# CALIFORNIA AVOCADO COMMISSION
# PROJECT PLAN – RESEARCH GRANT PROPOSAL

**Proposal Budget Request:** $39,900
**CAC Fiscal Year 2008:** November 1, 2007 – October 31, 2008
**Anticipated Project Duration:** 12 months
☐ **This project is** New

**Project Title:** **Remote Estimation Of Avocado Plant Moisture To Support Irrigation Management**


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**Name of Research Institution:** GeoSpatial Partners LLC.


**Review of Literature**

Water is an important commodity for agricultural production, especially for avocado crops in California. Avocado is highly sensitive to water availability, since too little water during flowering or fruit setting will limit growth and production and too much water can cause root rot (Paulin, 2005). Research showed an increase in Hass avocado yield with a concomitant increase in the water regime; however, higher salinity levels limited production from reaching maximum yield (Oster and Arpaia, 2007; Yate et al., 1992). Because of its perennial nature, avocado requires irrigation throughout the year when evaporative demand exceeds effective rainfall. However, Water District officials are planning to decrease water supplies by 30% and are imposing Conservation measures in response to a recent court ruling to stop pumping water from the Bay-Delta (CAC, 2007). The decision, if upheld, will have a severe economic impact on 755,000 acres of agriculture production.

An efficient irrigation management plan for avocado is critical to reduce pressures on water resources, cope with increased water cost and ensure a sustainable production regime. Different ground methods to estimate avocado plant water needs have been proposed to support irrigation management (Snyder et al. 2000, Witney and Bender, 1992). The direct ground measurement techniques estimate soil or plant water status using instruments such as the pressure chamber, the infrared thermometer, the gravimetric oven-dry approach and the visual water stress symptoms detection. The weather-based technique measures weather variables affecting water loss assuming that free evaporating surface water is similar to the transpiration loss from leaves of a well-watered crop. Calculated water-loss is then used in irrigation planning programs (Witney and Bender, 1992). All of these techniques, in spite of their variable degree of easy-to-use and accuracy, have limited commercial appeal to estimate within-field spatial variation of plant moisture.

Satellite remote sensing technologies with their spatial, temporal and radiometric characteristics can help assess crop conditions and develop a robust irrigation management program. Because of their all-weather capability, satellite based radar systems have been used to estimate corn moisture (McNairn et al., 2000), but when corn plant height is above 1 meter, the sensor saturates and shows no sensitivity to crop attributes including moisture. Optical imagers such as Ikonos and Landsat were used to characterize corn moisture (UMAC, 2004), however, the satellite derived index showed significant sensitivity to crop biomass and underlying soil and no calibration of the data was suggested to generate a consistent measurement over time. In addition, the satellite systems could not meet the high temporal revisit for commercialization. More recently, we developed a technique using SPOT moisture sensitive bands to estimate corn moisture (Touré, 2005). We estimated average cornfield moisture with 2.5% residual errors. The technique was limiting because the temporal revisit of the satellite system was low and the cost of the imagery was high. We propose to enhance the technology and adjust it to estimate avocado canopy moisture with a higher temporal revisit to support a commercial application.

**Statement Of Objectives And Accomplishments For The Funded Year**

The objective of this project is to (1) remotely estimate avocado plant moisture and (2) develop a spatial interpolation technique that will utilize imagery from the daily revisit coarse resolution satellite system to mimic avocado moisture at higher spatial resolution (sub-field). For the funded year, we expect the following achievements:

1. January 2007: Completion of the spatial interpolation algorithm that will help estimate sub-field level avocado moisture from the coarse resolution imagery with daily revisit;
2. April 2008: Completion of all field data collection and processing including avocado plant samples and satellite imagery;
3. June 2008: Completion of the corn moisture algorithm adaptation to avocado plant moisture estimation;
4. August 2008: Final report describing the methodology used, the algorithm performance and the protocol for commercial application.

**Relevance to List of Priorities**

This work targets the following area of interest to the industry: "Irrigation and salinity management in avocado, including water management strategies designed for optimal yield, with attention being given to varying: (4) environmental conditions."

**Responsiveness of the Project**

The industry objectives and mission are to provide customers with high quality avocado, create a sustainable production environment for all players, and gain a high return on investment. A map of avocado fields, showing the spatial distribution of avocado whole canopy moisture accuracy better than 95%, delivered to the grower on a daily basis, will help apply the right amount of water where and when it is needed on the field. This in turn will help mitigate pressures on water resources, optimize avocado production and yield by making it more sustainable through reduction of diseases and pests, and reduce the negative environmental impact of chemical leaching.

**Research Approach**

The research work will attempt to answer the following questions:

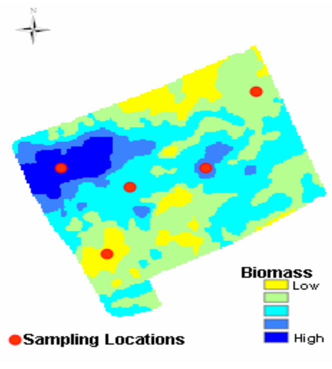
- Can we estimate avocado canopy moisture, at the sub-field level, with uncertainties better than 5% by adapting results from corn canopy moisture estimation?
- How can we use coarse resolution (250-500 meter pixel size) satellite imagery with high temporal resolution (daily) to infer avocado canopy moisture at the sub-field level (10-20 meter pixel size)?
- What is the accuracy of the algorithm when avocado field ground cover is low, especially for young groves?

*Assumption* - The spatial interpolation technique assumes that the relative moisture change at sub-field level is proportionate to moisture at the field level and that the spatial distribution of moisture early in the season does not change over time, only the magnitude of moisture can change implying that there is no reversal of moisture pattern at the field level.

*Work Plan* - The work will involve (1) study sites selection, (2) field data collection, (3) data processing and analysis, (4) algorithm refinement and development and (5) final report preparation and presentation of results. We will execute the following specific tasks and sub-tasks:

*Task 1 - Study Sites Selection* - We will arrange with growers with help from CAC to have access to six (6) fields with varying growth stages and at three (3) different times during the growing season with all fields fitting within a 60x60km footprint.

*Task 2 - Field Data Collection* - All field data collection will take place before, during and after avocado fruit setting. We will task satellites from SPOT Image to coincide with both MODIS imagery collects and the plant sample collection on the field. We will use a "smart sampling" scheme developed by GSP (**Figure 1**) to collect, three times during the season, statistically significant samples for algorithm development and testing. We will use the gravimetric approach to calculate sample leaf moisture content.




*Task 3 – Data Processing and Algorithm Development*
Collected dataset will be quality controlled and analyzed. We will develop the algorithms required to meet the objective of this project.

**Figure 1**: Field level zone map with sampling locations. We will use five (5) zones to collect five (5) samples per field per collection day. Sampling locations with exact coordinates will guide the scout on the field to collect plant samples for analysis.

*Task 4 - Final Report and Presentations*
A final report, presenting the details of works done including analysis results and limitations, will be developed and presented to CAC prior to the end of the 12-month timeframe allotted to the project.

**Work Impact on Existing Knowledge and Practice**
The proposed research work will help remotely estimate avocado canopy moisture on a daily basis under clear sky conditions. Significant number of samples will be collected at the field level to account for moisture variation to support variable irrigation. As described in the literature review section, ground measurement and weather based moisture sensors are not cost effective to estimate moisture variation within the field. This work will enhance previous published efforts with accuracy better than 95% and a daily revisit.

**Expected Project Duration**
We will execute this project in 12 months between November 1, 2007 and October 31 2008. This timeframe will provide enough flexibility to collect ground data for different groves phonological stages.

**References**

1. CAC, 2007. Ruling to Shut Delta Pumps Could Jeopardize Southern California Water Supplies. www.scawr.com/pdf/deltaApr07.pdf
2. Hofshi R., S. Hofshi and B. Faber, CIMIS Irrigation calculator. www.avocado.org/growers/irrigcalc.php
3. McNairn, H, Brown, R J, McGovern, M, Huffman, T, Ellis, J. 2000. Integration of Multi-Polarized SAR Data and High Spatial Optical Imagery for Precision Farming; in, Proceedings of the 22nd Canadian Symposium on Remote Sensing, Victoria, B.C., August 21-25, 2000.
4. Oster J.D. and Arpaia. 2007. Comments about crop coefficients for Hass Avocado on Mexican Seedling Rootstocks. Accepted for publication by the J. Amer. Soc. Hort. Sci.
5. Paulin B. July 2005. Irrigation requirements of Avocado. Department of Agriculture, Western Australia.
6. Snyder, R.L., M. Orang, S. Matyac, S. Eching, 2001. Crop Coefficients. UC Davis publications. Created in January 25, 2001 and updated March 2, 2007.
7. Touré, 2005. Remote Estimation of Moisture for Corn Silage Harvest Management, Internal Document.
8. UMAC, 2004. “Success story using remote sensing imagery to estimate corn grain moisture.” http://www.umac.org/content/farming/stories/corngrain_story2004.shtml
9. Witney, G.W., G.S. Bender, 1992. Water Conservation Strategies for California Groves. Proc. of the Second World Avocado Congress, pp. 349-355.
10. Yates M.V., Stottlemyer D.E., and Meyer J.L. 1992. Irrigation and Fertilizer Management to Minimize Nitrate Leaching in Avocado Production. Proc. of Second World Avocado Congress, pp. 331-335.

## PROPOSED PROJECT BUDGET

**Budget Year 2007-2008 (November 1, 2007 – October 31, 2008)**

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|---|---|
| **Salaries & Benefits:** | |
| Primary Researcher/ Project Leader: | $18,400.0 |
| Benefits: | $4,600.0 |
| Postdocs/Research Assistants: | N/A |
| SRAs: | N/A |
| Subtotal: | $23,000.0 |
| **Supplies/Expenses:** | $10,200.0 |
| **Equipment:** | $1,200.0 |
| **Operation Expenses:** | $1,000.0 |
| **Travel:** | $4,500.0 |
| **Other:** | $0.0 |
| **Total:** | $39,900.0 |

Is satisfactory execution/completion of this research project contingent upon receiving support funding in addition to CAC funding? NO

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**Signature (Project Leader):** ____________________

**Date:** 05/29/07

**Approved By:** Dr. Alassane Toure

**(Organization's Authorized Representative):** ____________________

**Date:** 05/29/07

**CALIFORNIA AVOCADO COMMISSION Approval:**

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Tom Bellamore, Corporate Counsel/Senior Vice Pres. **Date**

## Bibliographical Sketch

Dr. Alassane Touré is President and Chief Technical Officer of GSP, LLC, a Colorado-based corporation that provides remote sensing based geospatial products and services to clients in the agricultural and natural resource management sectors. Dr. Touré's career experience includes more than 10 years of private-sector practice, working with a variety of clients to develop innovative precision agriculture products based on remote sensing data, and 5 years as a research scientist for Agriculture and Agri-food Canada where he conducted climate change studies and the synergetic use of radar and optical data for product development. Dr. Touré's expertise focuses on the development of commercial applications of remote sensing technology that meets the needs for land resource management products. He recently developed an algorithm to remotely estimate field-level canopy moisture content to support corn silage harvest management.

Dr. Touré's recent works has involved collaboration and partnership with DOW-AgroSciences, the USDA Agricultural Research Service, the University of Colorado, The Colorado State University and the California Avocado Commission. He has also been involved in activities of the American Society of Photogrammetry and Remote Sensing (ASPRS), the Canadian Remote Sensing Society (CRSS) and the Canada-Colorado Association. Dr. Touré obtained a Master in Physics and his Ph.D. in Remote Sensing at Laval University, Québec, Canada.

### Education

- **Ph.D.** Remote Sensing, 1992, University of Laval, Quebec, QC, Canada
- **MSc.** Remote Sensing, 1989, University of Laval, Quebec, QC, Canada
- **MSc.** Physics, 1986**,** University of Abidjan**,** Abidjan, Cote d'Ivoire
- **BSc.** Mathematics and Physics, 1982, University of Abidjan**,** Cote d'Ivoire.

### Employment

- **President and CTO,** GeoSpatial Partners LLC. Aurora, CO**.,** 01/06 – Present
- **Chief Technical Officer**, Earthmap Solutions Inc., Longmont, CO**.,** 11/04 – 01/05**.**
- **Chief Technical Officer**, GeoSpatial Partners LLC., Aurora, CO**.,** 01/04 – 10/04 **.**
- **Research Scientist,** RESOURCE21, LLC., Denver, CO., 04/98 – 12/03
- **Senior Research Scientist,** DEVEL TECH. INC., Saskatoon, SK, Canada, 06/96 – 03/98.
- **Post-Doctoral Fellow and Research Scientist,** AGRICULTURE and AGRI-FOOD CANADA, Lethbridge, AB, Canada**,** 01**/**92 – 04/96

### Relevant Publications

- Touré, 2005. Remote Estimation of Moisture for Corn Silage Harvest Management, Internal Document.
- Touré, A., Major D.J., Zhao S., Baumeister R. 2004. Use of Landsat 5 and 7 Data to Predict Within-Field Variation of Corn Yield. ASPRS 2004 Annual Conference, May 23-28, 2004, Denver, CO.
- Major D., R. Baumeister, A. Touré, S. Zhao. 2003. Method of Measuring and Characterizing the Effect of Stresses on Leaf and Canopy Structures. In, Digital Imaging and Spectral Techniques: Application to Precision Agriculture and Crop Physiology – ASA Special Publication Number 66.
- McGinn S.M., A. Touré, O.O. Akinremi, D. J. Major and A.G. Barr, 1999. Agro-climate and Crop Response to Climate Change in Alberta, Canada. Outlook on Agriculture. Vol 28, 1: 19-28.

- Smith A., A. Touré, D. J. Major. 1997. Modeling NOAA AVHRR data to estimate land use on the Canadian Prairies Submitted to IGARSS'97.
- Touré, A., K. P. B. Thomson, G. Edwards, R. J. Brown and B. Brisco, 1994. Application of the MIMICS backscattering model to the agricultural context: wheat and canola at L and C bands. IEEE Transactions on Geoscience and Remote Sensing, 32: 47-61.