radiocarbon* 46(2): 911 – 916.

Five other significant publications

- Nakamura T, Kojima S, Ohta T, Nishida M, Rakowski A, Ikeda A, Oda H, Niu E. 2007. Application of AMS C-14 measurements to criminal investigations. *Journal of Radioanalytical and Nuclear Chemistry* 272 (2): 327-332.
- Pazdur A, Nakamura T, Pawełczyk S, Pawlyta J, Piotrowska N, Rakowski AZ, Sensuła B and Szczepanek M. 2007. Carbon isotopes in tree rings: Climate and Human activities in the last 400 years. *Radiocarbon* 49 (2).
- Catanzariti G, McIntosh G, Osete ML, Nakamura T, Rakowski AZ, Ramírez González I, Lanos Ph. 2007. A comparison of radiocarbon and archaeomagnetic dating from an archaeological site in Spain. *Radiocarbon* 49 (2).
- Rakowski A.Z., Pawełczyk S., Pazdur A., 2001. Changes of ¹⁴C Concentration in Modern Trees from Upper Silesia Region, Poland. *Radiocarbon* 43 (2B): 633-643.
- Rakowski AZ, Pawełczyk S, Pazdur A, 2000, Radiocarbon concentration measurements in contemporary tree rings from Upper Silesia. *Geochronometria Vol. 18, Journal of Methods and Applications of Absolute Chronology*, 19-21.

Synergetic activities

- 2004 – Principal Investigator, Sasagawa Foundation Grant: “Archives of annual post-bomb changes of radiocarbon concentration in the North and South Hemisphere”.
- 2003 – Manuscript review for *Journal of Environmental Radioactivity, NIMB Section – B, Geochronometria*.
- 1997 – Principal Investigator, Polish State Committee for Sciences Research Grant: “Anthropogenic changes of radiocarbon concentration in tree rings”
- 1994 – Participant of number projects in Division of Radioisotopes, Silesian University of Technology, Gliwice, Poland.

Internal Revenue Service

Date: May 11, 2005

SAN DIEGO STATE UNIVERSITY
FOUNDATION
% BUSINESS MANAGER
5250 CAMPANILE DR
SAN DIEGO CA 92182-1901 502

Department of the Treasury
P. O. Box 2508
Cincinnati, OH 45201

Person to Contact:

Ms. K. Hilson 31-07340
Customer Service Representative

Toll Free Telephone Number:

8:30 a.m. to 5:30 p.m. ET
877-829-5500

Fax Number:

513-263-3756

Federal Identification Number:

95-6042721

Dear Sir or Madam:

This is in response to your request of May 11, 2005, regarding your organization's tax-exempt status.

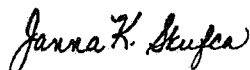
In May 1944 we issued a determination letter that recognized your organization as exempt from federal income tax. Our records indicate that your organization is currently exempt under section 501(c)(3) of the Internal Revenue Code.

Our records indicate that your organization is also classified as a public charity under section 509(a)(2) of the Internal Revenue Code.

Our records indicate that contributions to your organization are deductible under section 170 of the Code, and that you are qualified to receive tax deductible bequests, devises, transfers or gifts under section 2055, 2106 or 2522 of the Internal Revenue Code.

If you have any questions, please call us at the telephone number shown in the heading of this letter.

Sincerely,



Janna K. Skufca, Director, TE/GE
Customer Account Services

ATTACHMENT A

**Proposer's Equal Opportunity Program
San Diego Unified Port District**



**Submitted to:
San Diego Unified Port District**

Submitted by: San Diego State University
Research Foundation

**Request for Proposal
Environmental Projects Benefiting San Diego Bay**

Date: April 30, 2009

RESPONDENT'S EQUAL OPPORTUNITY PROGRAM

Report all permanent full-time or part-time employees. Refer to Section D for instructions to complete this Section. In Section E, identify the working titles found within each job group.

A. Corporate Work Force Location: 5250 Campanile Dr., San Diego											
Job Group	Total	Male					Female				
		WH	BL	HI	AP	AI	WH	BL	HI	AP	AI
Officials/Managers	29	7	1				18	1	1		1
Professionals	45	6		1			28	1	5	3	1
Technicians	50	3		3	2		26	3	6	3	4
Sales Workers											
Admin Support	20				2	1	8	3	3	2	1
Craft Workers	8	5	1	1	1						
Operators											
Laborers	2	1				1					
Service Workers											
Total:	154	22	2	5	5	2	80	8	15	8	7
B. San Diego Work Force Same as above											
Job Group	Total	Male					Female				
		WH	BL	HI	AP	AI	WH	BL	HI	AP	AI
Officials/Managers											
Professionals											
Technicians											
Sales Workers											
Admin Support											
Craft Workers											
Operators											
Laborers											
Service Workers											
Total:											
C. Project Work Force											
Job Group	Total	Male					Female				
		WH	BL	HI	AP	AI	WH	BL	HI	AP	AI
Officials/Managers											
Professionals											
Technicians											
Sales Workers											
Admin Support											
Craft Workers											
Operators											
Laborers											
Service Workers											
Total:											

Contact Person: S. Fileman
 Signature: *S. Fileman*
 Title: HR Specialist

Phone: (619) 594-1085
 Date: April 30, 2009
 Company Name: SDSU Research Foundation

D. Explanation for Completing Employment Data

Employment data must include ALL current full-time and part-time employees. Employees must be counted by sex and race/ethnic category for each of the nine occupational categories. You may acquire the race/ethnic information necessary for this report either by visual surveys of the work force, or from post-employment records as to the identity of employees. Eliciting information on the race/ethnic identity of an employee by direct inquiry is not encouraged.

For the purpose of this report, an employee may be included in the group to which he or she appears to belong, identifies with, or is regarded in the community as belonging. However, no person should be counted in more than one race/ethnic group. The race/ethnic categories for this survey are:

WH - White (not of Hispanic origin) - All persons having origins in any of the original peoples of Europe, North Africa, or the Middle East.

BL - Black (not of Hispanic origin) - All persons having origins in any of the Black racial groups of Africa.

HI - Hispanic - All persons of Mexican, Puerto Rican, Cuban, Central/South American, or other Spanish culture/origin, regardless of race.

AP - Asian or Pacific Islander - All persons having origins in any of the original peoples of the Far East, Southeast Asia, the Indian Subcontinent, or the Pacific Islands. This area includes, for example, China, Japan, Korea, the Philippine Islands, and Samoa.

AI - American Indian or Alaskan Native - All persons having origins in any of the original peoples of North America, and who maintain cultural identification through tribal affiliation or community recognition.

Every employee must be accounted for in ONLY one of the categories. Employment data must be reported by job category. Report each employee in only one job category.

To assist you in determining where to place your jobs within the occupational categories, a description of job categories is as follows:

Officials and Managers - Occupations requiring administrative and managerial personnel who set broad policies, exercise overall responsibility for execution of these policies, and direct individual departments or special phases of a firm's operations. Includes: officials, executives, middle management, plant managers, department managers, and superintendents, salaried supervisors who are members of management, purchasing agents and buyers, and kindred workers.

Professionals - Occupations requiring either college graduation or experience of such kind and amount as to provide a comparable background. Includes: accountants and auditors, architects, designers, dieticians, editors, engineers, lawyers, personnel and labor relations specialists, and kindred workers.

Technicians - Occupations requiring a combination of basic scientific knowledge and manual skill, which can be obtained through 2 years of post high school education, such as, is offered in many technical institutes and junior colleges, or through equivalent on-the-job training. Includes: computer programmers, drafters, engineering aides, photographers, surveyors, technical illustrators, and kindred workers.

Sales Workers - Occupations engaging wholly or primarily in direct selling. Includes: advertising agents and sales workers, insurance agents and brokers, stock and bond sales workers, sales clerks, cashiers, and kindred workers.

Admin Support - Includes all clerical-type work regardless of level of difficulty, where the activities are predominantly non-manual though some manual work not directly involved with altering or transporting the products is included. Includes: bookkeepers, collectors (bills and accounts), messengers and office helpers, office machine operators (including computer), shipping and receiving clerks, stenographers, typists and secretaries, telephone operators, legal assistants, and kindred workers.

Craft Workers (skilled) - Manual workers of relatively high skill level having a thorough and comprehensive knowledge of the processes involved in their work. Exercise considerable independent judgment and usually receive an extensive period of training. Includes: building trades, hourly paid supervisors and lead operators who are not members of management, mechanics and repairs, compositors and typesetters, electricians, engravers, bakers, decoration occupations, and kindred workers.

Operators (semi-skilled) - Workers who operate machine or processing equipment or perform other factory type duties of intermediate skill level which can be mastered in a few weeks and require only limited training. Includes: apprentices, operatives, attendants, blasters, chauffeurs, delivery workers, equipment assemblers, and kindred workers.

Laborers (unskilled) - Workers in manual occupations which generally require no special training or perform elementary duties that may be learned in a few days and require the application of little or no independent judgment. Includes: garage laborers, laborers performing lifting, digging, mixing, loading and pulling operations, and kindred workers.

Service Workers - Workers in both protective and non-protective service occupations. Includes: professional and personal service, including nurses aides and orderlies, barbers, cleaners, cooks, counter and fountain workers, elevator operators, door keepers, janitors, police officers and detectives, waiters and waitresses, amusement and recreation facilities attendants, guides, ushers, and kindred workers.

E. Working Titles

List the working titles of all employees by category, e.g., Professionals: Civil Engineer, Structural Engineer; and Technicians: Drafter, Computer Programmer, Surveyor.

Officials/Managers	Professionals	Technicians
Administrator	Specialists	Payroll Technicians
Coordinator	Analysts	IT Analyst
	Accountants	IT Programmer
	Account Administrators	IT Consultant
		Accounting Technician II's
		Buyer
		Staff Services Technician
		Development Technician
		Sponsored Research Tech.
Sales Workers	Office/Clerical	Craft Workers
	Accounting Technician II	Maintenance Worker
	Admin. Support Assistant	
Operatives	Laborers	Service Workers
	Laborer	

Statement of Compliance

EQUAL EMPLOYMENT OPPORTUNITY

THE FOLLOWING CERTIFICATE SHALL BE SIGNED BY THE CHIEF EXECUTIVE OFFICER OF THE SERVICE PROVIDER AND SUBMITTED WITH SERVICE PROVIDER'S REQUIRED EQUAL EMPLOYMENT OPPORTUNITY PROGRAM.

Agreement Description: **Environmental Projects Benefiting San Diego Bay**

Service Provider/Lessee: SDSU Research Foundation

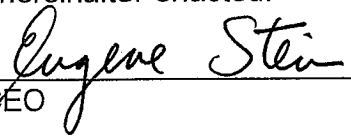
Address: 5250 Campanile Dr.

City, State, Zip Code: San Diego, CA 92182-1931

Telephone Number: (619) 594-5731

The Service Provider shall not discriminate against any employee or applicant for any employment action because of race, color, religion, sex, national origin, ancestry, physical or mental disability, veteran status, medical condition, marital status, age (40 years and older), sexual orientation or pregnancy.

Service Provider shall certify that Service Provider is in compliance with and throughout the term of the contract or lease will comply with: Title VII of the Civil Rights Act of 1964, as amended; the Civil Rights Act of 1991; the California Fair Employment Practices Act; and any other applicable Federal, State, and local law, regulation and policy including without limitation, those adopted by the District relating to equal employment opportunity, including any such law, regulation, and policy hereinafter enacted.



Signature of CEO

Eugene Stein

Printed Name

April 30, 2009

Date

Note: Please refer to the San Diego State University Research Foundation Board Resolution memo signed by Executive Director Mr. Dan Gilbreath designating Mr. Eugene Stein with signature authority.
Thank you for your consideration.



**SAN DIEGO STATE
UNIVERSITY**

Research Foundation

At a meeting of the Board of Directors held on October 9, 1975, the following resolution was adopted unanimously:

RESOLVED, That contracts and grants accepted on behalf of the University for research and educational projects may be signed by the Vice President of the Foundation, the Vice President for Business and Financial Affairs of the University, the Executive Director of the Foundation, or their designees.

In accordance with the above action taken by the Board of Directors, I, Dan M. Gilbreath, Executive Director of San Diego State University Research Foundation, hereby designate: Melinda S. Coil, Chief Financial Officer; W. Timothy Hushen, Chief, Sponsored Research Services; Eugene L. Stein, Director, Sponsored Research Development; and Michèle G. Goetz, Director, Sponsored Research Administration, the authority to sign contracts and grants for research and educational projects accepted by San Diego State University Research Foundation on behalf of San Diego State University.

February 17, 2009

Date

Dan M. Gilbreath
Executive Director