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Editorial

We have just finished the largest annual Academy meeting since our 1999 meeting in Tupelo. The Academy had experienced several years of smaller meetings and smaller membership, and we hope that trend has ended. One of the points about this last meeting that I wish to emphasize was the diversity of special events embedded within the regular program of scientific talks and posters. These special events can enhance a good meeting and make it even more worthwhile to attend. Any why am I mentioning this? Because hosting such events is not just the responsibility of the Academy President and a handful of division chairs. Many of you are in admirable positions to bring something special to the next meeting that will be a credit to you and to your institution. This is the time to be thinking about such events, since they frequently require months of advance planning to be part of the annual meeting. If you would like to contribute in this way to the Academy and to your scientific community, I encourage you to contact me or the Academy president-elect, Sarah Lea McGuire.

Our annual meeting next February (2005) will be at the north end of the state. Two sites are under consideration: Olive Branch and Oxford. Olive Branch is near the north Mississippi border very close to Memphis, TN. The hotel is readily accessible from the interstate, I 55. Oxford is not quite so far north and is the home of the University of Mississippi. Oxford is getting a new convention center that is currently under construction, so we still must explore its suitability for our meeting. Some of you might have suggestions for future meeting sites. Consider that we have 13 divisions that require no less than 10 rooms plus a large room for our exhibitors and another large room for our keynote speaker (the Dodgen lecture). Ideas should be forwarded to me or to our executive officer, Charles Swann.

Some of you that presented at the Academy meeting have a completed research project that would benefit from being published in this journal. If your research involved graduate students, consider especially the benefits to your students of having their manuscript go through the peer review process. Research that you and your students have completed should not just be filed away.

By tradition, this issue carries photographs from the annual meeting. Unfortunately the film from the meeting was ruined, so a general set of photographs cannot be presented. Fortunately photographs of selected aspects of the meeting have been generously supplied by Juan Silva, Olga McDaniel, Michelle Tucci, and Ham Benghuzzi.—Ken Curry

Aeromonas salmonicida, Freshwater Wetland Rhizobacterium, Fish Pathogen, and a Potential Environmental Indicator

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The objective of this study was the development of potentially pathogenic bacteria as environmental indicators for freshwater wetlands. *Aeromonas* spp. was selected as a potential environmental indicator because these water-borne bacteria are both fish and emerging human pathogens. Selected bacterial isolates were analyzed using classical microbiological methods, API20E, API20NE, 16S rRNA sequencing, and susceptibility to antibiotics. The selected *Aeromonas* spp. isolates were identified by 16S rRNA sequencing as *Aeromonas salmonicida*. The rate of antibiotic resistance (< 50 µg/ml) was high for ampicillin yet low (>10 to 20 µg/ml) for kanamycin, tetracycline, and chloramphenicol for all strains tested. The rate of resistance for ampicillin suggests acquisition by gene transfer. However, the rate of resistance for kanamycin, tetracycline, and chloramphenicol suggests intrinsic antibiotic resistance. Because increased incidence of resistance to ampicillin in freshwater wetlands reflects responses to the increased exposure to antimicrobial compounds (especially ampicillin) over the past several decades, monitoring the response of antibiotic resistant *A. salmonicida* to environmental changes rather than entire bacterial assemblage represents a potentially productive approach for biomonitoring of natural systems. Utilizing the distribution and antibiotic resistance of *Aeromonas* spp. in the environment as warning of possible contamination and as index of water and soil/sediment quality deterioration should significantly contribute to the long-term protection of freshwater wetlands.

Keywords: *Aeromonas* spp., 16S rRNA, antibiotic resistance, environmental indicators

Bacteria are potentially useful indicators of water and soil/sediment quality because of their species diversity and ability to respond rapidly to changing environmental conditions (Lemke et al., 1997). Previous data have shown that monitoring the response of antibiotic resistant enteric bacteria, rather than the entire assemblage, is a potentially productive approach to the examination of the responses of natural populations of bacteria to anthropogenic disturbances (Halda-Alija et al., 2000; Halda-Alija et al., 2001). Over 12 million kg of antibiotics are produced annually in the United States for use in man (Mazel and Davis, 1998) and almost as much for animal use. Increased introduction of antimicrobial agents into the environment via medical therapy, agriculture, and animal husbandry has resulted in new selective pressures on bacterial populations (Col and O'Connor, 1987). Despite the acquisition and transfer of antibiotic resistance genes in different environments worldwide (Alonso et al., 2001; Lederberg et al., 1992), resistant determinants persist in bacterial genomes over hundreds of generations, even in the absence of antibiotics as selective agents (Jabes et al., 1989). Consequently, there are two general categories of antibiotic resistance traits displayed by bacteria: (i) those that allow bacteria to withstand relatively high levels of a specific antimicrobial agent and conferred by mutations in genes responsible for antibiotic uptake or binding sites, as well as those gained by acquisition of genes on mobile elements (Davis, 1996); and (ii) those provided by genes conferring nonspecific low-level resistance (background levels of resistance) (Davis, 1996). Most investigations of antibiotic resistance in the aquatic habitat have addressed bacteria of fecal origin because they are used as pollution indicators and may be associated with infectious diseases. However, fecal bacteria are of little numerical significance in many freshwater systems, despite the fact that they are discharged into almost all inland waters

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(Jones et al., 1986). Thus, if the environmental pool of resistance is to be measured, bacteria other than those of fecal origin must be considered (Goňi-Urriza et al., 2000).

Aeromonads are ubiquitous, gram-negative bacilli which are autochthonous to aquatic environments (Austin et al., 1996). The widespread use of antimicrobial agents for treating bacterial diseases in aquaculture has been associated with increased antibiotic resistance in *A. hydrophila* and *A. salmonicida* (fish pathogen) (Goňi-Urriza et al., 2000; Schmidt et al., 2001). When antibiotics are used in aquaculture, they remain in the open environment or may eventually flow into open waterways with unknown consequences with regard to overall rates of antimicrobial resistance acquisition. Our understanding of the ecological aspects of antibiotic resistance in this regard is rudimentary.

The primary objective of this study was to assess sediments for possible pathogen loads and select alternative indicators of water and sediment deterioration. The rate of acquired antibiotic resistance was investigated for water borne *Aeromonas* spp. for which antibiotic resistance patterns are well known. Additionally, *Aeromonas* spp. is fish and emerging human pathogen, and thus may be used as environmental indicator. *Aeromonas* spp. was selected from the rhizosphere of the freshwater wetland plant *Juncus effusus* L. and sediments (Subgani, 2002). The secondary objective of this study was to assess the rate of the acquisition of antibiotic resistance for *Aeromonas* spp. obtained from freshwater wetlands.

MATERIALS AND METHODS

Sampling Sites—Sediment samples were collected at a pristine, forested site located in Stewart county, Tennessee (Halda-Alija and Johnston, 1999) and an agricultural site located in Calloway county, western Kentucky (Halda-Alija et al., 2001) in spring, summer, and fall of 1997. Physical, chemical, and hydrological characteristics of the streams were described in detail elsewhere (Halda-Alija et al., 1999; Hendricks and Rice, 2000). Briefly, the chemistry of the agricutural site was highly variable (Halda-Alija et al., 2001) with high turbidity (14.1 NTU) and high total suspended solids (14.1 mg/L). The average annual surface water temperature was 13.9°C and the pH was 7 (calculated for 1997). The chemistry of the pristine site was highly variable with low phosphate inputs (0.02–0.06 mg/L), low nitrate inputs (0.03–0.12 mg/L), and low total suspended solids (3.9 mg/L) (Halda-Alija and Johnston, 1999; Halda-Alija et al., 1999; Hendricks and Rice, 2000).

Additionally, wetland sediments and *Juncus effusus* L. roots were collected at the University of Mississippi Field Station (UMFS) in wetland areas located in northern Mississippi in March and June 2000. UMFS (www.baysprings.olemiss.edu) is located in Lafayette County, northern Mississippi at the headwaters of the Little Tallahatchie River watershed (Figure 1). The soil type is Lexington silt loam (fine silty mixed thermic Typic Paleudalfs), the average annual air temperature is 15.9°C, and soil pH is 6.5 (Soil Survey of Lafayette County, MS; UMFS). The average winter temperature in Lafayette County is 5.7°C, spring air temperature 16°C, and summer 26°C (Soil Survey of Lafayette County, MS). *Juncus effusus* L. (soft rush) is one of the most robust and hardy of the native perennial wetland plant species surveyed at UMFS (Holland and Cooper, 1999). Plants were collected from four 4-m^2 plots and subdivided into planting units, consisting of no less than six shoots and their associated roots. To obtain bacterial isolates, three replicated planting units with associated sediments were collected to a depth of 30 cm at each 4-m^2 plot. Microbiological analyses (below) were initiated within 24 h of sample collection.

Enumeration and Characterization of Freshwater Wetland Microflora—Rhizosphere sediments (10.0 g), closely attached to roots, were homogenized in saline and rhizosphere suspension serially diluted as described previously (Halda et al., 1991; Van Elsas and Smalla, 1997; Zuberer, 1994). Rhizosphere is defined as the thin layer of soil or sediment adhering to the root system after loose soil has been removed by shaking (Dandurand and Knudsen, 1997). In this case, rhizosphere extends up to 5 mm (millimeters) from the root surface. Roots were not included in this study. Briefly, rhizosphere suspension was serially diluted in saline until an appropriate dilution has been reached (up to 10^{-8}). Using dilution tubes, samples (0.1 ml) were pipetted and spread onto appropriate agar medium. Four replicate spread plates per dilution tube were used. Sediment samples were homogenized in saline and serially diluted as described above. The following culture media were used for bacterial enumeration: Tryptic Soy Agar (TSA, Difco Laboratories, Detroit, MI) for culturable, heterotrophic aerobic bacteria and MacConkey (Difco Laboratories) for gram-negative bacteria. Plates were incubated at 30°C in the dark; heterotrophic bacteria were enumerated after 48 to 72 h of incubation and gram-negative bacteria were counted after 48 h of incubation. Obtained isolates were purified and initially assessed for gram-negative and gram-positive reaction using 3% KOH method and the Gram staining method (Baron et al., 1994).

***Isolation and Identification of Aeromonas spp*—**MacConkey agar (Difco Laboratories) was used for the selection of gram-negative bacteria. Representative colonies having different colonial and cellular morphology were purified, stored, and characterized as previously described (Halda-Alija and Johnston, 1999; Halda-Alija et al., 2001). Preliminary identification of strains obtained in pure culture was based on Gram staining, respiration-fermentation tests, and oxidase reaction (Baron et al., 1994). Biochemical tests were performed with the API bacterial identification system from Bio-Merieux Inc., Hazelwood, MO. API 20E test kits were used for identification of enteric bacteria and API 20NE for aeromonads. Bacteria were identified according to Krieg and Holt (1984). Final identification of *Aeromonas* spp. was carried out according to criteria for environmental isolates recommended by Austin et al. (1996). Strains that could not be identified at the genus level were grouped as "unidentified." Identification of representative isolates was confirmed using 16S rRNA sequencing (MIDI Inc., Newark, DE).

***16S rRNA Sequencing*—**The 16S rRNA gene was PCR amplified from genomic DNA isolated from pure bacterial colonies (PrepMan™ Ultra Sample Preparation Reagent, Applied Biosystems Inc., Foster City, CA) following standard PCR protocols (Halda-Alija and Johnston, 1999) and using primers corresponding to *E. coli* positions 005 and 531 (500 bp packages). Amplification products were purified from excess primers and dNTPs using Microcon 100 (Millipore Inc., Bedford, MA) molecular weight cut-off membranes, and checked for quality and quantity by running 5 µl of the products on 2.5% NuSieve/Sea-Kem agarose gel (Biowhittaker Inc., Rockland, ME) at 148 V (Sambrook, 1989).

Cycle sequencing of the 16S rRNA amplification products was carried out using AmpliTaq FS DNA polymerase (Applied Biosystems Inc., Foster City, CA) and dRhodamine dye terminators (Applied Biosystems Inc., Foster City, CA). Excess dye-labeled terminators were removed from the sequencing reactions (Applied Biosystems Inc., Foster City, CA) using a Sephadex G-50 spin column (Sephadex-Amersham Inc., Upsala, Sweden). The products were collected by centrifugation (1000 g for 2 min) at 4°C, dried under vacuum and frozen at -20°C until ready to load. Samples were resuspended in a solution of formamide (83% v/v)/blue dextran (0.8% w/v)/5 mM EDTA and denatured prior to loading. The samples were electrophoresed on an ABI Prism 377 DNA sequencer (Applied Biosystems Inc., Foster City, CA). Data were analyzed using Applied Biosystems DNA (Applied Biosystem Inc., Foster City, CA) editing and assembly software and sequence comparisons were

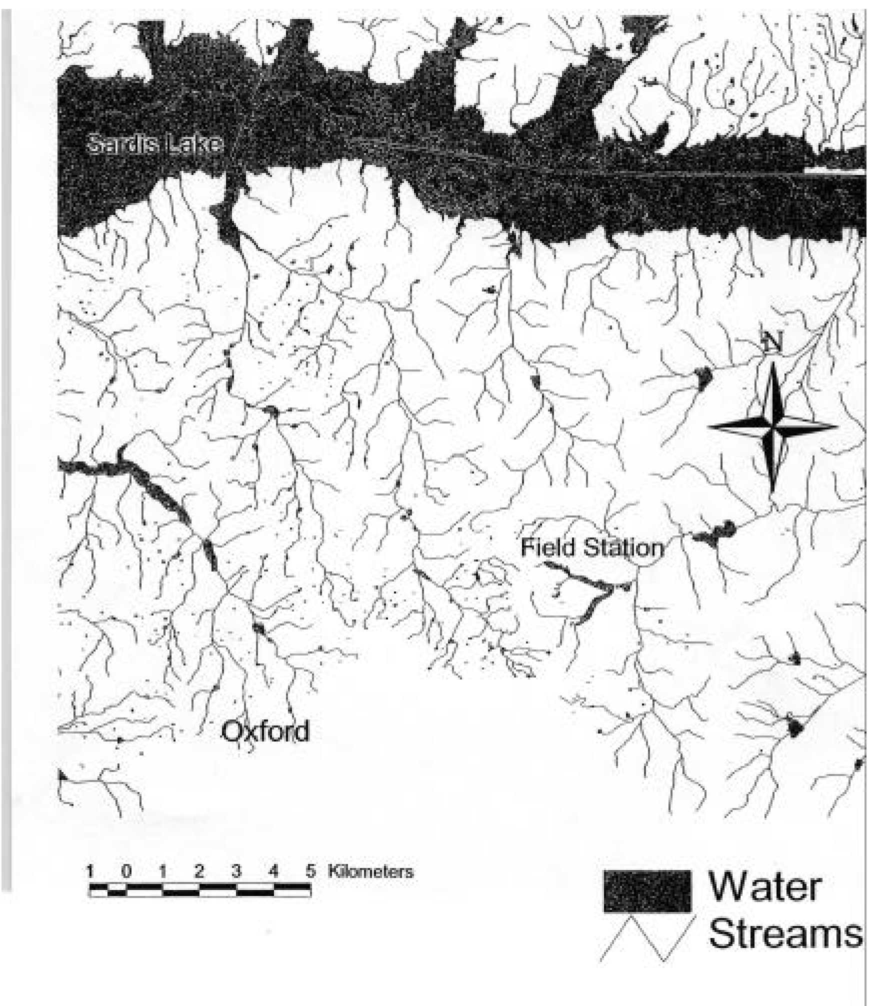

Figure 1. Location of the University of Mississippi Field Station (wetland areas in northern Mississippi).

obtained using the MicroSeq software (Applied Biosystem Inc., Foster City, CA). Bacterial identifications were based on 16S rRNA gene sequence similarity. Sequence analysis was performed using Applied Biosystems MicroSeq™ microbial analysis software and database (Applied Biosystem Inc., Foster City, CA). The top ten alignment matches were presented in a percent genetic distance format. Neighbors joining phylogenetic trees (Saitou and Nei, 1987) were generated using the top ten alignment matches.

Antibiotic Susceptibility Testing—Antibiotics representing different chemical families were employed. Antibiotic susceptibility was determined by the plate agar and disk diffusion tests (Leboffe and Pierce, 2002). For both tests, Nutrient Agar (NA, Difco Laboratories) medium was used. In the plate agar method, test plates were identical to control plates except that 10, 50, and 100 μg of either ampicillin (β-lactams), kanamycin (aminoglycoside), tetracycline, or chloramphenicol per ml was added. The results obtained by the plate agar method were confirmed with disk diffusion test (Leboffe and Pierce, 2002). The results from three to four replicates were averaged. Statistical tests and the differences in mean values were compared using SYSTAT v.9.2.1 (SPSS Inc., Chicago, IL).

RESULTS

Samples collected from sediments and the *Juncus effusus* L. rhizosphere gave rise to colonies exhibiting disparate morphologies on the TSA and MacConkey media. Occurrence of *Enterobacter* spp. did not exceed 5.6% (as a percentage of total number of heterotrophic bacteria) in the pristine stream and 8.5 % in the *Juncus effusus* L. rhizosphere (Tables 1 and 2). The occurrence of *Enterobacter* spp. and *Aeromonas* spp. decreased in winter. Abundance of culturable enteric bacteria was higher in the agricultural streams (11.9% in fall) than in other environments (Halda-Alija and Johnston, 1999; Halda-Alija et al., 2001; this study). Enterobacteriacae and *Aeromonas* spp. are of little numerical significance compared to *Pseudomonas* and *Bacillus* spp. in freshwater wetlands (Tables 1 and 2; Halda-Alija and Johnston, 1999; Halda-Alija et al., 2001). Because *Pseudomonas* spp. is characterized by an extraordinary nutritional versatility (Palleroni, 1984), population sizes of *Pseudomonas* spp. do not reflect environmental differences. Antibiotic resistant pseudomonads are common in wetlands (Halda-Alija, unpublished). Although most strains of *Pseudomonas* spp. are significantly more resistant to many

Table 1. Seasonal pattern of the occurrence of *Enterobacter* spp., *Aeromonas* spp., *Pseudomonas* spp., and *Bacillus* spp. in a pristine and an agricultural stream as the percentage of the total number of isolates[a].

	Genus			
Season	*Aeromonas* spp.	*Enterobacter* spp.	*Pseudomonas* spp.	*Bacillus* spp.
Winter				
Pristine stream[b]	0.6 a	ND[c]	32.7 a	9.6 a
Agricultural stream[b]	0.6 a	3.7 a	29.8 a	10.2 a
Summer				
Pristine stream	3.6 b	4.6 a	23.8 b	14.8 b
Agricultural stream	4.6 b	11.4 b	25.1 b	14.3 b
Fall				
Pristine stream	3.1 b	5.6 a	24.8 b	13.9 b
Agricultural stream	4.7 b	11.9 b	23.6 b	11.7 b

[a]Values are average of three subsamplings and three replicates.
[b]Data obtained at five stream sites were combined and average is presented (see Materials and Methods for details).
[c]Not determined.
abc-or each column, means followed by a common letter are not significantly different according to LSD test ($P < 0.05$).

Table 2. Seasonal pattern of the occurrence of *Enterobacter* spp., *Aeromonas* spp., *Pseudomonas* spp., and *Bacillus* spp. in wetlands as the percentage of the total number of isolates[a].

Season[b]	Genus			
	Aeromonas spp.	*Enterobacter* spp.	*Pseudomonas* spp.	*Bacillus* spp.
Winter				
Wetland sediment	0.9 a	4.3 a	17..3 a	16.1 a
Rhizosphere (*Juncus effusus* L.)	0.7 a	2.1 a	16.1 a	13.6 a
Spring				
Wetland sediment	1.7 b	5.1 a	20.3 b	17.3 a
Rhizosphere (*Juncus effusus* L.)	2.2 b	8.5 b	18.7 b	15.3 a
Summer				
Wetland sediment	3.4 c	6.3 c	15.6 c	19.2 b
Rhizosphere (*Juncus effusus* L.)	3.7 c	8.1 c	13.9 c	18.6 b

[a]Values are average of three subsamplings and three replicates.
[b]Data are not available for fall.
abc-For each column, means followed by a common letter are not significantly different according to LSD test ($P < 0.05$).

antimicrobial agents (including β-lactams, tetracycline, chloramphenicol, and fluoroquinolones) than most other gram-negative rods, this resistance has been assumed to be intrinsic resistance (Li et al., 1994).

Despite the polyphasic approach employed, identification to the species level was inconclusive for most of the bacterial strains. Sequencing of 16S rRNA revealed *A. hydrophyla* and *A. salmonicida* to be among the antibiotic resistant rhizobacteria (Figure 2).

The resistance to β-lactams was prevalent for aeromonads (Table 3). β-lactams and tetracycline are widely used in human and veterinary practices and isolates resistant to these compounds were the most frequent. Results for chloramphenicol and kanamycin were similar. Chloramphenicol resistance was low; thereby suggesting it is conferred by nonspecific low-level resistance genes (i.e., background level of resistance). This is in agreement with other studies (Goňi-Urriza et al., 2000), and probably the result from the restricted use of kanamycin and chloramphenicol. Although kanamycin is an effective antibiotic against a number of pathogenic bacteria, they have side effects that limit their use (Salyers and Whitt, 2002).

DISCUSSION

This study focused on antibiotic resistant *Aeromonas* spp. and demonstrated the abundance of antibiotic resistance in non-clinical environments. This observation is in agreement with four independent studies of antibiotic resistance in bacteria isolated from European mineral water (Massa et al., 1995; Mary et al., 2000; Papatropoulou et al., 1994; Rosenberg and Hernandez, 1989).

High level of resistance (< 50 µg/ml) for ampicillin indicates that ampicillin resistance was acquired through gene transfer. The ampicillin was deployed in 1961 and the resistance developed in 1973 (Lewis et al., 2002). It has been reported that *Aeromonas salmonicida* has the ability to transfer the antibiotic resistant phenotype to *E. coli* by R-plasmids (Adams et al., 1998). The hypothesis that antibiotic resistant genes are transferred between enterics and aeromonads in the environment requires further testing.

Our understanding of antibiotic resistance is rudimentary, especially with respect to the ecological aspects (Lemke and Leff, 1999). One study showed an increase in antibiotic resistance in an industrially perturbed stream, which positively correlated with mercury concentrations in the sediments (McArthur and Tuckfield, 2000). Antibiotic resistance genes can be present in replicons that contain other selectable markers and that might explain the predominance of ampicillin resistance in the wetland plant rhizospheres. Consequently, selection for antibiotic resistance determinants might occur in the environment as a function of high levels of antibiotic use and chemical or heavy metal pollution (McArthur and Tuckfield, 2000). Aeromonads play multiple roles in the environment as wetland plant-growth promoters (Subgani, 2002), nitrifiers (DeBoer and Kowalchuk, 2001; Nemergut and Schmidt, 2002), and potential environmental indicators (present study).

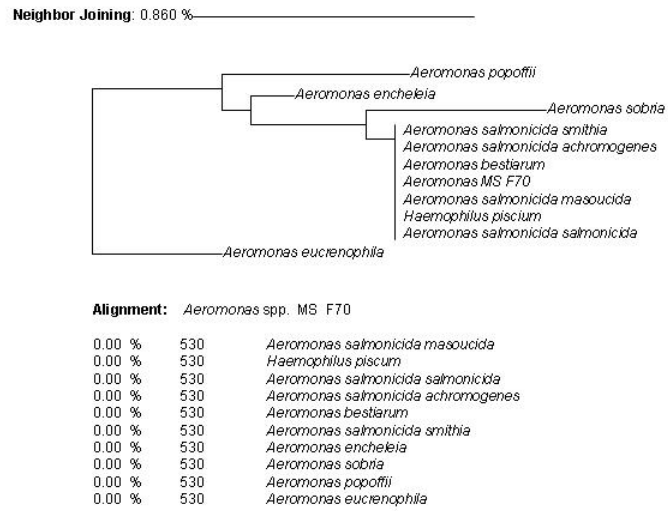

Figure 2. Identification of *Aeromonas salmonicida* MS F70 based on 16S rRNA sequencing (see text for details).

Aeromonads present adequate markers because they are ubiquitous in aquatic environments such as wetlands. We propose using aeromonad species, specifically *A. hydrophyla* and *A. salmonicida*, as environmental indicators of pollution because *Aeromonas* is considered an emerging human pathogen (suspected to cause a wide variety of diseases including gastroenteritis, septicaemia, endocarditis, osteomyelitis, myonecrosis, haemolytic uraemic syndrome, meningitis, peritonitis, respiratory tract disease and ocular infections) (Austin et al., 1996). In addition to being pathogenic to humans, *Aeromonas* spp. are also important pathogens in amphibians, reptiles and fish with the latter resulting in economic problems for the fish farming industry (Austin and Austin, 1993). *Aeromonas* species have also been isolated from a variety of foods such as vegetables, raw milk, ice cream, meat and seafood (Austin et al., 1996). Therefore, monitoring the presence of environmental aeromonads in order to detect possible

Table 3. Percentage of *Aeromonas* spp. isolates obtained from different environments resistant to antibiotics[a].

Environment	% of resistant *Aeromonas* spp.		
	Ampicillin (β-lactam)	Tetracycline	Chloramphenicol
Pristine stream	ND[c]	ND	ND
Agricultural stream	ND	ND	ND
Wetland sediment[b]	17.30 a	7.30 a	0.50 a
Rhizosphere[b] (*Juncus effusus* L.)	23.50 b	3.40 b	1.10 a

[a]Values are average of three subsamplings and three replicates.
[b]Combined data for spring and summer are presented (no significant differences were found between spring and summer at $p<0.05$).
[c]ND = Not determined.
abc-For each column, means followed by a common letter are not significantly different according to LSD test ($P < 0.05$).

contamination and water and soil/sediment quality deterioration will significantly contribute to the long-term protection of human health and the environment.

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Characterization of Vehicle Test Courses by Power Spectra

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In the last several years, smaller robotic vehicles and all-terrain vehicles have introduced a need to re-evaluate some of the previous vehicle testing methodology that we use to test vehicles. The Mobility Systems Branch of the Geotechnical and Structures Laboratory has several vehicle ride courses used to evaluate the dynamic vibrational effect of cross-country of terrain on vehicles. This paper explains ways we characterize terrain for vehicle testing and generate performance analyses. Mathematical formulas have been derived for characterizing the terrain in terms of the dimension of its power spectral density curve. Also, the slope of the line relating the elevation profile detrending[1] length to some power of the detrended root mean squared (RMS)[2] value is used. The plots of some courses and their power spectral density curves are shown and then several different detrending values are considered in order to illustrate the application of the formulas. The paper also includes a short discussion of how the mathematical theory of wavelets is related to the averaging and detrending kernels.

Purpose. The purpose of the research reported in this paper is threefold: (1) to assist the ERDC in quantifying micro-terrain for generating performance analysis with current test data sets, (2) to develop methodology to supply representative micro-terrain for vehicle dynamic analysis and simulators, and (3) to lay a mathematical foundation for further research into a better method of realistic automatic terrain generation for vehicle simulations.

Outline. In its introduction, this paper provides a short history of the work on cross-country terrain characterization for vehicle testing up to this time. In the introduction and appendix, there is a short discussion of the relation of various types of wavelets to several types of detrending formulas that can be used to help smooth the terrain profiles. This smoothing process helps to better define the characterization of the terrain profile's power spectral representation. Wavelets are related to detrending in that they are averaging kernels that are summed over the profile data. In the appendix, several mathematical formulas[3] are derived for characterizing the terrain in terms of the dimension of its power spectral density and the slope of the line relating the detrending length to some power of the detrended RMS value. Then, in the main part of the paper, the validity of the current methodology of using the root-mean-squared (RMS) statistic associated with cross-country micro-terrain is re-evaluated in terms of the use of the frequency analysis of power spectrum transforms. In the main part of the paper we consider whether it is useful to use several different detrended lengths in the design of off-road vehicle test courses. The elevation profiles from three representative test courses were considered in order to characterize them using this mathematical methodology. We plot the original course and its power spectral density curves and then consider several different detrending values in order to apply the formulas. In the reference by Van Deusen (1996), the differences between natural and man-made terrain were evaluated from the viewpoint of measuring these terrain by surface profiling. In this report Van Deusen considered the short falls of using RMS alone for all man-made or modified terrain. We examine the cross-country and road surface profiles already measured and in use for testing at ERDC. After the profiles have been analyzed and studied, we will look at a new methodology and formulas derived in the appendix as a means of representing scaling effects in modeling and representing this terrain for vehicle testing.

Scope. As outlined in the Purpose section, this paper considers how how to quantify micro-terrain for use in performance analyses of test vehicles. It lays a mathematical foundation for further research into better methods of generating realistic automatic terrain for vehicle tests and simulations. The paper does not consider the relationship of this method of statistically determining the dimension of power spectral density curves to the theory of other methodologies related to statistically sampling fractal terrain (see Harte, 2001), nor does it consider how to relate the detrending length used to calculate the RMS to the expected normal modes of vibration in the test vehicles (see Harrell TR-01-16, 2001) as an introduction to this.

Background. As mentioned above, the problem of how to represent micro-terrain for vehicle studies was considered by Van Deusen (1966), in his report for the Chrysler Corporation on the design of the lunar vehicle for the National Aeronautics and Space Administration (NASA). He wrote programs using several different methods to detrend the radar elevation data from the Ranger program of lunar exploration. Some runway profile data and highway profile data were also considered. Van Deusen found when assuming a power spectral density curve proportional to negative two power, that the detrending parameter[4] needed could be related to the variance of the data for cross-country or natural terrain. In 1972, the Directorate of Research, Development and Engineering, AMC[5], authorized a vehicle mobility study by TACOM[6] and WES[7] for an assessment of mobility of wheeled vehicles already in the fleet and candidates for their replacement. One important focus of this study was to define the different vehicle mission levels and quantify the performance of military vehicles while operating at different mobility mission levels. These definitions and evaluations were developed using the Army Mobility Model (AMM, AMC-71) produced by WES. The approach was to evaluate the vehicle's speed as it traversed different terrain types, such as primary roads, secondary roads, trails, and cross-country, in a given mission and combine these predicted movement velocities over the various terrain in a quantitative manner. The resulting method was used to successfully rank the performance of different military vehicles while operating at different mission levels. In 1974, the US Army Training and Doctrine Command (TRADOC) initiated a study to determine future requirements for high-mobility vehicles in the Army inventory and determine and compare the effectiveness of high-mobility and standard-mobility (tactical) vehicles in combat support. The TRADOC mobility levels, which were generated from the 1972 study, were used to define the vehicle's mission. These mobility levels were defined as:

Tactical high mobility: A level of mobility designating requirements for extensive cross-country maneuverability characteristics involved in operating in ground-gaining and fire-support environments.
Tactical standard mobility: A secondary level of mobility designating the requirement for occasional cross-country movement.
Tactical support mobility: A level of mobility designating the requirement for infrequent off-road operations. These operations occur over selected terrain with the preponderance of movement on primary and secondary roads.

The tactical mobility assessment required additional detail beyond the general description of terrain types (cross-country, primary and secondary roads) to include terrain classification and mission percentages over each terrain type. Standard terrain type definitions were used for primary and secondary terrain as well as for cross-country terrain.

Primary Roads: Two or more lanes, all-weather, maintained, hard surface roads with good driving visibility used for heavy and high-density traffic. These roads have lanes with a minimum width of 2.7 m (9 ft.) and the legal maximum GVW/gross combined weight for the country or state is assured for all bridges.
Secondary Roads: Two lanes, all-weather, occasionally maintained, hard or loose surface (paved, crushed rock, gravel) roads intended for medium-weight, low-density traffic. These roads have lanes with a minimum width of 2.4 m (8 ft.) and no guarantee that the legal maximum GVW/gross combined weight for the country or state is assured for all bridges.
Trails: One lane, dry weather, unimproved, seldom maintained, loose surface roads intended for low-density traffic. Trails generally have a minimum lane width of 2.4 m (8 ft.), no large obstacles (boulders, stumps, logs), and no bridging.
Off-Road: Vehicle operations over virgin terrain that has had no previous traffic (cross-country) and over combat and pioneer trails.

METHODS AND MATERIALS

Transforms. Transforms are the result of transforming a function of one independent variable to that of another. A common example of a transform of $f(t)$ is the cosine transform

$$f(t) = \sum_{k=0}^{\infty} A_k \cos(2p \frac{kt}{T}) ,$$

or

$$f(t) = \sum_{k=0}^{\infty} A_k \cos(2pw_k t)\,,$$

where $w_k = k/T$ is the frequency. The cosine transform of $f(t)$ is literally the coefficients in the series $A_k = A(w_k)$ which are given by

$$A_k = \frac{2}{T}\int_0^T f(t)\cos(2pw_k t)dt\,.$$

Thus the function in the *time domain* is transformed to a function in *frequency domain*. The cosine transform is an example of a more general class of *linear* transforms referred to as *Fourier* transforms. Note that the transform is a *linear* combination of the sequence of cosine functions, a property of the transform, and the constant A_k , a property of the data. The cosine functions are referred to as the *basis* functions or *kernel* of the transform. Other choices of basis functions give different transforms having different properties.

Consider a function as a list, or time record, of *N+1* numbers that is a discrete sampling of a continuous function in time, $f(t)$. The readings are equally-spaced over a total time of $T = (N+1)\,\Delta t$ such that the position, k, in the list corresponds to a time equal to $k\Delta t$. In the discrete transform, the list of *N+1* samples in time is transformed to a list of *N+1* numbers, each corresponding to a discrete frequency. Each record can be computed from the summation

$$f_N = \sum_{k=0}^{N} A_k \cos(2pw_k N\Delta t)\,.$$

For the general discrete Fourier transforms the basis functions consist of both sines and cosines,

$$f_N = \sum_{k=0}^{N} [A_k \cos(2pw_k N\Delta t) + B_k \sin(2pw_k N\Delta t)],$$

which is generally written in *complex form* as

$$f_N = \sum_{k=-N/2}^{k=N/2} F_k \exp(ipw_k N\Delta t)\,.$$

The algorithm for computing this transform efficiently is referred to as the *Fast Fourier Transform*.

Estimation of the Power Spectral Density. If the profile height, denoted by Y_i , is measured at equal increments Δx over a finite course length, the autocorrelation function can then be defined and computed by the formula:

$$f_l = 1/n - l\sum_{i=1}^{n-l} Y_i * Y_{i+l}\,.$$

The corresponding definition and estimate of the power spectral density (PSD) is

$$P(n) = 2\Delta x(f_0 + 2\sum_{i=1}^{m-1} f_i \cos(i\,l\,p\,/\,m) + f_m \cos(ip))\,.$$

Due to the inability to precisely resolve any frequency in a finite sample, it is necessary to smooth the spectral estimate from the above equation over neighboring frequencies.

$$\overline{P(n)} = \sum_{k=-\infty}^{\infty} w_k(l)P(n-k)$$

where l is the detrending length and w is a smoothing (detrending) window. The question then arises how does varying the detrending length affect the accuracy of the PSD estimation?

Wavelets. Wavelets are mathematical families of functional atoms or functional components. They can be generated from a single function y by dilations and translations in the form: $y_{a,b} = |a|^{1/2} y((t-b)/a)$; where the parameters a and b are often restricted to a discrete set. This defines a discrete wavelet transform which provides one way to detrend elevation profiles. In this form they provide a way to decompose an arbitrary function similar to the way sines and cosines are used in the mathematical theory of Fourier analysis. Wavelet transforms are defined and used in wavelet methods to analyze signals in a way analogous to Fourier Transforms:

For a and b real numbers, a, b < > 0 the discrete wavelet transform is

$$(Tf)_m = \langle y_{m,n}, f\rangle = |a_0|^{-m/2}\int dt * y(a_0^{-m}t - nb_0) * f(t)$$

where $a = a_0^{\,m}$ $\qquad b = nb_0 a_0^{\,m}$.

These methods provide an improved way to analyze and represent functions of which the spatial form has representations changing with time. The book by Krantz (1999) gives a good overview of some of the mathematical topics in the theory of real analysis and functional analysis, which played a part in their invention and development.

The uses of wavelets are varied. Fournier (1995) contains an introduction to their use in computer graphics and image compression, and Charles Chu (1997) explains the uses of them to improve the functional representation by interpolation of the spline[8] of the data for numerical partial differential equations. The papers by Newland and Butler (1999) use wavelets for the study of centrifuge experiments related to earthquake engineering. The reference Torrence and Compo (1998) provides data on using them to prove the statistical significance of El Niño related sea surface temperatures.

There are many different type of wavelets, corresponding to different uses: continuous wavelets (Meyer and Ryan, 1993), discrete wavelets (Chu, 1997), orthogonal wavelets, biorthogonal, and compact wavelets (Daubechies, 1992). The Daubechies scaling function, wavelet function, and filter coefficients are shown in the logistic test vehicle ride results report (Harrell, 2001). The definitions of the scaling function and wavelet function in this report are based on the mathematical algorithm used to compute the wavelet decomposition by Chu (1997). The wavelet filter coefficients are the multipliers used in the wavelet transform to extract the high and low frequency components of the signal. Chu (1997) has a good reference to help understand how wavelet function, scaling function, and filter coefficients work together to decompose, reconstruct, and approximate the signal. The particular wavelet that ERDC has been using to date to do its detrending of vehicle test course elevation profiles is: $w_j = e^{-x*j/l}$. The use of functions of this type to do detrending was first studied mathematically by Wigner (1932) and Ville (1948); Mallat (1998) explains the connection of this to wavelet theory. The exponential function decays fairly fast in terms of units of detrending length. The normal modes of vibrational response of vehicles to terrain can often be expressed in functions of this type (Harrell, 2002). The ERDC technical report by Harrell (2001) gives additional information about the relationship of wavelets to vehicle testing.

Some other possibilities for smoothing (detrending) windows are in Press et al. (1992):

$w_j = 1 - \left|(j-(1/2N))/(1/2N)\right|$ "Bartlett window"

$w_j = 1/(2(1-\cos(2pj/N))$ "Hann window"

$w_j = 1-(j-(1/2N)/(1/2N))^2$ "Welch window"

The amplitudes of the Fourier coefficients of the above spectral windows are shown in Table 1. Comparing the values gives some idea of how they average the data differently. But, according to Several Theorems of Wiener (Weiner, 1957) the extent of the different types of functions that these different detrending wavelets can represent is equivalent[9].

RESULTS

In 1971, the WES conducted a statistical analysis of terrain-vehicle-speed relative to dynamics of wheeled vehicles. One important conclusion to this effort was the acceptance of a single statistical measure of terrain micro-surface roughness developed by the Chrysler Corporation in 1966 for NASA. The NASA was interested in describing naturally occurring extraterrestrial terrain for the development of extraterrestrial land vehicles. The Chrysler Corporation concluded that micro elevations of a naturally-laying terrain could be described by the standard deviation of the detrended terrain elevations or the RMS, of the detrended terrain elevations. The term detrended terrain elevations refers to applying the various wavelet transforms to the terrain elevations. The formulas for these procedures will be explained in the following sections. Van Deusen's work in this area, using an exponential weighting factor, indicated that the RMS of the detrended course depended on the detrending parameter. This was a simplication of the earlier methodology which made it easier to construct a series of off-road test course using only a single parameter (the RMS). The terrain surface roughness (the RMS) was shown, in the 1971 WES study, to be a significant factor in vehicle speed when traversing natural cross-country terrain. The smoother the terrain surface, the faster the vehicle would travel and the rougher the terrain surface, the slower the vehicle would travel. This dynamic performance and terrain description technique was accepted by the TRADOC study to classify the different terrain types. Classes of surface roughness were assigned to the different terrain descriptions. Typical RMS values for off-road areas and roads are as follows:

Primary Roads: Surface roughness values range from 0.1 inch RMS to 0.3 inch RMS.

Table 1. Coefficients of Spectral Windows. Values measured as the smoothing operator moves aways from the center point—computed in units of the detrending length.

Coefficient	Hann Values	Bartlett Values	Welch Values	Exponential Values
A_0	1	1	1	1
A_1=A_{-1}	0.97553	0.9	0.99	0.36788
A_2=A_{-2}	0.90451	0.8	0.96	0.13534
A_3=A_{-3}	0.77389	0.7	0.91	0.04978
A_4=A_{-4}	0.65451	0.6	0.84	0.01832
A_5=A_{-5}	0.50000	0.5	0.75	0.00673
A_6=A_{-6}	0.34549	0.4	0.64	0.00247
A_7=A_{-7}	0.20611	0.3	0.51	0.00091
A_8=A_{-8}	0.09549	0.2	0.36	0.00033
A_9=A_{-9}	0.024471	0.1	0.19	0.00010
All others	<0.02	0	< 0.15	<0.0001

Secondary Roads: Surface roughness values range from 0.1 inch RMS to 0.6 inch RMS.
Trails: Surface roughness values range from 0.1 inch RMS to 2.8 inch RMS.
Off-Road: Surface roughness values ranges from 0.6 inch RMS to 4.5 inch RMS.

In retrospect, a problem that arose with this decision was using an analytical method proven for natural terrain for man-made terrains like roadways. The Chrysler Corporation in its earlier reports had defined its conclusions based on natural terrain and proved that the RMS of a made-man terrain was not adequate to describe the frequency content of the changes in the micro-terrain elevations.

In the WES report by Murphy (1984) off-road elevation profile data from the ERDC ride courses at Letourneau, MS were studied. It was determined that a single RMS statistic with a detrending parameter of 10 feet could be used to adequately represent the observed power spectral density curves (of vehicle response to off-road terrain, but not roads). The implementation of how to design test courses based on this conclusion was followed by the study by Lessum (1971) in which he used Wiener-Bose theory to characterize the power spectrum in ride courses.

To summarize the previous history of research in this area:

- Military vehicle mission levels were defined to compare vehicle mission performance.
- Terrain descriptions were assigned to the different terrains encountered during military vehicle mission scenarios.
- Terrain micro-surface roughness was calculated on the different terrain types due to the vehicle-terrain/surface roughness performance relationships.

The TRADOC used the results of its study to assist in the creation of military vehicle operational requirements document. The requirement documents now state required vehicle mission levels, as defined in this report, associating percentages of terrain types for each mission level. Table 2 below summarizes the values that define this mobility classification system.

With the description of the different missions in measurable terms, the vehicle design and performance specifications developed by TACOM uses these same descriptions to determine how the vehicle would be physically tested. The decision to test new vehicles, using these terrain definitions, required the test community to monitor and maintain test courses to these classification levels. These criteria are also used to develop test courses for mission scenario testing and for durability testing.

In the last several years, smaller robotic vehicles and all-terrain vehicles have introduced a need to reevaluate some of the previous testing methodology. ERDC has expanded its research in this area to make use of some new techniques in mathematics which could possibly improve the characterization of vehicle response to micro-terrain. Some questions have arisen in the vehicle testing community about the adequacy of using a single RMS statistic to represent the terrain micro-geometry for vehicle testing. The general mathematical theory of wavelets, as they shed light on different detrending methods, can be considered as a more adequate solution to the problem than the more limited and specific Wiener-Bose theory. That is, the problem of how to improve the Fourier representation of time series is better understood in the more general mathematical theory of averaging kernels and wavelets. The formulas that arise from this approach are related mathematically to the previously used exponential detrending methodology. Several families of wavelets have already been used for characterizing the results of vehicle ride tests on the ERDC Logistics Test Vehicle (LTV). In the two ERDC reports listed in the references below, wavelet methodology was used to: (1) determine whether the power spectral densities resulting from vehicle drops of the ERDC LTV had higher normal modes than of the vehicle's frame vibration frequencies, (2) investigate the possibility of redesigning some of the Letourneau ride courses, and (3) test ways to represent the vehicle's response in terms of wavelet expansion coefficients resulting from the vehicle's response to the test courses.

Table 2. Definition of Mobility Levels.

	Operation Mix Percentage of Mission			
Mission	Primary Roads	Secondary Roads	Trails	Off-Road
Central Europe Scenario Areas				
Tactical-High	10	30	10	50
Tactical-Standard	20	50	15	15
Tactical-Support	30	55	10	5
Mid-East Scenario Areas				
Tactical-High	5	20	25	50
Tactical-	15	35	35	15

In this paper we follow the overall approach in the reference by Van Deusen (1966). It assumes that the power spectral density of the elevation profile of the test course is of the form:

$$P_d(\Omega) = C * \Omega^{-n} ,$$

where n = inverse power of the curve representing the spectral density, which is constant for any given spectral estimate, and Ω = spatial frequency in cycles/foot. The formula to be derived for n = 2 is:

$$s^2 = (Cp^2 l)/2$$

where s = RMS, l =detrending length, and C is a constant to be determined that characterizes the vehicle test course. It is due to Van Deusen (1966). This formula applies only in the case where the inverse power of the spectral density curve is 2. Not all the details of the mathematical derivation of this formula were given in Van Deusen's report. So, it is rederived in Appendix A along with a new corresponding formula for the case where the dimension of the inverse power of the spectral density curve is n = 4, i.e.,

$$s = C * (4p^4 l^3)^{1/2} .$$

From the formula, derived from the assumption of an n = 2 power law, $s^2 = (Cp^2 l)/2$ and knowing the slope of the line from the above graph, we have that $C = 2(.0059)/p^2$ = 1.1955 x 10^{-3} (feet)^2 cycle/foot or 3.644 x 10^{-4} (meter)^2 cycle/meter.

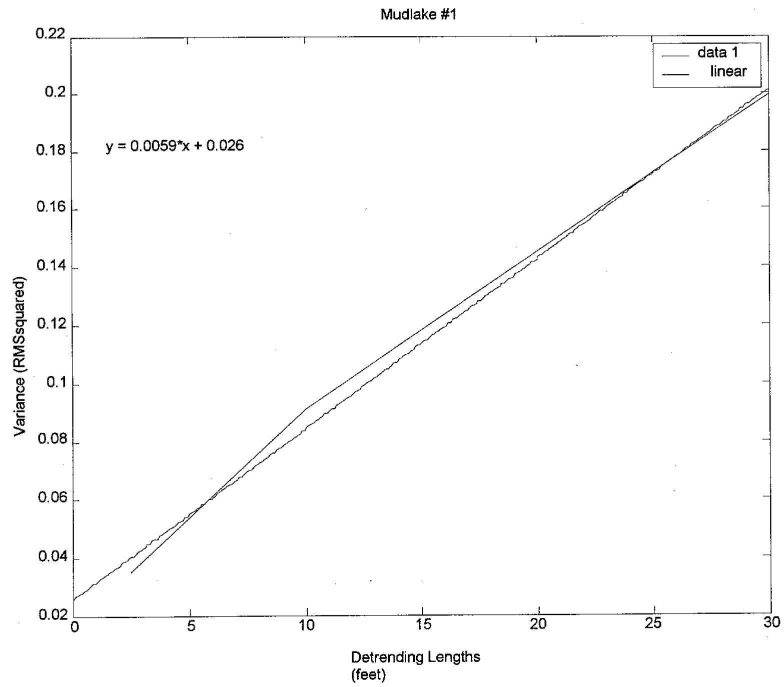

Figure 1. Relation of the square of the Mud Lake detrended RMS to the detrending length. Determining which log power fits the data linearly determines the course spectral density law, n, and fitting the slope allows the determination of C. slope = 0.0059, y-intercept = 0.026

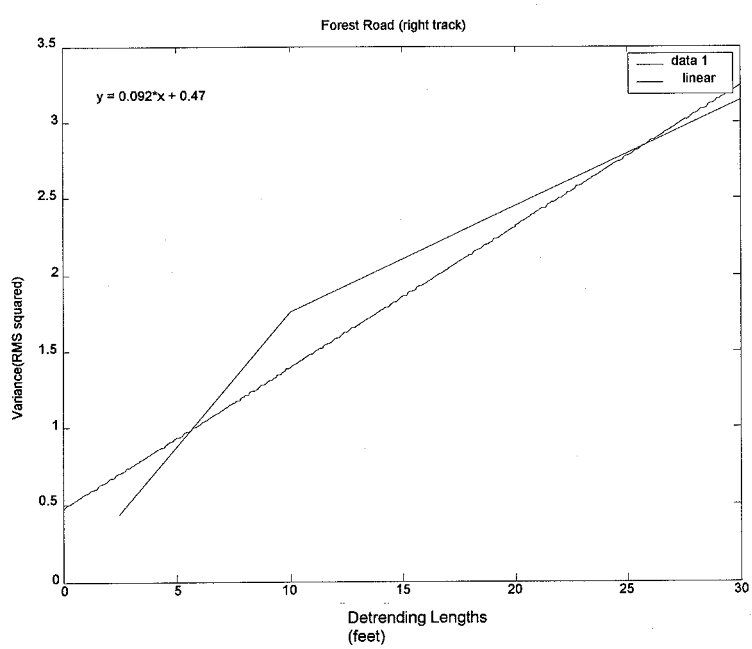

Figure 2. Plot of the Forest Road RMS squared versus detrending length. Determining which log power fits the data linearly determines the course spectral density law, n, and fitting the slope allows the determination of C. slope = 0.092, y-intercept = 0.47

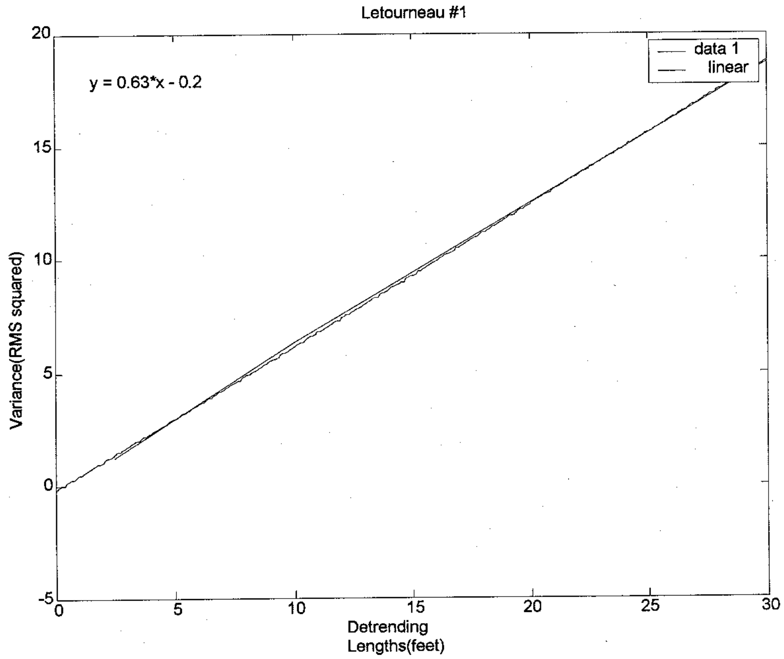

Figure 3. Plot of the Letourneau test course RMS squared versus detrending length. Determining which log power fits the data linearly determines the course spectral density law, n, and fitting the slope allows the determination of C. slope = 0.63, y-intercept = 0.2

The course is characterized by the PSD curve dimension of n = 2. From the formula $\sigma^2 = (C\pi^2\lambda)/2$ and knowing the slope of the line from the above graph, we have that $C = 2(.092)/\pi^2$ = 1.8643 x 10^{-2} (feet)^2 cycle/foot or 5.6824 x 10^{-3} (meter)^2 cycle/meter.

From the formula $\sigma^2 = (C\pi^2\lambda)/2$ and knowing the slope of the line from the above graph, we have that $C = 2(.63)/\pi^2$ = 1.276 x 10^{-1} (feet)^2 cycle/foot or 3.8912 x 10^{-2} (meter)^2 cycle/meter. Looking at the formula we see that in this case the size of the square of the coefficient C that characterizes the test course is directly proportional to the surface roughness.

In the course of the analysis, plots were also made for each of the test courses of the linear RMS and the RMS to the ⅔ power versus detrending length. These were the other cases where, if the spectral density curve were of a certain inverse power, the analysis in the appendix indicated a possible formula relating these two variables. These results are shown in figures 10, 19, 20, 29. However, the goodness of linear fit of the relation of the detrending length to the RMS was not as good in these cases.

CONCLUSIONS

Considering the above graphs and the analysis that is given below in this paper, it seems reasonable to conclude that a dimension of n = 2 should be used for the inverse power of the spectral density curves of the test courses. There are two advantages of using this methodology over that of a simple RMS value. One is that the spectral power curve dimension along with the coefficient of the power spectral curve gives a more powerful means of differentiating test courses at a higher resolution. Another is that the parameters used do not depend on the detrending length used to smooth the elevation profile data. It seems reasonable to use these two parameters to characterize and differentiate the vehicle test courses that were considered: (1) the inverse power of the curve representing the course's spectral density, and (2) the coefficient C in the numerator of the curve representing the course's spectral density. Their computed values are given in Table 3 below.

Table 3. Characterization of Two Road Sections and One Vehicle Test Course by the Spectral Characteristics of Their Elevation Profiles.

Course Name	Spectral Density Coefficient $(feet)^2$ cycle/foot	Spectral Curve Inverse Dimension
Mud Lake Farming Road	1.2×10^{-3}	2
Forest Road	1.9×10^{-2}	2
Letourneau #1	1.3×10^{-1}	2

Table 4. Estimates of Parameters Defining Military Roads, and Trails.

Primary Roads	RMS LL	RMS UL	Spectral Density Coefficient	Spectral Curve Inverse Dimension
high quality	0.1	0.1	1.4×10^{-7}	2.5
secondary pavement	0.2	0.2	1.9×10^{-7}	2.5
rough pavement	0.3	0.3	8.0×10^{-7}	2.5
Secondary Roads				
loose surface	0.3	0.6	3.0×10^{-5}	2
loose surface w/potholes	0.3	0.6	4.0×10^{-6}	2.4
Belgian block	0.3	0.6	5.0×10^{-4}	1.4
Trails				
one lane, unimproved	0.6	2.8	5.0×10^{-4}	1.9

Table 5. Representative Values Previously Used to Characterize Terrain and Roads.

Course Name	Spectral Density Coefficient $(feet)^2$ cycle/foot	Spectral Curve Inverse Dimension
Aircraft Runway 12	2.5×10^{-6}	2
Smooth Highway	1.2×10^{-6}	2.1
Aircraft Runway 3	2.2×10^{-7}	2
Highway with gravel	1.1×10^{-5}	2.1
Lunar profile	1.2×10^{-3}	2
Aberdeen, MD vehicle test course	1.6×10^{-3}	2

According to the parameters and classification scheme on the National Automotive Test Center (NATC) website the upper (RMS UL) and lower limits (RMS LL) for the values of RMS which were computed for the MudLake Farming Road and the Forest Road place them in the category of a loose surface secondary roads.The values computed for the Letourneau Test Course place it in the cross-country category. Table 4 show these parameters, which were determined from performance specification information. The MudLake Farming Road has a 10 foot parameter detrended RMS of 0.3 and a 30 foot detrended RMS of 0.45 The Forest Road has a 10 foot detrended RMS of 1.21 and a 30 foot detrended RMS of 1.7.The Letourneau #1 course has 10 foot detrended RMS of 2.5 and a 30 foot detrended RMS of 4.3.

For comparison purposes, the above table by Van Deusen contains parameters measured from detrended data for aircraft runways.

DISCUSSION

Details of the Analysis of the Vehicle Test Course Profiles. In the following pages three different vehicle test courses are analyzed: (1) Mud Lake #1, a Delta, LA farm road, (2) Forest Road (right track), a road test section at the ERDC, Vicksburg, MS Geotechnical pavements test facility, and (3) Letourneau #1, at the Geotechnical Mobility Branch's specially constructed military vehicle ride course. Gravel was used to construct the Letourneau course in order to represent a wide spectrum of square wave frequencies. The difference of the frequencies occurring in this constructed course were replicated from those occurring in natural terrain. This can be seen by comparing the 1997 Letourneau course elevation profile readings and power spectrum plots (Figures 22, 23, 24) with those of the Mud Lake and Forest Road sites (Figures 1, 2, 10, 18). However, profile analysis of data measured in 1999 shows that some of these frequencies have disappeared from the Letourneau course. This is possibly due to vehicle trafficability passes, rain, and soil consolidation. In order to characterize the test courses for purposes of testing smaller vehicles, the elevation profile data were measured at 3-inch intervals. This compares to the previously used profile data station increments of 1 foot. Figures 4 through 10 show the Mud Lake elevation profile and power spectral density of the test courses both before and after they have been detrended (using three different detrending lengths). In Figures 1 and 11, the results of the detrending in terms of RMS and variance are plotted against the detrending length in order to test Van Deusen's theoretical formula[10].

Again, we assume that the power spectral density of the elevation profile of the test course is of the form:

$$P_d(\Omega) = C * \Omega^{-n},$$

where n = inverse power of the curve representing the spectral density, which is assumed to be constant for any given spectral estimate. Ω = spatial frequency in cycles/foot[11].

The results of the analysis in the rest of this section show, as Van Deusen theory claims, that for the Mud Lake road and Letourneau off-road course profiles a fairly exact linear relation exists between the detrending length squared (the variance) and the RMS. After the data have been plotted this way, the fitting constant C along with the dimension of the inverse power of the spectral density curve can be used to characterize the elevation profile for vehicle test purposes. The detrending data was plotted against a linear relation (n = 1), quadratic (n = 2), and cubic (n = 4) power of the detrending length. These three dimensions satisfy the conditions that allow the integral representing the exponential detrending wavelet (Wigner-Ville tranform) applied to the sine and cosine function to converge. Although it is not as clearcut as in the case of the other test courses, a look at the three figures (2, 20, 21) shows that the Forest Road data can also be best fitted linearly if the detrending length squared is plotted versus the square of the RMS. Thus, in all three cases, Mud Lake, Forest Road, and Letourneau, the detrended power spectrum is best characterized by a power spectrum of type represented functionally by a polynomial curve of the degree inverse power squared.

Mud Lake. After the profile has been detrended according to the formulas listed above, using a range of smoothing parameters, the results may be analyzed. The formula derived in the appendix relating the resulting RMS of the detrended profile to the smoothing (detrending) parameter can be used to test the assumption regarding the dimension of the power spectral density of the profile. The dimension computed using the formula can be used to characterize the test course. In the graph in Figure 1 a value of n = 2 is used as the inverse dimension of the power spectral density curve. The graph below shows a different value, n = 1, and clearly does not give as good a fit to the data as the value n = 2 in Figure 1.

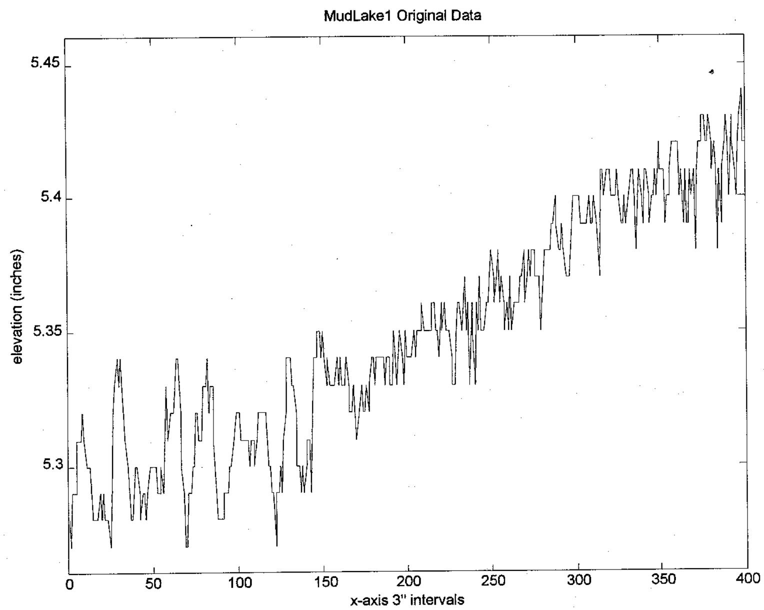

Figure 4. Original Mud Lake elevation data. undetrended mean = 5.3481 RMS = 4.238

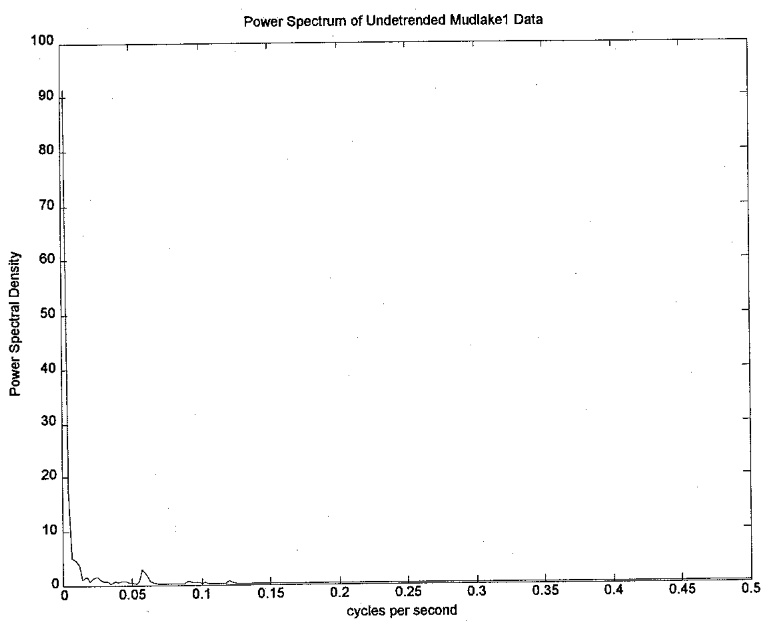

Figure 5. Power spectrum of the original Mud Lake data.

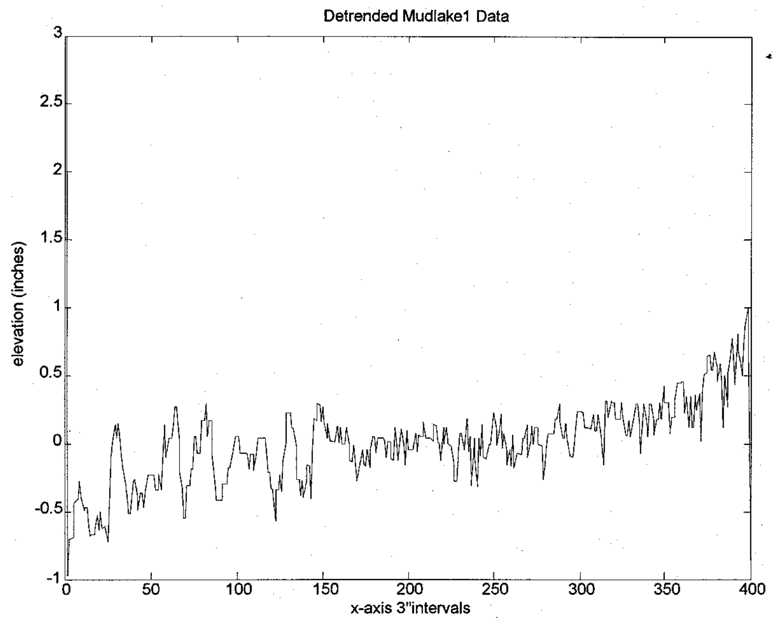

Figure 6. Mud Lake elevation profile detrended using a 10 foot parameter length. 10 foot detrend distance RMS = 0.302

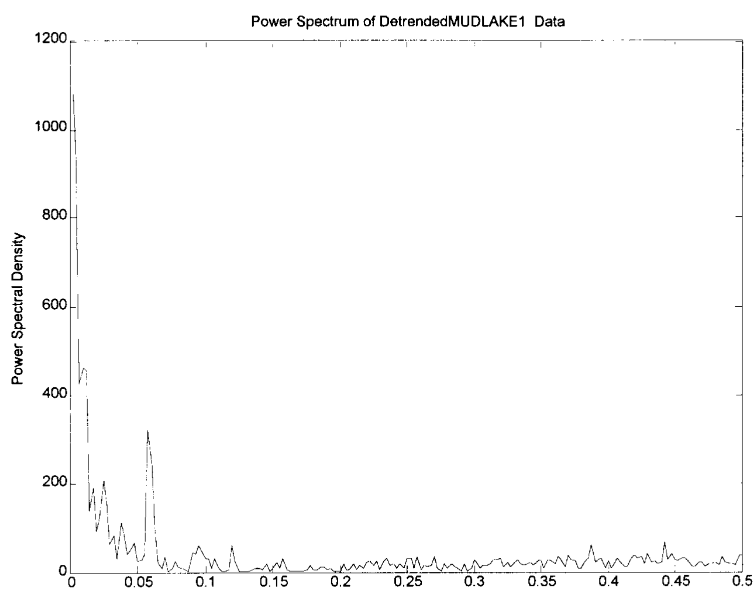

Figure 7. Power spectrum of the Mud Lake elevation profile after detrending. 10 foot detrend distance RMS = 0.30

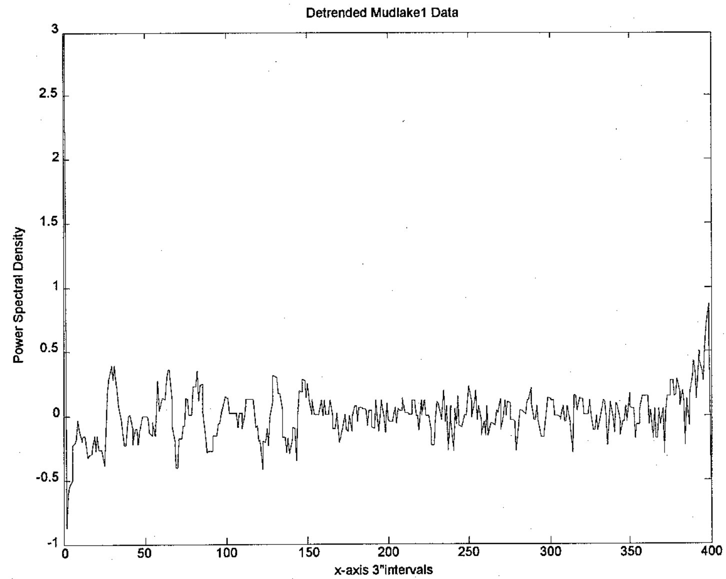

Figure 8. Mud Lake profile detrended using a 2.5 foot parameter length. 2.5 foot detrend distance RMS = 0.1872

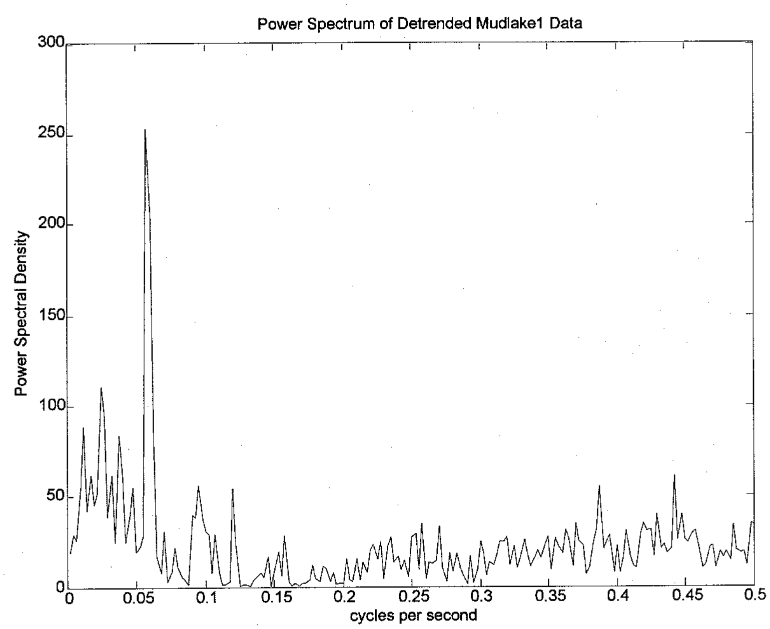

Figure 9. Power spectrum of the Mud Lake data detrended using a 2.5 foot detrend length. 2.5 detrend distance RMS = 0.187

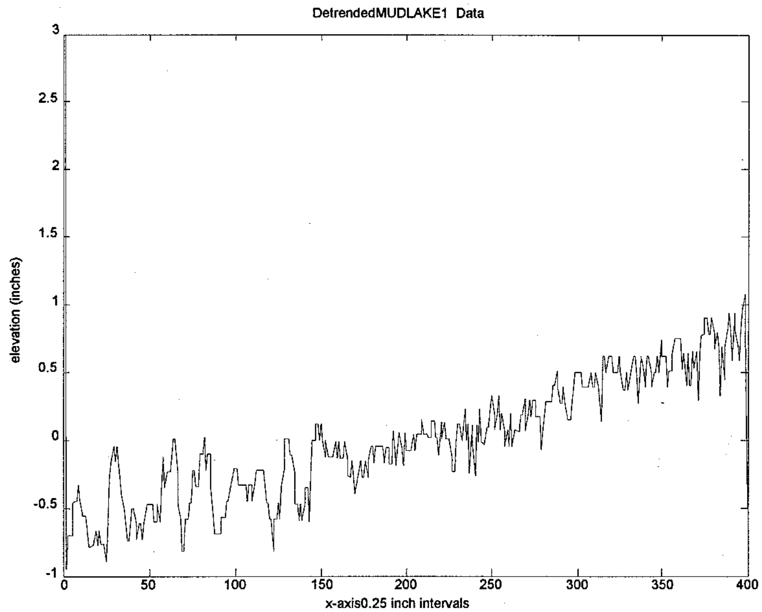

Figure 10. Mud Lake profile detrended using a 30 foot parameter length. 30 foot detrend distance RMS = 0.4464

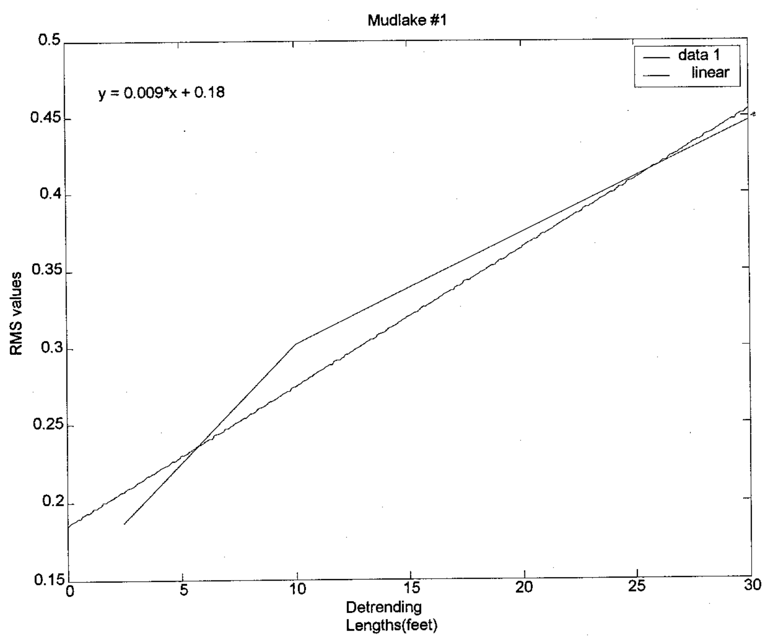

Figure 11. Mud Lake profile detrended RMS values versus the detrending lengths. slope = 0.009 y-intercept = 0.18

Forest Road. Turning now to a different test course, Figures 12 through 19 show the elevation profile and power spectral density of this course both before and after it has been detrended (using three detrending lengths). In Figures 2, 20, and 21, the results of the detrending in terms of RMS and variance are plotted against the detrending length in order to test Van Deusen's theoretically derived formula. Again, we assume that the power spectral density of the elevation profile of the test course is of the form:

$$P_d(\Omega) = C * \Omega^{-n},$$

where n = inverse power of the curve representing the spectral density, which is assumed to be constant for any given spectral estimate. Ω = spatial frequency in cycles/foot.

The detrending data was plotted against a linear relation (Figure 20, n = 1), and a fractional power (Figure 21, n = 0.66) of the detrending length. These three dimensions satisfy the conditions that allow the integral representing the exponential detrending wavelet (Wigner-Ville transform) applied to the sine and cosine function to converge. Although, it is not as clearcut as in the case of the other test courses, a look at the three figures (2, 20, 21) shows that the Forest Road data can also be best fitted linearly if the detrending length squared is plotted versus the square of the RMS.

By comparing the two graphs below, we can see the degree to which the power spectral density dimension n = 2 has been correctly fitted to the Forest Road data in Figure 2. Two different values n = 1 and n = ⅔ are tested in the figures below to compare how closely the data fits the line with the linear fit to the data in Figure 2.

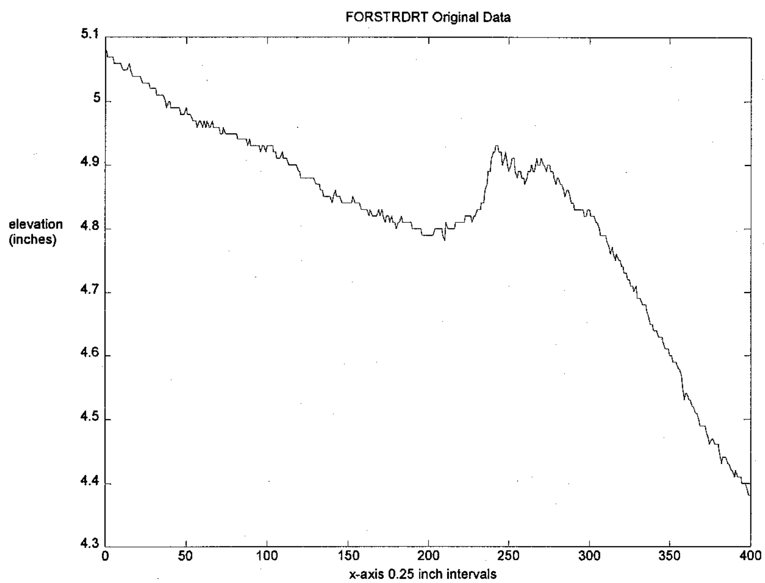

Figure 12. Original profile data for the Forest Road course.
undetrended mean = 4.9074 RMS = 3.7801

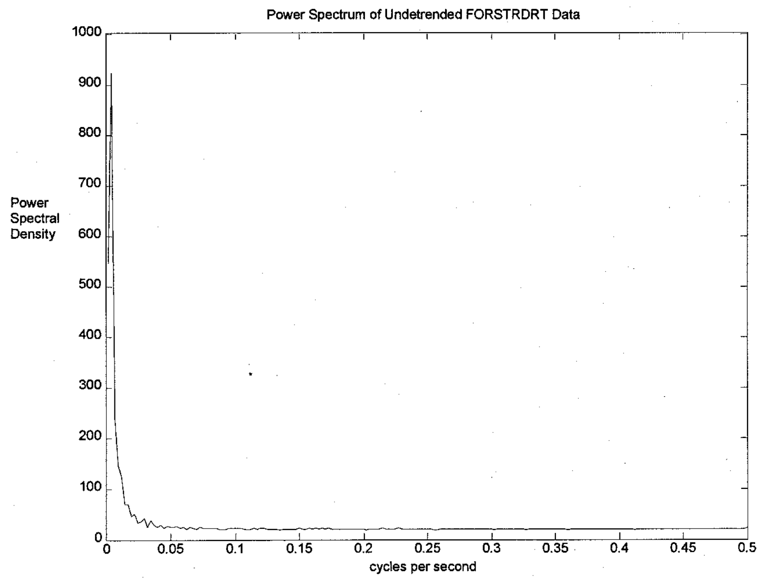

Figure 13. Power spectrum of the original data for the Forest Road course.

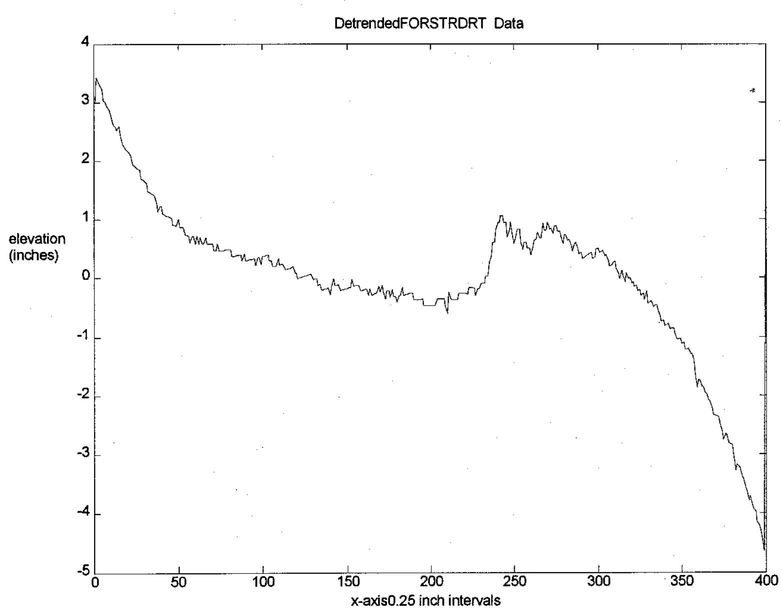

Figure 14. Detrended Forest Road profile using 10 foot detrending length. 10 foot detrend distance RMS = 1.325

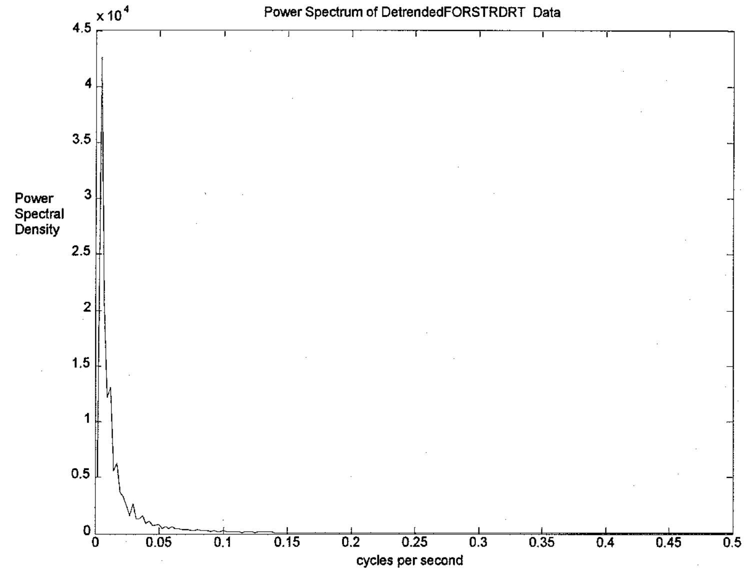

Figure 15. Power spectrum of the Forest Road 10 foot detrended profile. 10 foot detrend distance RMS = 1.325

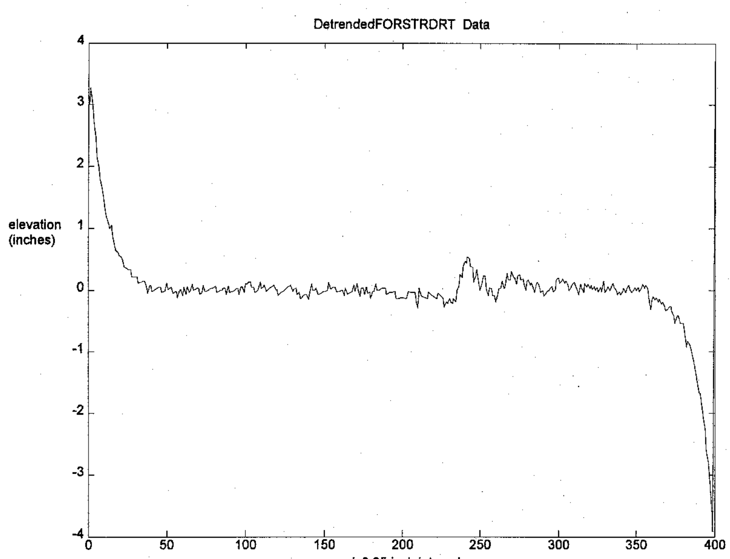

Figure 16. Forest Road 2.5 foot detrended profile. 2.5 foot detrend distance RMS = 0.6624

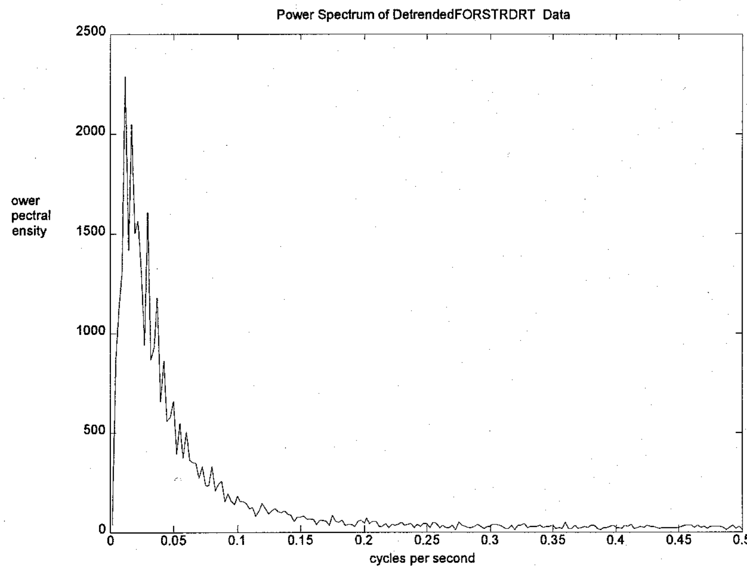

Figure 17. Power spectrum of the Forest Road 2.5 foot detrended profile. 2.5 foot detrend distance RMS = 0.6624

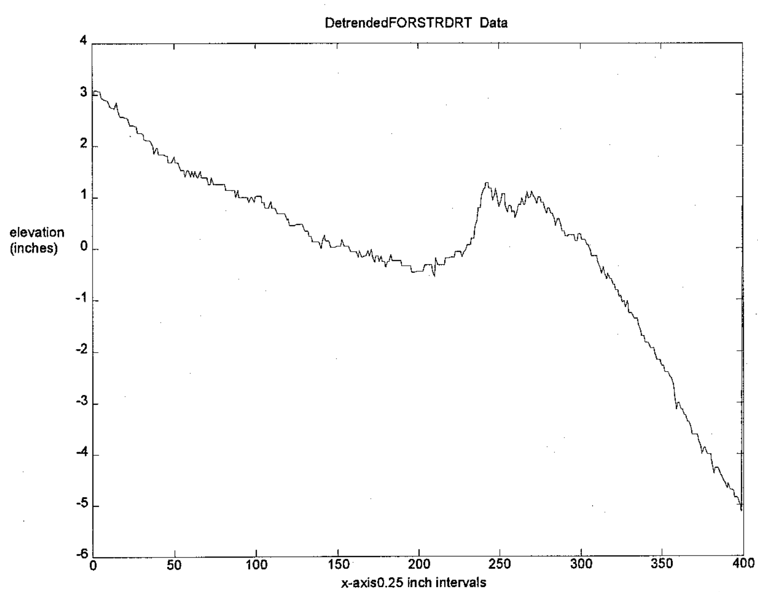

Figure 18. Forest Road 30 foot detrended profile. 30 foot detrend distance RMS = 1.7712

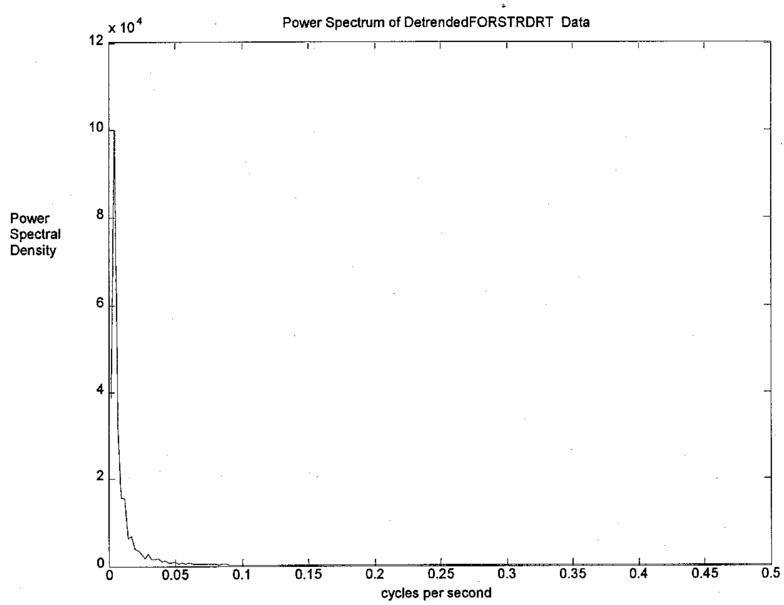

Figure 19. Power spectrum of the Forest Road 30 foot detrended data. 30 foot detrend distance RMS = 1.7712

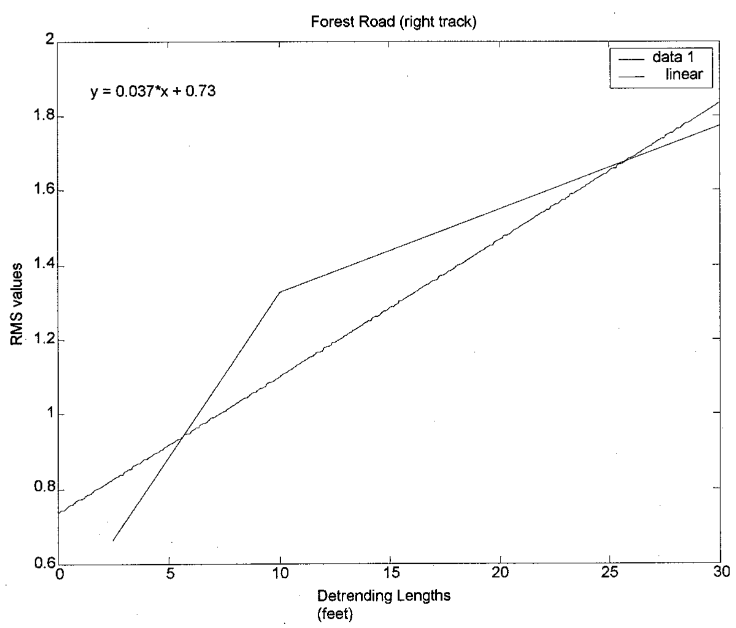

Figure 20. Plot of the unsquared Forest Road RMS versus detrending length. slope = 0.037 y-intercept = 0.73

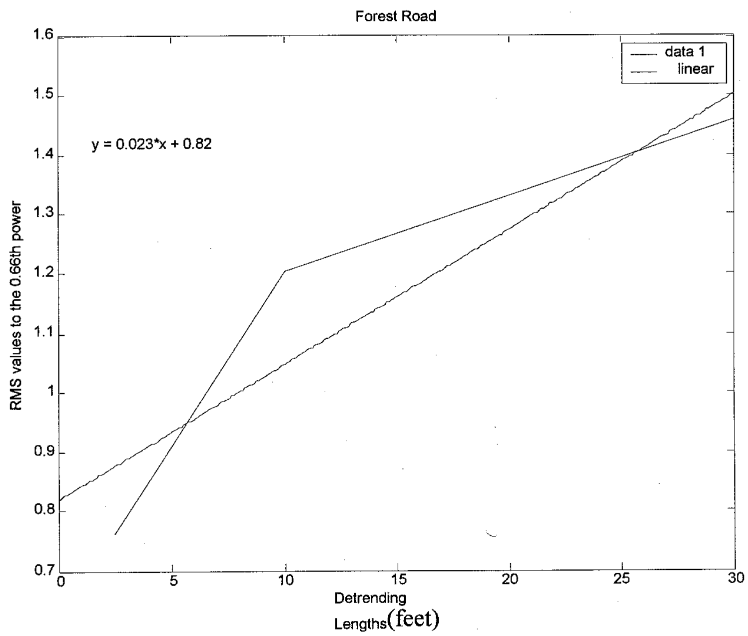

Figure 21. Plot of the Forest Road RMS to the 0.66 power versus detrending length. slope = 0.023 y-intercept = 0.82

Letourneau. Figures 22 through 29 show the elevation profile and power spectral density of the test course both before and after it has been detrended (using three detrending lengths). In Figures 3 and 30 the results of the detrending in terms of RMS and variance are plotted against the detrending length in order to test Van Deusen's theoretical formula. Again, we assume that the power spectral density of the elevation profile of the test course is of the form:

$$P_d(\Omega) = C * \Omega^{-n},$$

where n = inverse power of the curve representing the spectral density, which is assumed to be constant for any given spectral estimate. Ω = spatial frequency in cycles/foot.

The results of the analysis show, as Van Deusen theory claims, that for the Letourneau off-road course profiles a fairly exact linear relation exists between the detrending length squared (the variance) and the rms. The detrending data is shown plotted against a quadratic (Figure 30, n = 2) power of the detrending length.

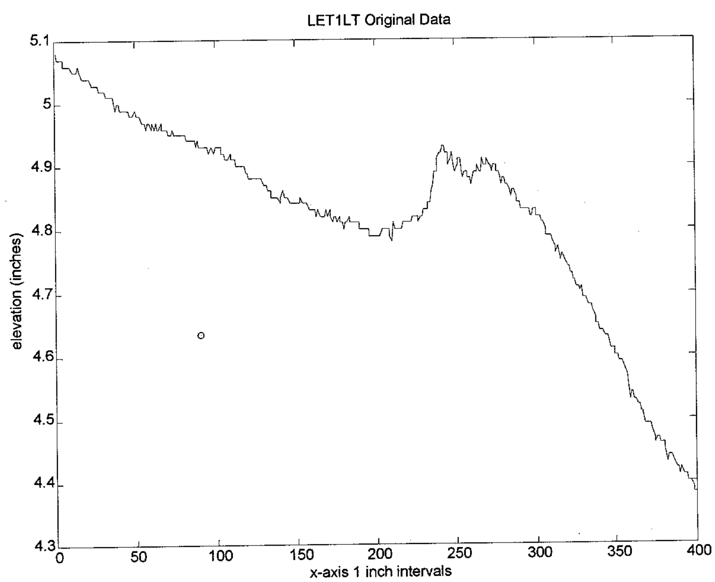

Figure 22. Original Letourneau course elevation profile data. undetrended mean = 5.1244 RMS = 4.0873 (1997 measurements)

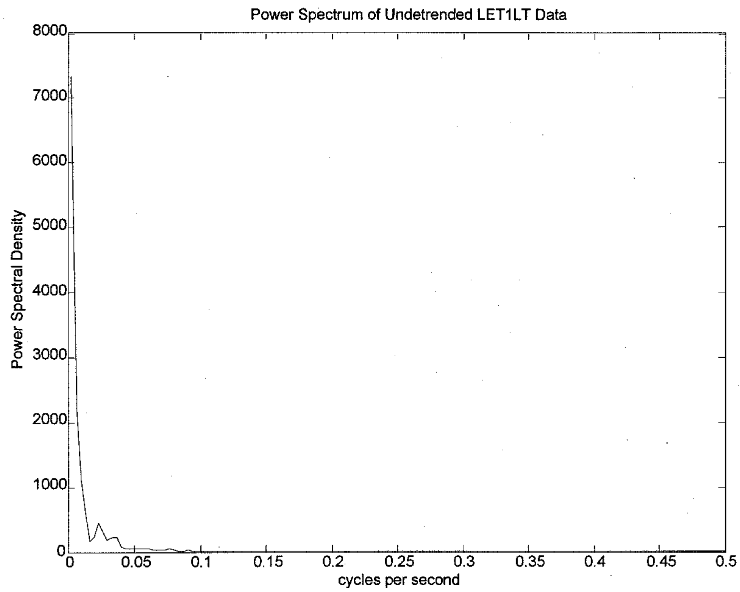

Figure 23. Power spectrum of the original Letourneau course profile data.

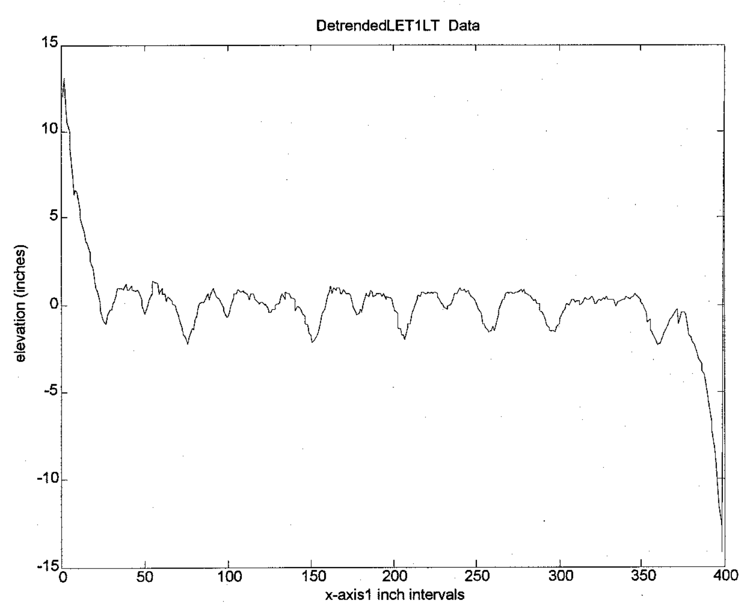

Figure 24. Letourneau test course profile detrended using a 10 foot detrend distance. 10 foot detrend distance RMS = 2.52 (1997 measurements)

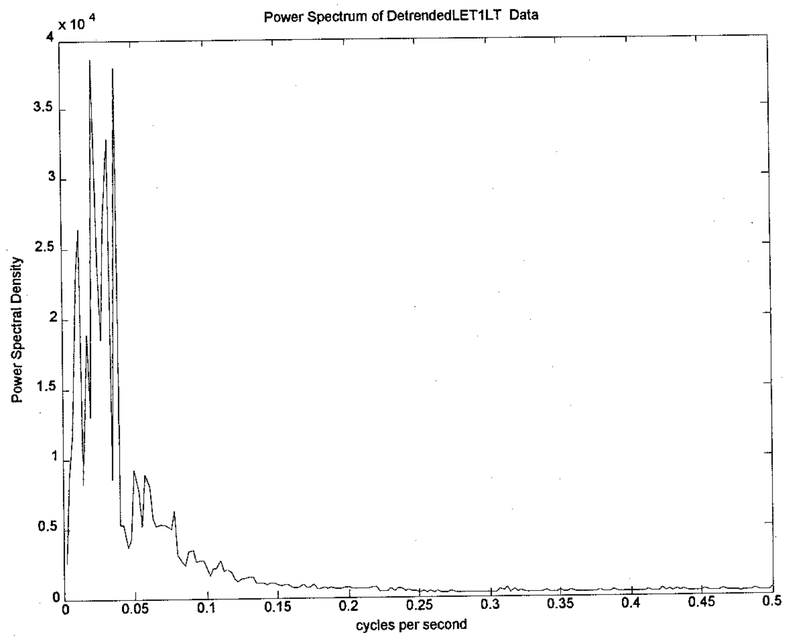

Figure 25. Power spectrum of Letourneau test course, detrended using a 10 foot smoothing parameter data. 10 foot detrend distance RMS = 2.52 (1997 measurements)

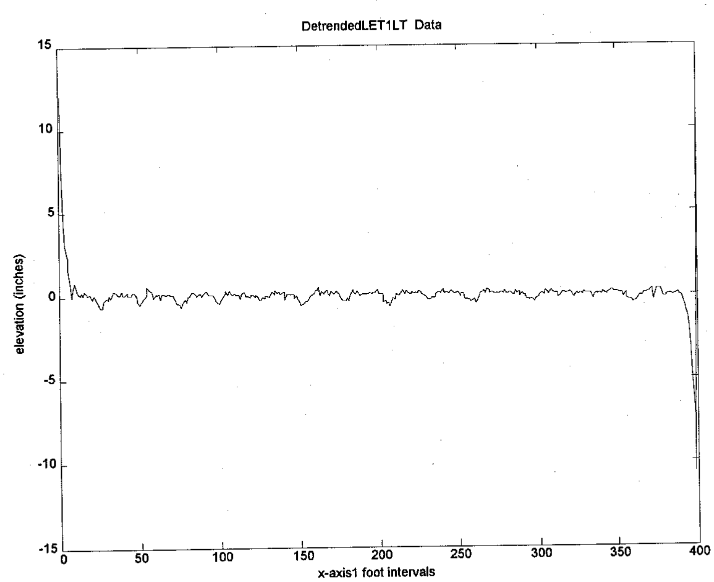

Figure 26. Letourneau test course data detrended using a 2.5 foot detrend distance. 2.5 foot detrend distance RMS = 1.0944

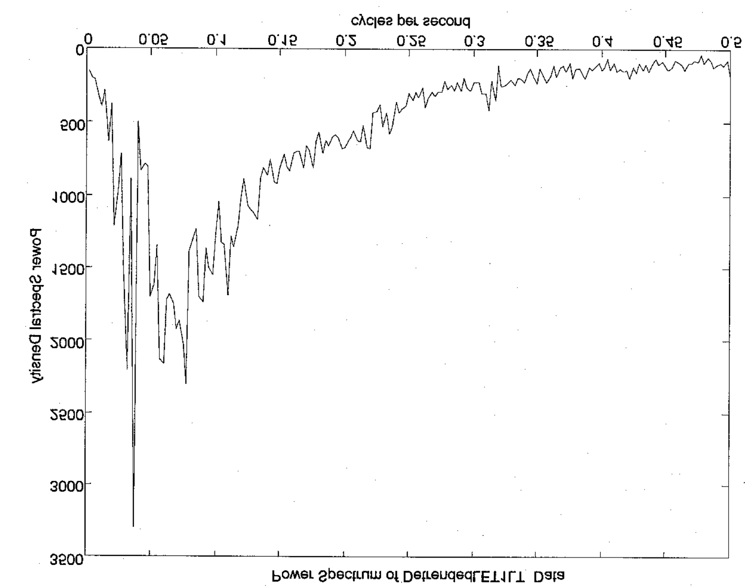

Figure 27. Power spectrum of the Letourneau test course data, detrended using a 2.5 foot parameter. 2.5 foot detrend distance. RMS = 1.0944

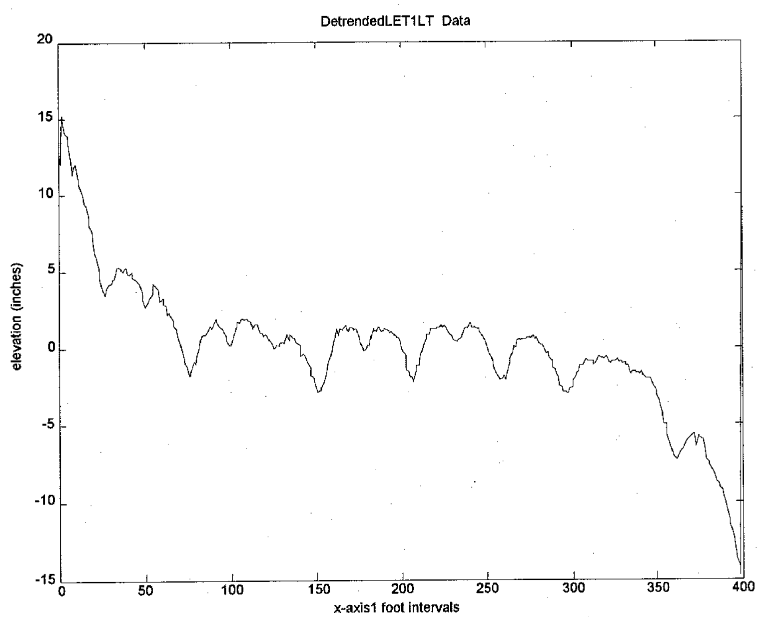

Figure 28. Letourneau test course data detrended using a 30 foot detrend distance. 30 foot detrend distance RMS = 4.32 (1997 measurements)

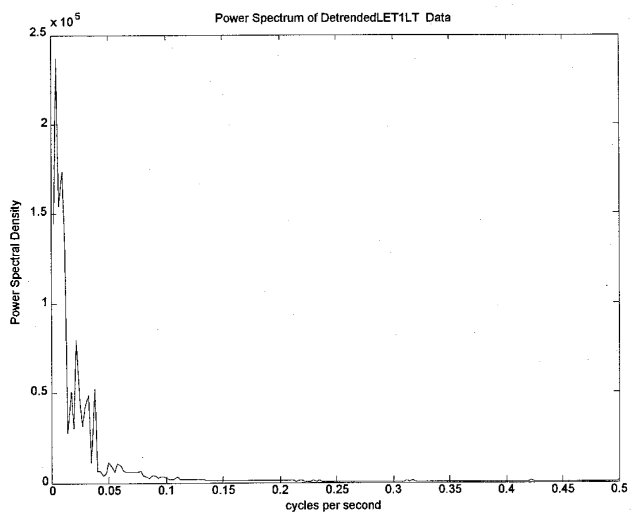

Figure 29. Power spectrum of the Letourneau test course 30 foot detrended data. 30 foot detrend distance RMS = 4.32 (1997 measurements)

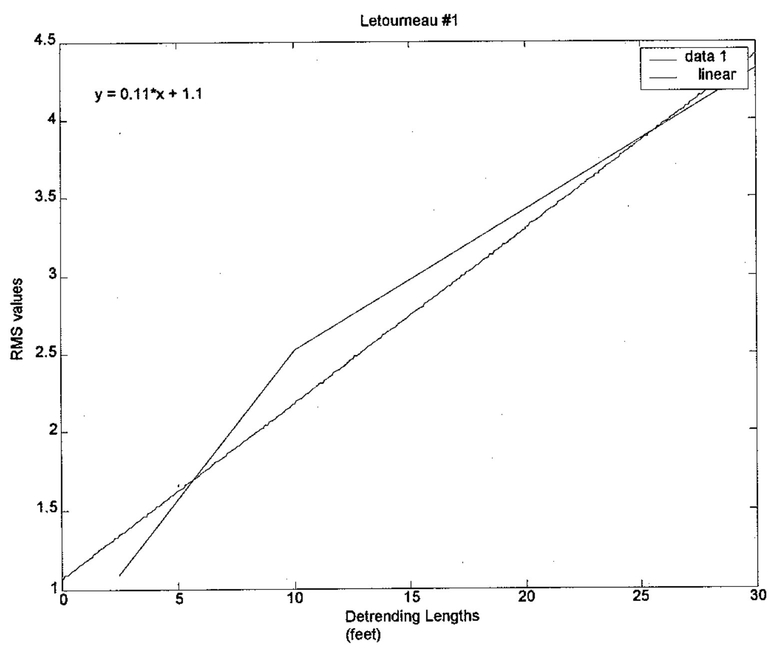

Figure 30. Plot of the Letourneau test course RMS versus detrend length. slope = 1.1 y-intercept = 1.1

ACKNOWLEDGMENTS

The author acknowledges Mr. Dennis Moore and Mr. Wendell Gray of the Mobility Systems Branch, GSL, ERDC, who provided the test course elevation profile data files. Randolph Jones of the Mobility Systems Branch generously shared reports and information and wrote a short summary about past work in this area. This written material was incorporated in the outline section of the paper's introduction and parts of the methods and materials section. Dr. William Willoughby of the Mobility Branch GSL, Dr. John Peters of GSL, and Dr. Joseph Kolibal of the Mathematics Department of the University of Southern Mississippi read an earlier version of the manuscript and provided many useful questions and comments that improved its exposition.

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Endnotes for Paper

[1] Detrending is a method of filtering the terrain elevation profiles by taking a weighted average of the elevation profile value at which the trend is being computed. There are several possible mathematical approaches and formulas which can be used. Details are given later in the method and materials section of the paper.

[2] RMS is an acronym used in the characterization of the surface roughness of terrain, meaning root mean squared. It is determined by first detrending the surface elevation measurements taken at one foot intervals in a terrain profile and then computing the ordinary square root of the variances of the measurements from the detrended values of the terrain profile data set. Let the detrended data be denoted $F(x)$ and its mean $\overline{F(x)}$ then

RMS = $(\sum_i (F(x_i) - \overline{F(x_i)})^2 / n)^{1/2}$

[3] Some originally given in the Van Deusen reference without proofs.

[4] The value used in the weighted average of the coefficient in the exponent used to do the profile detrending.

[5] US Army Materiel Command.

[6] US Army Tank Automotive Command.

[7] US Army Waterways Experiment Station.

[8] A spline of interpolated data assumes the data comes from a continuous function. The spline of the interpolated data is then a polynomial approximation to the assumed function whose coefficients are determined to agree with the value of the function and a certain number of its derivatives at the points which are specified.

[9] This statement can be made for precise using functional analysis and the theory of Hilbert spaces along with their different infinite dimensional basis functions and the degrees of differentiability of the functions that are represented.

[10] See Appendix A for a mathematical derivation of this formula.

[11] Van Deusen uses meters, but because the WES/ERDC elevation profiles are measured in English units, feet are used here.

APPENDIX A

Derivation of the formula relating the RMS to detrending length

(assuming the spectral density curve is an integral inverse power)

This appendix assumes that the power spectral density of the elevation profile of the test course is of the form:

(A1) $P_d(\Omega) = C\Omega^{-n}$,

where n = inverse power of the curve representing the spectral density, which is constant for any given spectral estimate. Ω = spatial frequency in cycles/foot[1]. The formula to be derived for n = 2 is:

(A2) $s = (Cp^2 l / 2)$,

where s = RMS, l = detrending length, n = the inverse power of the curve representing the spectral density, and C is a constant to be determined that characterizes the vehicle test course (Van Deusen, 1966).

Weiss (1981) assumed the power spectral density to be of the form:

$$P_d(\Omega) = A\Omega^{-2} + B\Omega^{-3} + C\Omega^{-4}$$

where A, B, C are positive or negative coefficients to be determined from s_d, s_c, s_s the detrended RMS of the information contained in the elevations, curvatures, and slopes respectively of the course elevation profiles.

Our approach is to first determine the best single inverse power fit, by plotting only the data profile elevations versus the detrending parameter. Then the spectral power curve coefficient is determined by calculating the slope of the linear fit of the logarithms of the RMS versus detrending length parameter.

Because of what we have learned about the fractal nature of terrain since Dr. Weiss wrote his paper in 1981, it makes sense to use the detrending parameter as a variable to calculate the spectral parameters instead of s_d, s_c, s_s. This is because the terrain is no longer considered to be approximated well at the micro-roughness level by the continuous polynomials (e.g., Pietgen and Saupe 1988; Mandelbroit, 1977; and Turcotte, 1992). The earlier approach calculated the coefficients of polynomials by interpolating values of slopes and curvatures measured at discrete intervals and inverting the determinant of a matrix. This does not work well for fractal terrain objects whose parameters are better estimated from looking at the effect of scaling or detrending transformations on parameters that characterize the data.

The detrending process that the exponential filter applies to the profile data can be represented by the discrete variable equation:

(A3) $\overline{F(x)} = \sum_{n=0}^{\infty}(F(x+nu)+F(x-nu))e^{-nu/l}))/(2\sum_{n=0}^{\infty}e^{-nu}/l)$.

In the limit, as n approaches infinity, this equation takes the continuous variable form:

(A4) $\overline{F(x)} = (1/(4p\,l\,\Omega))\int_{u=0}^{\infty}(F(x+u)+F(x-u))e^{-u/l}\,du$.

Note that the integration in the transform is with respect to the variable u[2]. We assume that the terrain profiles fall into the class of functions which are measurable (see Apostol [1974] for the mathematical definition of a measurable function) and for which this continuous variable transform exists. Detailed conditions under which the continuous variable form of this transform is equal to the discrete form were given by N. Wiener (1957). By Theorem 28, page 160, in this reference, the two are equal for a class of measureable functions if, and only if, the power spectrum is continuous. The assumption that the power spectrum of the terrain can be given in the form of an integral inverse power satisfies this condition of Wiener except at the point zero. We must then make the further assumption for the purposes of this analysis that there is an upper limit and finite cutoff of the frequencies considered which affect the vehicle's response to the terrain. The frequencies of the vehicle frame axis normal modes of vibration, generated by terrain test courses, and measured over the years at ERDC for test vehicles have been less than a 100 cycles per second[3]. Therefore, this assumption will not cause a problem for our application area. An example of an application area in which this assumption would not be justified would be in the use of a similar methodology to make measurements to characterize atmospheric conditions from satellite or ground-based radar reflections.

Following Van Deusen (1966), in order to understand this transform, we calculate its effect on functions of the form:

(A5) $F(x) = \sin(2p\Omega x)$.

To calculate the result we need to use the indefinite integral formula from calculus:

(A6) $\int (e^{ax}\sin(bx+c)dx = (e^{ax}/(a^2+b^2))(a\sin(bx+c) - b\cos(bx+c))$

where a, b, c are arbitrary constants.
We now can proceed with the integration if we let $a = -1/2p\Omega l$, $b = 1$, and $c = 2p\Omega x$ in the above formula:

(A7) $\int (\sin(2p\Omega x + u) * e^{-1/2p\Omega l u} du =$

$(e^{-1/2p\Omega u}/((1/2p\Omega l)^2 + 1)((-1/2p\Omega l)\sin(2p\Omega x + u) - \cos(2p\Omega x + u))$ and

(A8) $\int (\sin(2p\Omega x - u) * e^{-1/2p\Omega l u} du =$

$(e^{-1/2p\Omega u}/((1/2p\Omega l)^2 + 1)((-1/2p\Omega l)\sin(2p\Omega x - u) + \cos(2p\Omega x - u))$.

To complete the full calculation indicated in formula (B4), formulas (B7) and (B8) need to be added together. To simplify this part of the calculation, we use the elementary trigonometric identities:

$\sin(2p\Omega x + u) + \sin(2p\Omega x - u) = 2\sin(2p\Omega x)\cos(u)$, and
$\cos(2p\Omega x + u) + \cos(2p\Omega x - u) = 2\sin(2p\Omega x) * \sin(u)$.

We obtain:

$$\overline{F(x)} = 1/(4p\Omega l)(e^{-1/2p\Omega u}/((1/2p\Omega l)^2 + 1)((-1/2p\Omega l) * 2(\sin(2p\Omega x)\cos(u) + \sin(2p\Omega x)\sin(u))\Big|_0^{np}$$

where the indefinite integral is to be evaluated at the midpoint and end of the averaging interval:
0 and np . Doing this, we finish the evaluation of the definite integral:

(A9) $\overline{F(x)} = 1/(4p\Omega l)(1/((1/2p\Omega l)^2 + 1)((-1/2p\Omega l) * 2(\sin(2p\Omega x) - e^{-n\Omega/2}(\sin(2p\Omega x))$

And, as n (which measures the size of the averaging interval in increments of 2π) approaches infinity this goes to:

(A10) $\overline{F(x)} = -1/(2\Omega p\, l\,)^2 (1/((1/2p\Omega\, l\,)^2 + 1)(\sin(2p\Omega x)))$.

Now the amplification factor of the detrending transform on the function (A5) $F(x) = \sin(2p\Omega x)$ can be determined as:

(A11) $F(x) - \overline{F(x)} = A\sin(2p\Omega x)$

where A = the amplitude ratio.
Where, we have derived that :

(A12) $A = (1-(1/2p\Omega\, l\,)^2 (1/(1/2p\Omega\, l\,)^2 + 1) = 1-(1/2p\Omega\, l\,)^2 /(1/2p\Omega\, l\,)^2 + 1)$
$= 1/(1/2p\Omega\, l\,)^2 + 1)$.

Now, the following theorem is needed to go further in the derivation:
Theorem[4]. Assume that the variance, $s^{\,2}$ of the detrended increment[5]

$$I_{H,\Delta} = (\overline{F(x)} - \overline{F(x-\Delta)}) = s^{\,2}|\Delta|^{2H}$$

of a time series[6] is proportional to the increment Δ[7]. Let $g_\Delta(t) = d(t) - d(t-\Delta)$, then the power spectrum of the detrended increment is a stationary stochastic process of the form[8]:

(A13) $P_{I_{H,\Delta}}(\Omega) = s^{\,2}{}_H * \Omega^{-(2H+1)} \left|\hat{g}_\Delta(\Omega)\right|^2$.

This theorem says that although the original elevation profile may not be statistically stationary[9], the detrended increment of it is. Proof: By applying the assumptions of the Theorem twice, the covariance of $I_{H,\Delta}$ is equal to:

(A14) $E\{I_{H,\Delta}(t) * I_{H,\Delta}(t-t)\} = (s^{\,2}/2)(|t-\Delta|^{2H} + |t+\Delta|^{2H} - 2|t|^{2H})$.

If $f(t) = |t|^{2H}$, then, $\hat{f}(w) = -l_H * |w|^{-(2H+1)}$ (where $l_H \succ 0$ is some constant) by the standard formulas from Fourier transform theory. So, if $g_1(t) = |t-\Delta|^{2H}$ and $g_2(t) = |t+\Delta|^{2H}$, then $\hat{g}_1(w) = -(e^{-i\Delta w})\, l_H |w|^{-(2H+1)}$ and $\hat{g}_2(w) = -(e^{i\Delta w})\, l_H |w|^{-(2H+1)}$ by the standard formulas for the Fourier transform of the translation of a function. By noticing that $e^{i\Delta w} + e^{-i\Delta w} - 2 = 2(1-\cos(\Delta w)) = 2\sin^2(\Delta w/2)$, this gives the formula for the power spectrum

(A15) $P_{I_{H,\Delta}}(w) = 2s^{\,2}{}_H\, l_H w^{-(2H+1)} \sin^2(\Delta w/2)$

which proves the Theorem for the substitution $s_H^{\,2} = s^{\,2} l_H /2$.

Now in order to prove the formula (A2), assuming the PSD (power spectral density) is of the form (A1) we use the fact that by the above Theorem, s the variance or RMS squared, is equal to the PSD integrated over all frequencies; which by formulas (A1), (A11), (A12), and (A15) equals

(A16) $s^{2} = \int_{0}^{\infty} C * \Omega^{-n} d\Omega / ((1/2p\Omega l)^{2} + 1)^{2}$.

If we let $v = 2p\Omega l$ this can be written as

$$s^{2} = C(2pl)^{n-1} \int_{0}^{\infty} v^{-n} dv / ((1/v)^{2} + 1)^{2} = C(2pl)^{n-1} \int_{0}^{\infty} v^{-n+2} dv / (v^{2} + 1)^{2}$$

for n = 2, 3, 4, 5, respectively, this indefinite integral is equal to $C(2pl)^{n-1}$ times a factor which is:

$-1/2(v/(v^{2}+1)) + 1/2(\arctan(v))$, n = 2;
$-1/2(v/(v^{2}+1))$, n = 3;
$1/2(v/(v^{2}+1)) + 1/2(\arctan(v))$, n = 4;
$1/2(1/v^{2}+1) + 1/2(\ln(v^{2}+1))$, n = 5.

These formulas can be verified taking derivatives and using the fact that $(\arctan(v))' = 1/(1+v^{2})$. Using the fact that arctan(0) = 0, arctan($(\infty) = p/2$, ln(1) = 0, ln($\infty) = \infty$ these indefinite integrals can be evaluated as equal to: $p/4$ for n = 2 , 0 for n = 3 , $p/4$ for n = 4 , divergent for n = 5. We have:

(A17) $s^{2} = (Cp^{2} l)/2$ for n = 2, and $s^{2} = C(4p^{4} l^{3})$ for n = 4.

This result indicates that the RMS should be linearly proportional to the detrending length[10] for a PSD of curve of inverse power –2 and also for one of inverse power –4.

Endnotes for Appendix

[1] We shall use feet instead of meters for units in this paper because the WES/ERDC elevation profiles are measured in English units.

[2] This differs by a constant factor from the transform used by Van Deusen. The calculation to follow will show this constant factor is needed to make the amplification factor be equal to that stated in his report.

[3] See Harrell's 2001 ISTVS paper for an example and further discussion of how test vehicle normal modes of vibration are calculated.

[4] Mallat (1998) page 213.

[5] Here E means mathematical expectation of the function inside of the parenthesis. It is equal to the integral of the function divided by the measure of the region it is integrated over.

[6] H is a parameter called the Hurst exponent which relates to the case of fractional Brownian motion. See the references by Mandelbroit (1977), Mallat (1998), Harte (2001) for more information on its properties and definition.

[7] This is more general than assuming it to be independent of Δ and what is called a stationary stochastic process. This includes the case of what is sometimes called Fractional Brownian Motion stochastic processes. Mallat (1998) page 212.

[8] For a given function g, $\hat{g}$ denotes its Fourier transform.

[9] Having statistical properties varying with the sampling interval.

[10] Assuming, of course, that the wavelets used in the averaging or detrending functions are exponentials such as the ones we are using.

President's Column

It is with great pleasure to provide you with an update of the most recent Mississippi Academy of Sciences events. The 68th Annual Meeting of the Mississippi Academy of Sciences was held at the Broadwater Resort in Biloxi, MS on February 19-20th. The meeting overall was a spectacular event and a major success for the Academy. The success of the meeting is a direct reflection on the scientific contributions of our Academy membership. This year more faculty members as well as students submitted abstracts and presented their findings in various divisions. The division sessions and workshops were well attended and several of the meeting rooms were filled to capacity. The theme for this years' meeting was cardiovascular research, and the highlight was a state of the art Dodgen lecture delivered by a well-distinguished Cardiologist, Dr. Herman Taylor, Professor and Director of the Jackson Heart Study. In addition to the Dodgen lecture, we also implemented diverse plenary lectures and we were honored to have four keynote speakers, Dr. Audrey Tsao, Dr. Joseph A. Cameron, Dr. Richard Alley and Dr. Joan Fitzpatrick, who are experts in their fields and provided us with enlightening information. In addition, several divisions included outstanding symposia and workshops as a part of their meeting agenda.

"**No man is an island**" and this meeting would not have been such a success without a dedicated and hardworking team that really stepped up to the plate and took the challenge to go for a grand slam. On behalf of the Board of Directors, Drs. Sara McGuire, Robert Bateman, Charles Swann, Ken Curry, Aimee Lee, Dick Highfill, Maria Begonia, Roy Duhe and Ms. Cynthia Huff, I would like to thank the Chairs of the Standing Committees who took time from their busy scheduled to provide the Academy with their proficiency and perseverance. It was privilege for me to have worked with Dr. Kenneth Butler (Awards and Nominations Committee), Dr. Ibrahim Farah and Dr. Rob Rockhold (Local Arrangements), Dr. Michelle Tucci (Membership Committee), Dr. Elgenaid Hamadain (Exhibits), Zelma Cason (Poster Coordinator), Bette Groat, Cheryl Marble, Jack Gordy, Rose Willis, Reba Tullos, Barbara Holmes, and Louis Brown (Publicity Committee), Leslie Boyd (Audio-Visual), and Barbara Austin (Public Affairs at UMC). In addition, to these individuals, I would also like to recognize Drs. Jack Moody, Elgenaid Hamadain, Todd Nick, Faruque Fazlay, Margaret Drake, and Olga McDaniel for organizing top class workshops and special symposiums. Congratulations to each Division Chair for a job well done.

Last but not least, my utmost respect and gratitude to Dr. Dan Jones and Dr. W. Conerly for their support and vote of confidence in endorsing the 68th meeting as well as making the decision that The University of Mississippi Medical Center serve as a Major Sponsor for MAS-04.

Let's continue to keep striving for excellence. I leave you with a quote from Sir Winston Churchill, "Every day you may make progress. Every step may be fruitful. Yet there will stretch out before you an ever-lengthening, ever-ascending, ever-improving path. You know you will never get to the end of the journey. But this, so far from discouraging, only adds to the joy and glory of the climb."—Ham Benghuzzi

Executive Officer's Column

The annual conference in February was a success with good attendance numbers and a variety of workshops, symposia and plenary speakers. Success comes at a price, and the price consists of hours of free time donated by a variety of MAS members interested in making the meeting relevant to science and the State. Without the division and committee chairs, former officers, officers-to-be, students and MAS members, the meeting would not have been possible. On behalf of the MAS I thank all of you for the commitments you have made to the Academy.

An annual meeting should also be relevant to the members and to science. The goal of relevancy, I think, was accomplished as several members favorably commented on the meeting content and variety of subject matter. Some commented that they attended the annual meeting to be able to interact with scientists in other fields. Seldom does such a variety of research scientists congregate in one place to discuss their work. There is no better place to plan collaborative research than at the MAS meeting.

The 2005 annual meeting will be in northern Mississippi, so its not too soon to be thinking about how we can make it as much a success as the Biloxi meeting. The 2005 meeting will also be the celebration of the 75th anniversary of the formation of the MAS. Dr. John Boyle, Department of Biochemistry and Molecular Biology at Mississippi State University, has agreed to chair a committee to plan 75th anniversary activities. Give him a call if you have ideas for the 75th anniversary.

The MAS has made an effort to connect with other organizations with similar interests. Thanks to the efforts of MAS Director, Dr. Roy Duhe, we have established a linkage with the Mississippi Technology Alliance (MTA). We look forward to working to expand the MTA linkage and in the coming year we should seek other organizations.

Thanks again to the membership for the help in Biloxi. We look forward to working with everyone to make the coming year in MAS the best yet.—Charles Swann

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Mississippi Junior Academy of Science

http://www.mjas.org/

2004 MJAS Competition Report

The annual MJAS competition was held on February 18, 2004, at the Mississippi Gulf Coast Community College – Jefferson Davis Campus in Gulfport, MS in conjunction with the Mississippi Academy of Sciences annual conference. Dr. Richard Alley, a geologist from Penn State University, gave the keynote address. He presented his evidence and implications on making the case for rapid climate change. Attendance was down this year; however, the quality of presentations was outstanding. I plan on attending the MSTA meeting in October as well as regional science fairs to encourage MJAS participation next year. If you have any connections at the high school level and/or have ideas to help increase our numbers, please contact me at aimee.lee@usm.edu.

Attendance report:

# of presenters	9
# of observers	4
# of parents	7
# of teachers	2
# of judges	7
Total # in attendance	29

Schools represented:
- Jim Hill High School (Jackson)
- Oak Grove High School (Hattiesburg)
- Presbyterian Christian High School (Hattiesburg)
- St. Andrew's Episcopal High School (Jackson)

2004 MJAS Competition Overall Winners

First Place Winner (Clyde Sheely Award) – Charles Daniel Murin, Oak Grove High School
Second Place Winners (Tie) – Winston Messer, Presbyterian Christian High School & Anthony Yuen, Oak Grove High School
Special Recognition – Soumo De, St. Andrew's Episcopal School

2004 MJAS Competition Divisional Winners

Behavioral Sciences/Sociology/Psychology – Samanthia Thompson, Jim Hill High School
Biology – Charles Daniel Murin, Oak Grove High School
Computers – Anthony Yuen, Oak Grove High School
Medicine & Health – Soumo De, St. Andrew's Episcopal School & Winston Messer, Presbyterian Christian High School

2004-2005 MJAS Executive Board

President:	Winston Messer whmesser@comcast.net Presbyterian Christian Episcopal School
Vice-President:	Samanthia Thompson LadySam17@yahoo.com Jim Hill High School

Divisional Reports

Agriculture and Plant Science

The 2004 meeting was a success. The first "MSU-Life Sciences and Biotechnology Institute" Award was instituted thanks to the initiative of Dr. Alan Wood, Director of this institute. This award is for $500.00 for the first prize, oral competition (graduate) at the meeting. This year's winner was Jelena Stojanovic, a Ph.D. candidate in Food Science and Technology at MSU. Other contributors to the awards were the Mississippi Nurserymen Association, the AAL Farmers COOP, Reynolds Auto Van World, and others. A total of $800 were collected and awarded in the oral and poster competitions. Awards were presented to our student competition participants. Dr. Wood was also invited and delivered the first session Division Lecture, entitled "Proteomics: Not just Another Omics." There were a total of 18 papers submitted (one withdrawn), 10 oral and 7 for poster. Of these, 8 were participated in the student oral competition and 2 for poster competition. The presenters and winners were:

Oral competition:
1st place (MSU-LSBI Prize, $500), Jelena Stojanovic, MSU
2nd place ($150), Somsamorn Gawborisut, MSU
3rd place ($75), Angsana Tokitkla, MSU
Honorary mention: Tami Wells, USM; Zhijun Liu, MSU; Rachel Stout, MSU; Youkai Lu, MSU.

Poster competition:
1st place ($50), Youkai Lu, MSU
2nd place ($25), Sammera Bafeel, MSU

The awardees received their checks and certificates for participation. Dr. Wood was also recognized for his collaboration and support. There were three judges that participated in the evaluation of the entries. The judges were: Dr. James O. Garner, Jr. of University of Arkansas at Pine Bluff; Dr. Gregorio Begonia of Jackson State University, and Dr. Linda Andrews of Mississippi State University.

Dr. O.P. Vadhwa (Alcorn State U.) is the Chair for the 2005 meeting, and Dr. William Kingery (Mississippi State University) was elected as the Vice-Chair, to be chair in 2006.

The section was very much involved in a decision to rename the division. This was deferred to 2005. In the meantime, responses form division members have shown that most (53%) favor the national name, "Agriculture, Food, and Renewable Resources, some (20%) favor the present name "Agriculture and Plant Science", and a few (13%) favor the name "Agriculture and Environmental Science." However, most of the division members support a name that will be inclusive, up-to-date, and reflect the diversity of the division.

The meeting was closed by thanking Dr. Girish Panicker (past Chair) for his invaluable leadership, support and commitment to the division and MAS. The chair also acknowledged the support of the Vice chair, Dr. O.P. Vadhwa and the members.—Juan L. Silva

Agriculture and Plant Science

Sixty-eighth Annual Meeting

Dr. Alan Wood presents the divisional lecture on proteomics. He also is the donor of the MSU-Life Sciences and Biotechnology Institute award.

Youkai Lu explaining his poster results to the judges Dr. James O. Garner, Jr. (UAPB) and Dr. Gregorio Begonia (JSU, facing back). In the background you see Dr. Linda Andrews (MSU) and the Vice-Chair, Dr. O.P. Vadhwa.

Some of the student presenters and J.L. Silva (Chair): Somsamorn Gawborisut (2nd place oral), Chonthida Kaewplang, Jelena Stojanovic (1st place oral, MSU-LSBI winner), Youkai Lu (1st place poster).

Dr. Juan L. Silva, Chair of the Division of Agriculture and Plant Sciences, presents student awards for oral and poster presentations.

Jelena Stojanovic, first place oral presentation, the MSU-Life Sciences and Biotechnology Institute award

Angsana Tokitkla, third place oral presentation

Youkai Lu, first place poster presentation

Sameera Bafeel, second place poster presentation

Cellular, Molecular and Developmental Biology

Summary of meeting events. The recent MAS meeting was successful, we had total of 26 oral presentations and 12 posters. Among oral presentations, 13 were given by the undergraduate students. We also had one presentation given by a high school student. Several students faculty stayed through the entire presentations. Students Tricia Coleman, Dina Manceva, and Astrid Gutierrez-Zepeda, Rayn Day etc. should be commended for their commitment to the all program.

List of awards and awardees. This year's award was sponsored by MFGN ($300) and Fisher ($50). Judge committee members are: Dr. Ross Whitwam (Mississippi University for Women), Dr. Mary Haasch (University of Mississippi), and Dr. Naila Mamoon (University of Mississippi Medical Center)

Best Undergraduate Presentations:
1st place: Scott Walper, USM, Cannon/Heinhorst lab
2nd place: Kelly Counts, USM, Butko lab
3rd place: Kimberly Cornelius, UMMC, Duhe lab

Outstanding Graduate Presentations
Raj Menon, USM, Santangelo lab
Eric Williams, USM, Cannon/Heinhorst lab

Special Recognition to Outstanding High School Presentation
Daniel Murin, Oak Grove High School, Hattiesburg/USM, Cannon/Heinhorst lab

Future meeting, new Chairs elected for next year. At the business meeting, Dr. Stephen I.N. Ekunwe of Jackson State University was nominated and elected as the next vice chair for CMDB division and Dr. Mary Hassch of University of Mississippi was elected as the Chair for the CMDB division.—Yuan Luo

Geology and Geography

The Geology and Geography Division had a very ambitious vision of what could be accomplished this year. We started with the idea that we would put on a symposium for our division. Knowing that climate change is a science-based topic of wide interest we set that as the topic and pursued a guest speaker to build the meeting around. In that effort we ended up with two speakers, one of whom is considered one of the foremost, if not the foremost, geologists working in this field. With such a high-powered set of speakers we felt this was too good to keep to ourselves and consulted with Dr. Benghuzzi on the idea of opening our event up to the Academy and to the public. He was very enthusiastic and encouraged us to follow up our ideas with action. We decided to have our guest speakers, Dr. Richard Alley from Penn. State University and Dr. Joan Fitzpatrick with the United States Geological Survey, present their subject to the Academy as one of the three plenary sessions. The Geology and Geography Division then asked Dr. Chet Rakocinski if his Division of Marine and Atmospheric Sciences would like to co-sponsor a three-hour Climate Change Symposium and he eagerly joined in the effort. In the meantime we began working with Aimee Lee, who is doing a great job of building up the Junior Academy. That work ended up featuring Dr. Alley as the key-note speaker for the Junior Academy meeting being held on the coast the day before the senior meeting opened. We also made arrangements with the J.L. Scott Marine Center to hold an evening lecture at their facility which was targeted toward Mississippi science teachers and the interested public. As the time arrived for the meetings to begin, that being Wednesday, we had the newspaper announcing our public events, Dr. Fitzpatrick was a guest on the local afternoon TV talk show, and Dr. Alley addressed the Junior Academy, the first of four audiences he was to speak with. On Thursday Dr. Alley and Dr. Fitzpatrick spoke to the Academy plenary, then held a three-hour symposium open to the public, and ended the day with an evening presentation at the Marine Center. In these activities they presented their fascinating topic to more than 450 people. Our original ambitions had materialized into what was a wonderful series of presentations that reached not only those of us in the Senior Academy but well beyond our own borders.

On Friday the Geology and Geography Division held its normal program, which consisted of one poster and 13 presentations. The division business meeting was held and Dr. Stan Galicki was elected chairman and Barbara Yassin was elected vice chair. It was a very good year for this small division and we are glad to have had the opportunity to play a part in its activities.—Jack Moody

Health Sciences

The Health Sciences Division (HSD) at the 68th Annual Meeting was a success. Two full days of scientific sessions and activities brought together a large group of participants from a broad scientific background. The HSD was entertained with highly structured sessions, including, 1 special symposium; 2 mini-symposium, a poster session, 4 podium presentation sessions and a CPR workshop. The program started on Thursday, February 19, with a mini-symposium, on the History of Mississippi Health Care, followed by podium presentations. The afternoon started with a poster session, where 50 excellent posters from different student categories and a non-student group were placed side by side for competition. Each poster presenter had 5 minutes opportunity to convince the Judges about their high quality research. The afternoon continued with the Human Genomics mini-symposium where the impact of Human Genome Project on Biology, Health and Society was elegantly discussed, and a timeline of landmark accomplishments in genetics and completion of human genome sequence was viewed. The afternoon ended with second series of podium presentations.

The scientific podium presentations continued on second day of the meeting. The afternoon included the CPR course for Family and Friends. "The course was a great success, training 36 people in the lifesaving skills of adult CPR and foreign body airway obstruction," said Karen Yawn Bell the Regional Manager II of AHA. The highlights of CPR workshop are shown bellow.

A special symposium on Geographic Information Systems (GIS) and Remote Sensing (RS) in Health Sciences was held as part of the annual meeting of the Mississippi Academy of Sciences (MAS) on February 20, 2004, Friday, from 1:00–4:00 p.m. Special thanks to Dr. Faruque Fazaly, Director of the GIS for his efforts and hard work. The speakers included national experts from government, industry, and academia, and they were invited to the symposium through the UMMC. Attendees included representatives from MDA, US Air Force, NOAA, NASA, different Research Centers/Institutes, Industry, Universities, and Community Colleges. There were 50 participants for this symposium, although the number was not as high as was expected, but for Friday afternoon that was considered a great success. The symposium was a great opportunity for potential collaborations.

At the HSD business meeting, the current vice-chair, Dr. Michelle Tucci, from the University of Mississippi Medical Center, assumed the chair position and Dr. Audrey Tsao, from the University of Mississippi Medical Center, was elected vice-chair for year 2004-2005. The incoming chair will appoint an abstract review committee.

The student participation at all levels from numerous Institutions was highly appreciated. The projects were judged by as many as 8 judges in each student category. Overall, there were 3 high school students; 20 undergraduate; 8 undergraduate/allied health; 12 graduate; 8 graduate/allied health and 5 dental/medical students. Together there were 73 abstract presentations (combined podium and poster) and 10 invited speakers.

The following awards were given with the indicated prize.

High School Category:

Anderson Lampton	1st Place (Certificate and monetary award)
Gwen Ballard	2nd Place(Certificate and monetary award)
David Arrington	3rd Place (Certificate and Human Genome DVD)

Undergraduate Category:

Laura Franklin	1st Place (Certificate and monetary award)
Kristina Vaughn	2nd Place (Certificate and monetary award)
Rishi Roy	3rd Place (Certificate and Human Genome DVD)
Crystal Jones	3rd Place (Certificate and Human Genome DVD)

Undergraduate Allied Health Category:

Nourelhoda Farah	1st Place (Certificate and monetary award)
Russell F. Lyon	2nd Place (Certificate and monetary award)
Stevie Adams	3rd Place (Certificate and Human Genome DVD)
Shontell Credit	3rd Place (Certificate and Human Genome DVD)

Graduate Category:

Justin Thornton	1st Place (Certificate and monetary award)
George Howell	2nd Place (Certificate and monetary award)

Quincy Moore — 3rd Place (Certificate and Human Genome DVD)

Tabitha Hardy — 3rd Place (Certificate and Human Genome DVD)

Graduate Allied Health Category:

Joyce Brewer — 1st Place (Certificate and monetary award)

Felicia M. Tardy — 2nd Place (Certificate and monetary award)

Olivia R. Henry — 3rd Place (Certificate and Human Genome DVD)

Stacy Hull Vance — 3rd Place (Certificate and Human Genome DVD)

Medical /Dental Category:

Sebron Harrison — 1st Place (Certificate and monetary award)

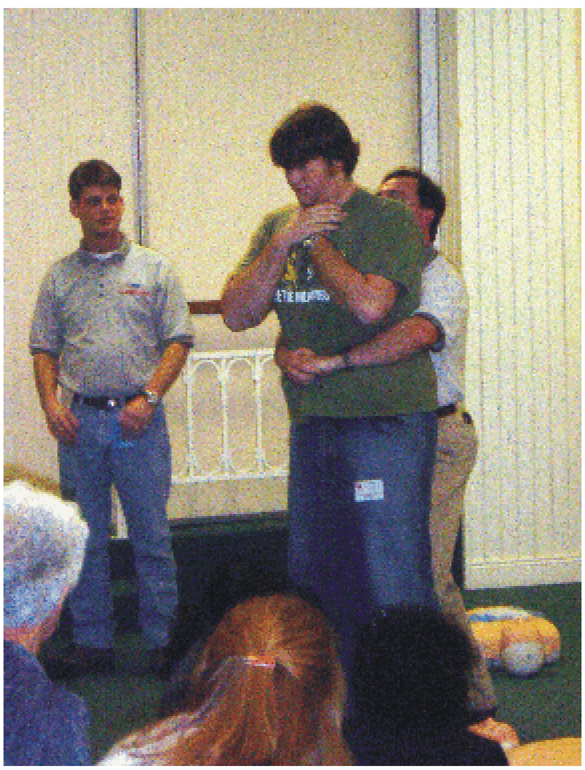
Andrea Barker — 2nd Place (Certificate and monetary award)

Jay C. Rutz — 3rd Place (Certificate and Human Genome DVD)

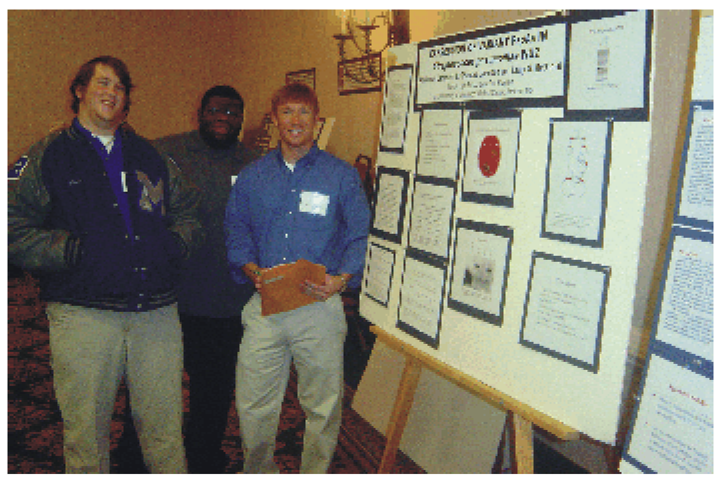
We would like to acknowledge the co-sponsors: Baptist Medical Center, Jackson MS, DePuy, DBA SYNTHES, Dr. Suman Das, Departments of General Surgery, Orthopedic Surgery and Rehabilitation at the University of Mississippi Medical Center, for their support. We are grateful to Leslie Boyd for his an outstanding audiovisual expertise and his patience. A special thanks to Karen Yawn Bell, Regional Manager II, Mississippi Emergency Cardiovascular Care Program, for coordinating the CPR workshop. Many thanks to the following Instructors from American Medical Response Training Center-Chris Powell, Howard, McDonnell, Mike Albritton, Mark Roberts, Roger Bardwell, Ed Friloux, Colby Snyder, Jimmie Albritton, Mark Bort and Scott Melton.—Olga McDaniel

Health Sciences

Sixty-eighth Annual Meeting



The instructor is demonstrating a universal Heimlich maneuver on Anderson Lampton from the base-pair program.



Justin Thornton (right) and Quincy Moore (middle), graduate students from UMMC are judging the posters.


Mr. William (Bill) Davenhall, manager of Health and Human Services Solutions, ESRI, discussed Enterprise GIS.


Dr. William D. Henriques, Commander, US Public Health Services, and Coordinator, Public Health Geospatial Analysis Program, CDC/ATSDR discussed the impact of geospatial technologies in public health, disease control, and emergency responses.


Olga McDaniel, PhD, Chair of HSD presenting a plaque to Dr. Fazlay Faruque, Director of GIS, in recognition of his organizing the special symposium GIS and Remote Sensing in Health Sciences.


Some of the participants in the CPR workshop for Family and Friends.


Dr. Joseph Cameron practicing CPR.


Leslie Boyd and Dr. Shelly Tucci are discussing whetherr the camera is loaded or not.


David Arrington, Andrea Barker, and Sebron Harrison.


Instructor Scott Melton demonstrating CPR procedure to participants.


Benjie Mangilog, Dr. Shelly Tucci, and Dr. Olga McDaniel are counting the scores.

Award winning students that remained at the close of the meeting are pictured with Drs. Shelly Tucci and Olga McDaniel. Students from left: Stevie Adams, Laura Franklin, Nourelhoda Farah, Russell F. Lyon, Tabitha Hardy, and Shontell Credit.

Dr. Shelly Tucci and special symposium speaker, Dr. Audrey Tsao.

History and Philosophy of Science

The past year (2003) proved to be an excellent period for us–the "soft scientists" who are interested in keeping track of what happened since science was born and in knowing why science exists. It climaxed in February 2004 at Biloxi where interesting presentations, followed by lively discussions, were made for one full day. The topics ranged from "The Scientific Contributions of the Arts Faculties at the Universities of Paris and Oxford in the 14th Centuries" to "Time to Face Reality: The Unreality of Time Could Very Well Be Real." At the business meeting we elected a divisional vice chair for next year.

I have noticed that during the 2004-annual meeting several presentations made in other divisions might have been more appropriate for our division. For example, the presentation "William Dunbar and the Exploration of the Southern Part of the Louisiana Purchase" in the Geology and Geography division might have been of interest to our division too. It seems that we need a mechanism to help the authors consider other "appropriate" divisions for their presentations.—Kant Vajpayee

Marine and Atmospheric Sciences

The Division of Marine and Atmospheric Sciences met for three sessions on the mornings of Thursday and Friday and on Friday afternoon, 19 and 20 February 2004, as part of the 68th annual meeting of the Mississippi Academy of Sciences. In addition, the Division co-sponsored the Climate Change Symposium featuring Drs. Joan Fitzpatrick and

Richard Alley from 1:00 to 4:00 pm on Thursday afternoon. The Division Chair was Dr. Chet Rakocinski and the Vice-chair was Dr. Charlotte Brunner. In all, there were 25 oral presentations and eight posters. Students gave seventeen of the oral presentations and all eight posters. In keeping with the outstanding support of the Division shown by student participants, best student paper awards were designated based on objective feedback from professional judges using standard forms. Special thanks are due to Drs. Charlotte Brunner, Gary Gaston, Julia Lytle, Tom Lytle, Cynthia Moncreiff, and Chet Rakocinski for providing service as judges. There was a tie for the Best student oral paper, which was awarded to Ms. Meagan Williams, who presented the paper, "Biochemical analysis of developing eggs of the American Horeshoe crab *Limulus polyphemus* from Delaware Bay and the Gulf of Mexico"; and Angelos Apeitos, who presented the paper, "The effect of diet on fecundity of *Acartia tonsa*, a calanoid copepod." The best student poster award went to Brent P. Thoma and John M. Foster for the poster entitled, "Preliminary investigations of the comparative occurrence of sponge dwelling amphipods in *Tedania ignis* (Porifera, Demospongiae, Myxillidae) from a turtle grass bed and a red mangrove forest in the Florida Keys, USA." Student winners will receive framed and signed paper award certificates. The quality of our student presentations, both oral and poster, was excellent, and all the students deserve recognition for their professionalism. Overall, attendance was moderate; and the individual sessions were generally attended by different audiences. Most presentations were given in PowerPoint format; although there were two overhead presentations, and one DVD movie presentation. The Divisional Business Meeting was held immediately following the Friday morning oral session. The current Vice-chair, Dr. Charlotte Brunner (The University of Southern Mississippi, Department of Marine Science), will assume the duties of Chair for 2004–2005. Dr. Paulinus Chigbu (Jackson State University; Department of Biology) was elected Vice-chair for 2004–2005 and will assume the duties of Chair for 2005–2006.— Chet Rakocinski

Mathematics, Computer Science and Statistics

1. All presentations listed in the meeting except poster presentation by Ms. LaTrese Davis were made as scheduled.
2. Biostatistical Analysis workshop and the workshop by Mississippi Super Computing Research were conducted as scheduled.
3. No awards were given in poster categories because the only student poster presntation was never made. One first prize and two second prizes were awarded to students in the oral presentation category. These awards consisted of (i) a statistics softwware (Active Stats donated by Addison Wesley), (ii) a book (donated by Brooks/Cole), and (iii) a certificate. The awardees were:
   a. First Prize—Tyler Simon (Grad; University of Mississippi): Performance Analysis Of Linear Algebra And Numerical Aerodynamic Simulation Benchmarks On The MCSR Beowulf Linux Cluster
   b. Second Prize—Tollie Thigpen (Undergrad; Alcorn State University): Evaluating Bias of the Kaplan-Meier ...
   c. Second Prize—Virgiania Moore (Grad; University of Mississippi): Looping Effect On Kindergarten And First Graders
4. Names of the awardees were passed on to Ms. Cynthia Huff.
5. The divisional meeting was held at 1:40 p.m on Thursday, February 29, 2004.
6. Dr. Andrew Harrell, (sitting vice-chair of the section) was elected chair; Dr. Lixin Yu, Department of Mathematical Sciences, Alcorn State University, was elected vice-chair. Information about both was passed on to Ms. Cynthia Huff.
7. The members present noted need to push for more mathematics participation at the conference.
8. It was decided to request the board to either give more break time for lunch or the academy locks the doors because equipment in the rooms has to be disconnected and connected again. Unlike most conferences, where the equipment belongs to a central management etc, the equipment used by sections is borrowed by the chair/vice chair and cannot be left unattended unless risk is covered by the academy. Under the present arrangement chair/vice chair are the last ones to leave the room and first ones to come back after lunch for removing and bringing back the costly borrowed equipment for smooth working of the session. That does not leave them enough time for lunch.
9. Personally, I will prefer the equipment stays connected and the rooms can be locked, so that lunch break does not have to be made longer.

10. Filled out questionnaire forms on the conference were handed over to Ms. Cynthia Huff.—Ravindar Kumar

Science Education

The Division of Science Education met on February 19, 2004 during the 68th annual meeting of the Mississippi Academy of Sciences at the President Casino Broadwater Towers in Biloxi, MS. There were 17 oral and five poster presentations during the day ranging from interesting projects/exhibits being created at the J.L. Scott Aquarium to the development of a 3-D DNA molecule model. The divisional business meeting was held immediately following the morning session. The current Vice-chair, Dr. Sheila Brown (The University of Southern Mississippi and the J.L. Scott Marine Education Center and Aquarium) will assume responsibilities of Chair for 2004-2005. Newly elected Vice-chair for 2004-2005 is Dr. Kay B. Baggett (The University of Southern Mississippi and the J.L. Scott Marine Education Center and Aquarium).—Aimée Lee

Physics and Engineering

The 2004 MAS Physics and Engineering Division meeting, Chaired by Atef Elsherbeni, Vice Chair Robert Fritzius, hosted 14 oral presentations and two poster presentations. A presentation on Gamma-ray Bursts, given by Dr. J. Patrick Lestrade, Physics and Astronomy, Mississippi State University, was judged to be the best overall division presentation. A presentation given by Matthew J. Inman, Electrical Engineering Ph. D student, University of Mississippi, was judged to be the best graduate presentation. Mr. Robert Fritzius, Starkville, Mississippi, moved up to Chair of the Division and in the Divisional Business Meeting Dr. Alexander B. Yakovlev, University of Mississippi, was elected as Vice Chair.—Robert Fritzius

Psychology and Social Science

The Division of Psychology and Social Science had a very successful meeting for 2004. In our third year as a combined division, we had a full day of excellent papers and posters from undergraduates, graduate students, and faculty.

Our day began with a poster session. The five posters showed the breadth of psychological and social scientific research covering topics as varied as asynchrony perception, the clinical usefulness of the Seeking of Noetic Goals (SONG) test, the benefit of spousal involvement in recruitment for clinical trials, using silhouette drawings to test perceptions of desirable body frames, and the behavior of captive bottlenose dolphins.

The rest of the day was given to lecture presentations starting with a special session, *Life during the 1700s on the Mississippi Gulf Coast—The Moran Studio (22HR511) Burials*, organized by Dr. Marie Danforth (USM-Anthropology). The session included seven papers presented by faculty and graduate students from Anthropology at The University of Southern Mississippi and a presenter from the Gulf Coast Chapter of the Mississippi Archeological Association. These papers analyzed what life was like on the Gulf Coast in the 1700s through the study of eight sets of remains found at the Moran Art Studio in Biloxi, MS. Presenters discussed the history and culture of the Native American populations found on the Gulf Coast, the original colonization of the coastal area, and the physical characteristics of the remains found at the art studio as well as their health and diet.

Our morning session concluded with four papers by undergraduates and graduate students in anthropology, sociology and psychology from USM and Tougaloo College. Due to the large number of papers received, the division split into concurrent sessions in the afternoon. Papers were presented by undergraduates, graduate students, and faculty from The University of Mississippi, Tougaloo College, Jackson State University, The University of Southern Mississippi, and Delta State University. Again, the breadth of psychological and social scientific research was highlighted with papers focusing on such varied topics as the American Community Survey, the Stroop effect, suicide, health behaviors of African-American college students, and mother-infant interactions among Garnett's Bushbabies.

Four awards were given in the division this year. This year's Best Undergraduate Paper Presentation Award went to Kendria Funchess, USM, for her paper, *Does Suicide History or Plan Influence Commitment Decisions*. The Best Graduate Student Paper Presentation Award went to Cindy Carter, USM, for her paper, *Ancestry, Robusticity, and Stature: Identification Through Long Bone Measurements at the Moran Burials, Biloxi, Mississippi*. The Best Undergraduate Poster Award went to

Angelique Horace, JSU, for her poster, *Temporal Limits in Asynchrony Perception*. The Best Gradu ate Student Poster Award went to Deidre Yeater, USM, for her poster, *Voluntary Regurgitation in Captive Bottlenose Dolphins (Tursiops Truncates)*. Each student received a certificate and a monetary award. Special thanks is given to Dr. Pamela Banks, Department of Psychology, JSU, for sponsoring these awards.

At the divisional business meeting, Dr. Ann Marie Kinnell (USM–Sociology) agreed to remain as chair of the division for 2004–2005. Dr. Sharee Watson (USM–Psychology) was elected vice-chair. Dr. Pamela Banks (JSU–Psychology) agreed to act as Awards Coordinator for the division.

Finally, special thanks goes to Dr. Marie Danforth who was a great help in transporting equipment for this years meeting.—Ann Marie Kinnell

MISSISSIPPI ACADEMY OF SCIENCES
Sixty-eighth Annual Meeting—February 2004
Late and corrected abstracts

Agriculture and Plant Science

QUALITY OF MISSISSIPPI TOMATOES AND ITS RELATION TO THE LYCOPENE CONTENT

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Tomatoes are very common fruits, consumed by most people in many different ways. Most tomatoes mature to a deep red color, given by a pigment called lycopene. Lycopene is in the carotenoid family, a fat-soluble pigment, precursor of vitamin A, with important health benefits. It is found in its trans form in nature and it is transformed, under heat or oxidation. Lycopene may reduce the risk of some epithelial cancers, eye disease, and the incidence of heart disease. A method to detect lycopene was developed by Holmes et al. (2002). This method utilizes normal phase liquid chromatography coupled with mass spectrometry. However, simpler methods are needed to screen large number of fruits or products. Since lycopene is related to tomato color, both surface and whole fruit (puree) color were assessed, along with other quality traits of the fruit. Values for lycopene, surface Hunter 'a' (redness), a/b and hue ranged between 1.35-43.8 ppm, 23.5-16.0, and 13.5-43.8, respectively. The whole (puree) tomato's Hunter 'a,' a/b, and hue ranged between 24.6-17.5, 2.24-1.17, and 38.0-22.5, respectively. The pH, titratable acidity (TA) and soluble solids (SS) ranged between 4.3-4.1, 0.50-0.35, and 5.0-3.6, respectively. The variation in pH, TA and SS may be due to differences in cultivars and/or maturity. These variations may account for the correlation between lycopene content and tomato color.

FATTY ACID COMPOSITION AND COLD HARDINESS OF PECAN CULTIVARS

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Low temperature is the most important factor limiting the distribution of plants. Only hardy plants can survive low temperature. During acclimation and deacclimation plants undergo a series of metabolic changes that lead to cold hardiness or loss of hardiness. One of these changes is the accumulation of certain lipids. This research was conducted to compare hardiness among three pecan cultivars: 'Desirable,' 'Jackson,' and 'Owens' growing under Mississippi condition and to determine the relationship between fatty acid levels and cold hardiness of pecan shoots. Differential thermal analysis (DTA), electrical conductivity, and tetrazolium tests were used to determine cold hardiness. Pecan stems were collected from September to March in 2002 and 2003 to determine cold acclimation and deacclimation. Fatty acid composition of pecan stems during this time period was determined by gas chromatography. DTA indicated that pecan stems acclimated in October and deacclimated in March. Total percentage of fatty acid significantly increased during cold acclimation and there was a shift in the fatty acid composition to more unsaturated fatty acids. The percentage of linoleic and linolenic fatty acids increased, while the percentage of palmitic and stearic fatty acids decreased. The correlation between unsaturated fatty acids and cold hardiness suggests that unsaturated fatty acid may play a role in membrane fluidity.

Cellular, Molecular and Developmental Biology

COMPARISON OF EARLY LIFE RESPONSES OF ZEBRAFISH TO BENZO(A)PYRENE AND RETINOIC ACID

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The zebrafish (*Danio rerio*) is a new model organism especially suited for early life stage developmental, molecular, and genetic toxicology. The effects of water pollution caused by the chemical output from factories, everyday activities such as driving an automobile, agricultural runoff, etc. can be analyzed with a fish-embryo life stage suite of bioassays. The compounds chosen were used to determine the points during the early life stages of a developing embryo that are most vulnerable to exposure by the two representative xenobiotics and the effects each compound will cause. Fertilized eggs were exposed to 0, 300, 400, and 500 micrograms/L of benzo(a)pyrene and 0, 400, 700, and 900 micrograms/L of Retinoic Acid. The preliminary results from this study indicate that Benzo(a)pyrene appeared to cause a light increase in average heart rate while Retinoic Acid caused a slight decrease. Also, as Retinoic Acid concentration was increased, mortality rates increased resulting in a lower percentage of embryos successfully hatching by 80 hours post fertilization; exposure to Benzo(a)pyrene resulted in an 80% hatch rate post fertilization. Even though Benzo(a)pyrene did not cause any statistical difference in mortality, curved and irregularly shaped tails and heads were observed.

Ecology and Evolutionary Biology

EFFECTS OF SEWAGE DUMPING ON MACROBENTHOS AT LAWSON'S BAY OFF VISAKHAPATNAM, EAST COAST OF INDIA

Shonda Moore[1]*, Akkur V. Raman[2], Bettaiya Rajanna[1], Sateesh Nanduri[2], T. Ganesh[2], Kasi V. Rao[2], Jai Kumar[2], and Leroy Johnson[1], [1]Alcorn State University, Alcorn State, MS, 39096, and [2]Andhra University, Waltair, Visakhapatnam, India

A study was conducted on macrobenthos along a gradient of sewage pollution representing 5, 10, 20, and 30 m sites at Lawson's Bay off the East Coast of India. The objectives of the study were to assess benthic species composition, abundance and distribution and evaluate the conditions based on benthic community structure and species diversity. The results suggested differences in species composition and abundance patterns between sites close to the outfall and those farther away. On the basis of infaunal and epifaunal collections,100 taxa were represented. Observations on sediment variables indicated that close to the outfall sediments consisting of 95% sand contained strikingly high amounts of organic matter (1.75%). While *Prionospio* sp. was the determining species for 5 m and 10 m sites, the *Eunice* sp. and the amphipod *Maera* sp. were characteristic of 20 m and 30 m. Species diversity indices were in conformity with benthos composition and abundance patterns being least at the outfall (5 m) relative to the open sea (30 m). Species cumulative dominance data have further confirmed these patterns. A close concurrence between benthos distribution and environmental conditions was evident. Presence of spionids in large numbers at 5 m and 10 m was conclusive evidence of the effects of sewage dumping on benthos at Lawson's Bay.

Marine and Atmospheric Sciences

DYNAMICS OF DIATOMS AND DINOFLAGELLATES IN TUMACO BAY (COLOMBIA) UNDER THE INFLUENCE OF CLIMATIC CHANGES DURING THE PERIOD 1995–2001

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This analysis was based in the information gathered in Tumaco's Bay (Colombia) during the years 1995 to 2000 to obtain a general picture of the dynamics of the community of diatoms and dinoflagellates in response to climatic changes and natural phenomena, such as "El Niño" and "La Niña," which potentially affect the composition of these groups. An increase in the population of diatoms was observed during La Niña and a decrease during El Niño. The response by the dinoflagellate group was completely opposite. The range of temperature in which the major abundance of diatoms occurred was from 26 to 27.5 °C, and for the dinoflagellates it was from 28 to 31 °C. The dynamics of the phytoplankton also showed a close relation with other variables, including daytime, months and nutrients.

SALINITY TOLERANCE OF RED SNAPPER (*LUTJANUS CAMPECHANUS*) EGGS AND LARVAE

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Gulf Coast Research Laboratory (GCRL) cultures red snapper larvae at 30 – 35 ppt to match conditions in the wild. However, red snapper larvae require live zooplankton cultured in 5 ppt to 20 ppt. Live zooplankton may experience salinity shock when transferred into salinities differing by 10 ppt or more. Therefore, the purpose of this study was to determine if red snapper larvae can be cultured at lower salinities without compromising survival and growth to reduce stress on live zooplankton. Red snapper eggs, day-0, day-1, and day-2 post-hatch larvae were tested at four different salinities (5, 15, 25, and 30 ppt) in a small-scale experiment. Eggs and larvae were monitored every 24 hours for percent survival. Average hatch rate and percent survival at 48 hours was highest in 25 ppt regardless of larval age at day of transfer. In addition, survival of larvae at two test salinities (25 ppt and 30 ppt) was compared in a 24-day production-scale experiment. Four 1,000-L tanks of each salinity were stocked at 5 larvae per liter. Growth and survival at day 24 were higher in 25 ppt. Results suggest that reducing the salinity of larval fish rearing may result in increased production.

Mathematics, Computer Science and Statistics

A SOFTWARE TOOL DEVELOPED FOR THE CLASSIFICATION OF REMOTE SENSING SPECTRAL REFLECTANCE DATA

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This paper describes the development and implementation of LIP (Leaf Identification Program), a pattern recognition software tool intended to classify remote sensing spectral reflectance data of stressed soybean leaves by using neural network and other statistical pattern recognition techniques. The development of this software tool takes advantage of the high performance computational and visualization routines of the MATLAB programming environment. LIP provides an integrated environment for various data analysis, data visualization and pattern recognition techniques to analyze remote sensing spectral reflectance data. Data analysis component of LIP includes: principal component analysis, fisher and variance weight calculations and feature selection. Data visualization tool permits visual assessment of the spectral reflectance data patterns and their relationships. Several classification methods have been implemented in LIP using both neural network and statistical pattern recognition techniques. Neural network methods include the back propagation neural network (BPN) and radial basis function (RBF) neural network. Statistical pattern recognition component of LIP includes linear discriminant analysis (LDA), quadratic discriminant analysis (QDA), regularized discriminant analysis (RDA), soft independent modeling of class analogy (SIMCA) and discriminant analysis with shrunken covariance (DASCO). The objective of this study funded by National Aeronautics Space Administration (NASA) at Stennis Space Center was to record and classify the spectral reflectance differences of leaf stress caused by drought, fungal disease, and lead contamination of the soil. LIP software tool has been used successfully to classify the different classes of stressed leaves from their spectral signature.

Physics and Engineering

A PROCEDURAL METHOD FOR DETERMINING MODEL ORDER FOR FEEDFORWARD NEURAL NETWORKS

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The effects of including lateral interconnections are investigated for feed-forward neural network. The architecture consists of one hidden layer with m- hidden neurons with neuron j connected fully to the inputs, the outputs, and hidden neruons j^{+1}. Each hidden neuron receives two signals in the back propagation process from the output and the lateral connections. The lateral connections provide a mechanism for controlled assignmentof role, and thus specialization. The simulations show an incremental assignment of role through controlled allocation of resources. A highly predictable evolution of the networks permits an estimation of the model order for a given problem. Both function approximation and classification examples are utilized to demonstrate the procedural method for determining model order.

Science Education

BIOTECHNOLOGY IN COMMUNITY COLLEGES

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The Biotechnology program at Mississippi Gulf Coast Community College, Jefferson Davis Campus, is designed to prepare students to enter the Biotechnology workforce. The curriculum is designed to allow students a "hands-on" approach to practical applications in laboratory techniques. Upon completion of the program, students will be skilled in laboratory techniques presently utilized in the Biotechnology industry. Techniques mastered during the program include agarose, polyacrylamide and protein gel electrophoresis, DNA sequencing, gene mapping, restriction enzyme cleavage of DNA, recombinant gene technology, cloning, polymerase chain reaction (PCR), reverse transcription polymerase chain reaction (rtPCR), Southern and Western blotting, analysis of restriction fragment polymorhisms (RFLP), analysis of variable number tandem repeats (VNTR's), DNA fingerprinting for paternity and forensics analysis, protein analysis and bioprocessing.