LOUISIANA'S UPLAND RESEARCH INITIATIVES

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ABSTRACT

The Louisiana Applied and Educational Oil Spill Research and Development Program (OSRADP) has an annual research budget of $530,000 and underwrites 10 to 15 projects annually. Although in some areas interest in oil spill research may be waning, this is not the case in Louisiana. In fact, the program is getting stronger. Since the fall of 1993, the OSRADP has granted 90 awards in support of 75 projects; $42,466 is the average award. Since oil and/or gas is produced in all 64 Louisiana parishes (counties) the program has underwritten upland, as well as marine-oriented research endeavors. OSRADP upland projects reflect the state's interest in spill response, prevention and cleanup. *Oil spill awareness through geoscience education (OSAGE)*; *Phytoremediation for oil spill cleanup in upland habitats*; *Use of donor seed banks in terrestrial vegetation recovery after an oil spill*; *Use of ammoniated bagasse for remediation*; and *The Louisiana GIS CD* and its importance in spill response and management are part of the state's strategy to address inland spill issues. From Louisiana's perspective, acceptance by the regulatory community can lead to better response in the future. The challenge is moving the research into the field with approval of all the appropriate agencies. On the shelf, these research initiatives are not meeting the program's applied mandate. The completed projects can be reviewed on the Internet at www.osradp.lsu.edu.

THE LOUISIANA APPLIED AND EDUCATIONAL OIL SPILL RESEARCH AND DEVELOPMENT PROGRAM (OSRADP)

The objective of the projects funded through the OSRADP is to deal with a broad range of problems associated with oil spills and use this information in the oil spill response, prevention, and training process. These strategies involve understanding the ecological risks posed by particular oil spills, socioeconomic impacts, response training, clean-up procedures, and using this information in decision or policy making purposes, as well as educating interested parties.

The program's research initiatives are divided into four categories: (1) spill of opportunity; (2) education, training and public awareness; (3) remote sensing and mapping; and (4) spill response cleanup and harmful ecological consequences. Each project's scientific merit is based on the simple question: Can the results be implemented in a spill event? To be a practical field tool, many of these projects need approval from the regulatory community. In this regard, efforts are underway to increase the collective awareness of the results of these research initiatives.

SPILL-OF-OPPORTUNITY

Spill-of-opportunity funds are used to apply and evaluate new and/or experimental technology to enhance the recovery of spilled oil or to test experimental cleanup techniques in a field situation. Four projects have used these funds; one deals with uplands.

In 1998, Research Planning, Inc. (RPI) conducted a literature compilation and review of data on the environmental effects of *in-situ* burning of inland and upland oil spills for the American Petroleum

Institute (API). There are relatively few documented case histories (only 31 were found) on the medium- and long-term recovery rates of habitats where *in-situ* burning was used. Louisiana State University's (LSU) Institute for Environmental Studies, in collaboration with the API-funded RPI project, is in the process of conducting chemical characterization studies of up to 30 sediment samples collected from five sites determined by RPI to be relevant. This is an on-going project that will not be completed until the summer of 2002.

EDUCATION, TRAINING AND PUBLIC AWARENESS

Education, training and public awareness have evolved into important components in the OSRADP's mission. Originally, the program focused on educating middle and senior high school students through the *"Oil spill awareness through geoscience education (OSAGE)"* CD-ROM. Nearly 10,000 copies of this CD have been systematically distributed to appropriate science educators throughout the state. The State Department of Education and the Louisiana Science Teachers Association are encouraging classroom instructors to incorporate the CD into their earth science classes. As part of Louisiana's Oil Centennial, the oil and gas industry is underwriting production of at least 5,000 additional copies of this CD.

Like OSAGE, the program felt the *Louisiana GIS CD: A Digital Map of the State* needed to be formatted as an educational tool (see Remote Sensing and Mapping section). Consequently, the program is finalizing a multi-disciplinary curriculum that involves mathematics, science, social studies and language arts. By modifying this oil-spill product, the curriculum team has added a significant element to the state's middle and senior high school's environmental curriculum.

Through generous donations of more than a dozen agencies, private foundations, and oil and gas companies 10,000 copies of the two CD-ROM set have been incorporated into 1,000 binders. Each school will receive 10 copies of the CD by the end of the first quarter of 2002.

Since the Mississippi River is a major transportation corridor in the movement of a wide array of petroleum or petroleum-based products, a series of projects were funded involving: (1) *"Modeling the Mississippi: oil spill risk on Louisiana's largest river"* (Dr. Craig Forsyth, Phone: 337-482-5372, e-mail:cjf5714@louisiana.edu, University of Louisiana at Lafayette [ULL]); (2)*"Modeling the Mississippi: transportation risks on the nation's busiest waterway"* (Dr. Robert Gramling, Phone: 337-482-5375, e-mail: gramling@louisiana.edu, ULL); (3) "*A test and refinement of a risk model for vessel traffic on the lower Mississippi River* (Dr. Robert Gramling); (4) *"A risk model for vessel traffic on the lower Mississippi River"* (Dr. Robert Gramling); and (5) *"Oil resource atlas for Louisiana: creating and maintaining a focused baseline for oil spill response"* (Dr. Robert Gramling).

Tankers (1994) and barges (1995) were tracked utilizing maritime experts, previous research, and existing databases to evaluate and assess risk factors on the Mississippi. Vessel traffic data and geographic risk location information were combined to produce relative risk scores for each mile along the river. The analysis extends from the mouth of Southwest Pass to the termination of shipping at the U.S. 190 bridge in Baton Rouge, Louisiana.

Many river pilots consider the most dangerous river situation to be a blind turn that leads into an

anchorage. Other combinations (e.g. a floating anchorage near rafts, barges, dangerous currents, or narrow channels) also affect the risk associated with particular portions of the river. It is important to assess accident risk along the lower Mississippi River in order to aid in development of realistic risk reduction, contingency, and response plans. Awareness of potential risk sites can reduce accidents considerably and thereby reduce insurance costs as well.

Further, the ULL team is completing a database of Louisiana's oil spills between 1992 and 1999. When combined with information that the Oil Spill Coordinator's office has been collecting since 2000, this database will provide a continuously updated coverage of oil spills from 1992. For each spill a variety of information will be included such as latitude and longitude coordinates, size in gallons or barrels, substance spilled (e.g. crude oil, diesel fuel, etc.), cause, and a description of the spill's physical location. In addition, this group currently has a project: *"Historical analysis of oil spills in Louisiana"* (Dr. George Wooddell, Phone: 337-482-6044, e-mail: gpw4993@louisiana.edu, ULL) that will provide, when completed in 2002, an analysis of the distribution and frequency of oil spills reported to state officials. A database containing the reported spills, as well as a historical analysis of major oil spills during the latter half of the 20th century will be included in this study. When completed, Louisiana will have a powerful planning tool for oil spill prevention and response.

Following a spill of potentially toxic materials into the Mississippi, rapid decisions must be made in order to protect human health and natural resources. Consequently, a river time-of-travel model has been developed for the Mississippi River. "*R-TOT river time-of-travel model: computer program extension, enhancement, distribution, and training"* and *"Emergency management river*

oil spill models" (Dr. Ehab Meselhe, Phone: 337-482-5802, e-mail: meselhe@louisiana.edu, ULL) are tools that can predict a spill's time of arrival and duration of passage. Additionally, if the quantity of material spilled is known, or estimated, the model predicts peak concentrations at any downstream location. The model is sufficiently accurate for most spill monitoring and risk management requirements and is simple enough to be applied in actual spill events. The zip download file contains the installation files and manuals for the Time of Travel model and can be accessed at: www.geocities.com/mwaldon/RiverSpill/riverspill.html.

"A legal guide of Louisiana's oil spill prevention and response act, regulations and associated laws" (Erinn Neyrey, Phone: 225-578-5932, email: eneyrey@lsu.edu) was completed in May 2001. This guide has been written for a broad audience, encompassing professionals in the field, as well as others that may be affected by the laws and accompanying regulation. It is designed to be a timesaving resource and reference book that is user-friendly and up-to-date, by compiling existing program information and materials, as well as reviewing any new legislation, case law, regulatory provisions, and natural resource damage assessment requirements. More importantly, the guide identifies the numerous agencies and agency programs that may be involved in an oil spill event.

REMOTE SENSING AND MAPPING

The Oil Spill Coordinator contracted research scientists at LSU to produce the *Louisiana Oil Spill Contingency Plan Map*. To improve the map's distribution, it is available on a CD-ROM with appropriate GIS overlays. The original product is a seamless satellite image at a resolution of 30 m (115.8 ft). A new version was released in 1999 that runs on Windows 95 ™ and NT ™. Nearly

10,000 copies of the new CD have been distributed to oil and/or gas companies and others doing business in Louisiana. This new product is based on Landsat Thematic Mapper (TM)™ imagery for background color, overlain with SPOT™ data to provide a false-color composite at 10 m (32.8 ft) resolution. Training is available in order to explain how to use the two CD-ROM set that, in addition to the image, contains more than 40 spatial data layers, a satellite tour of Louisiana, GIS software, and tutorials.

In addition, the Oil Spill Coordinator's office has developed a web-accessible database that includes 72 data bundles. Using Internet Explorer, go to http://atlas.lsu.edu, which will bring up the Louisiana statewide GIS. Along with more than 60 overlays, there are only 38 images left for 100% coverage at a resolution of one meter (3.28 ft). These images are available through the atlas web site. If help is required accessing this material, the atlas home page (http://atlas.lsu.edu) has detailed instructions on what one needs to download, unzip, and view the compressed map image and/or images.

With 100 years of oil and gas development in Louisiana, the state's oil and gas pipeline network is highly complex and routes are often not well documented. Recognizing this complication as a potential clean-up problem, a two-year study on: *"Research, compilation, and digitization of undocumented and abandoned Louisiana pipelines for the statewide pipeline digital database"* (Robert Pausell, Phone: 225-578-8655, e-mail:rpaulsell@lsu.edu) was initiated. This project generated data on the state's intricate pipeline network. This digital map will eventually provide a much better understanding of the rights-of-way, river crossings, pipeline corridors and pipeline

agglomerations throughout Louisiana. This is an ongoing project and is only beginning to yield information that can be properly mapped; however, a preliminary map is available. Two additional pipeline projects: *"Research and development of a GIS for oil and gas transmission pipelines in Baton Rouge"* (Robert Paulsell) and *"Field investigation and digital mapping of pipeline crossings of the Red River in Louisiana"* (John Snead, Phone: 225-578-6454, e-mail: snead@lsu.edu, LSU) are in progress and will be completed in the second quarter of 2002.

Recent highly publicized pipeline accidents involving injuries and deaths has heightened awareness of potential pipeline problems. With this as the backdrop, Mr. Paulsell will develop a GIS of crude oil, natural gas and petrochemical transmission pipelines used in the movement of butane, propane, and other products within the city limits of Baton Rouge. These data will be developed by collecting all pertinent source documentation (maps), compiling GPS data on transmission lines, and performing a GIS analysis with existing data. Special attention will be paid to locating undocumented and abandoned pipelines and to assess the spatial accuracy of existing digital data.

Continuing with this theme, Mr. Snead will investigate and digitally map the pipeline crossings of the Red River. Routine waterway incidents such as dragging anchor, dredging accidents, or shipwrecks pose a treat. In addition, the potential for flood waters to rupture and destroy pipeline crossings has been documented in floods on the Red River in Minnesota and the Trinity River in East Texas. Therefore, accurate and up-to date digital pipeline information is of fundamental importance to the oil spill community. A high-resolution pipeline crossing GIS of these streams offers previously unavailable information and will enable increased response efficiency by allowing

responders to access quickly the size, product carried, and operator of specific pipelines.

SPILL RESPONSE, CLEANUP, AND HARMFUL ECOLOGICAL CONSEQUENCES

Even though phytoremediation is neither a proven nor generally accepted practice, it holds some potential. The two-year field study *"Baseline experimental studies for onshore oil spills"* and *"Unassisted and enhanced remediation studies for onshore oil spills: concept development"* (Dr. Maureen McCurdy, Phone: 318-257-3165, e-mail: hillard@latech.edu, Louisiana Tech University [La Tech]) assessed the minimum baseline requirement for Louisiana's upland plants to recover naturally from oil spill damage. Although minimal revegetation occurred within the oiled plots during the first post-spill growing season, vegetative recovery increased during the second growing season.

Dr. Gary Breitenbeck (Phone: 225-578-1362, e-mail: gbreite@lsu.edu, LSU) investigated in the study *"Devices to support in-situ burning of oil on water"* . Using floating wicks, a thin veneer of diesel or bunker fuel can be burned as readily as slicks of weathered crude and heavier oils. When slicks are greater than 1.5 mm thick (.059 in), use of these devices results in rapid ignition of the entire oil surface. Slicks as thin as 0.15 mm (.0059 in) are also easily ignited and burned. Even emulsified oils can be ignited. These devices were designed to be biodegradable, non-toxic, water-resistant, light-weight, and easily deployed from fixed-wing aircraft. The most effective wicks were ellipsoid-shaped disks approximately 7.6 cm (3 in) in diameter and comprised of kenaf, a fiber crop, bonded and coated with a hydrophobic copolymer. Since the thickness of most oil slicks is not sufficient to maintain combustion without the addition of a wick, these devices allow controlled

burns of large and small spills even in close proximity to ships or other objects.

The program funded a two-year project led by Dr. Wayne Hudnall (Phone: 225-578-1344; e-mail: whudnall@agctr.lsu.edu, LSU): *"Remediation and restoration of an oil contaminated wetland and pine forest site."* The premise behind this effort is that accidental spills, leaks, or discharges can expose a wide variety of sensitive habitats to petroleum and brine contamination. The goal of this project was to introduce a successful remediation and restoration plan for a contaminated wetland and pine forest site impacted by an oil well blowout simultaneously.

The research site, located in Kisatchie National Forest, was polluted by an oil and brine spill (13,000 barrels of oil and 600,000 barrels of brine). The release resulted in oil and brine contamination of a 1.74 hectare (4.3 acre) freshwater wetland. Aerial spray of oil, brine, and gas from the blowout also killed or severely stressed numerous loblolly (*Pinus taeda*) and longleaf pine (*Pinus palustris*) trees in the vicinity of the well. Remediation of the wetland and restoration of the pine forest required a field and a greenhouse study. The field component examined the effectiveness of ammoniated bagasse (ABG) at enhancing bioremediation.

Burning was the most effective, ecologically sound, and economical method for removing the oil from the wetland. Once the area was burned, a combination of ABG, lime, and topsoil was applied *in situ* to 20 research plots. The results showed bagasse reduced the total petroleum hydrocarbons (TPH) over 300% in the top 10 cm (3.9 in) of the soil. Further more, greenhouse studies investigated the effect of foliar and soil applications of oil and brine on one year old loblolly pine

tree seedlings. Foliar application of oil has no effect on the trees (i.e. death, signs of stress). However, when 100% of the surface area of five trees was covered with oil new shoot growth on these trees died, while other areas of the trees showed no signs of stress. When oil was applied to the soil at a rate of 400 ml/tree (.42 quarts), the trees died or showed signs of severe stress within one week. Consequently, concentrations of oil and brine in the soil were not significant to cause death of the trees. Foliar brine had little or no effect on the trees. Results from this work suggests foliar oil contamination was the cause of the loblolly trees death at the blowout site.

The team that developed the baseline information for north Louisiana's uplands completed a study on *"In-situ burning and phytoremediation for onshore oil spills"* (Dr. Jeff Hillard, Phone: 318-257-3165, e-mail: hillard@.latech.edu, La Tech). Although *in-situ* burning was considered, the initial focus was on phytoremediation. More than 40 different species of native plants were observed growing in oil contaminated soil at existing upland spill sites in northern Louisiana. These observations indicated that a variety of plants might be able to survive in crude oil contaminated soil. Over the course of a 300-day greenhouse study, the team's analysis suggests the application of nitrogen, phosphorous, and potassium fertilizer may be an effective means of *in-situ* remediation. The researchers feel that reintroduction of vegetation into oiled upland sites is also desirable to prevent soil erosion, improve habitat, and may actually accelerate the natural attenuation of crude oil. Because of problems with some of the GC/FID samples, a team led by Dr. Ed Overton (Phone: 225-578-8521, email: ebovert@lsu.edu, LSU) is currently re-evaluating the samples for accuracy in the project *"Re-evaluation of soil from in-situ and phytoremediation studies for onshore oil spills."*

Three other studies concentrated on plants and their ability to survive in oiled upland environments: (1) : *"Development of a sensitivity index for plant response to applied oil"* (Dr. William Campbell, Phone: 318-257-4573, e-mail: campbell@latech.edu, La Tech); (2) *"Development of a germination index of sensitivity to applied oil"* (Dr. Milan Vavrek, Phone: 318-257-4573, e-mail: mvavrek@latech.edu, La Tech); and (3) *"Use of donor seed banks in terrestrial vegetation recovery after an oil spill"* (Dr. Milan Vavrek). These projects involve the survivability of plants in an oiled environment and the accessibility of seed banks that can be used to reseed the environment.

It has been shown that recovering plant communities may become re-established through regrowth of below-ground plant parts, (1) by germination of seeds immigrating into the site, (2) by germination of dormant seeds in the soil bank, or (3) by restoration efforts (e.g., planting of nursery stock). Ideally, complete recovery would be characterized by a plant community that includes the original species in the same relative proportions, in the same structure, as well as restored primary productivity. Preliminary results suggest seed banks are an effective component of vegetation recovery after a spill. However, in the case of severe spills *in-situ* seed banks may not promote complete recovery. Active restoration, including planting nursery stock or sowing seeds, may also be necessary. Alternatively, donor seed banks may be applied, particularly after degradation of oil has occurred.

The literature indicates that plants accelerate degradation of oil after a spill. By identifying specific plant traits that are responsible for the stimulated microbial growth and metabolism, plant species selection for remediation can be simplified (i.e. species native to the spill site can be chosen on the

basis of their characteristics). To test the effectiveness of particular traits, Dr. Milan Vavrek's two-year study *"Phytoremediation of petroleum: identification of plant traits that enhance degradation"* selected plants on the basis of growth rate, root morphology, water use efficiency, photo-synthetic pathway, and nitrogen fixation. These varieties were grown in a greenhouse in sterilized soil. After about 20 weeks, the TPH in the soils indicated that plants and microbes contributed little to bioremediation. In contrast, a bioassay (germination) indicated a significant reduction in soil toxicity. The difference between these two analyses may be a function of soil sampling, transformation of petroleum constituents, and the binding of petroleum components to humus. Three species, *Panicum virgatum* (switch grass), *Festuca arundinacea* (tall fescue), and *Cajanus cajan* (pigeonpea) possessed some tolerance to oil and enhanced microbial degradation. All three species are perennial and tolerate drought and moderate to high temperatures. Drought tolerance may be advantageous because of the hydrophobic nature of oil contaminated soils. Thus, water-use-efficiency may be an important trait for tolerance to oil. Additional studies are necessary to further identify plant traits that are effective in remediation. In this regard, Dr. Vavrek is continuing this work in the study: *"The role of plant-bacterial-fungal interaction in remediation of oak-hickory-pine systems."* Preliminary results suggest that by facilitating the interactions of plants, bacteria, and fungi, oil degradation can be accelerated. These organisms potentially improve each other's performance and act on oil directly. However, any restoration plan may require monitoring soil nutrients, repeated applications of fertilizer, and consideration of interactions among biological components.

When one has a spill two questions are often asked: How clean is clean? and Should we clean a site?

To help answer these queries, Dr. Howard Hunt's (Phone: 318-257-4141, e-mail: hhunt@latech.edu, La Tech) study *"Arthropod indicators of onshore oil spill severity"* indicates arthropods might have potential as indicators of the severity and degree of recovery from oil spill events. Dr. Hunt's two-year study used pit-traps to capture arthropods in 1 m (3,28 ft) blocks of habitat exposed to different intensities of waste oil within a fenced enclosure. By using broad arthropod groupings the team will reduce species-specific variability between samples and make broad-scale community changes easier to quantify. Preliminary results suggests the use of arthropod indicators may allow the identification of spills sites requiring little or no clean up, thereby saving the cost of expensive and unnecessary soil remediation treatments.

Three upland-related studies will be published in 2003. *"Detecting the chronic effects of oil development in Caddo Lake"* (Dr. Charles Ramcharan, Phone: 225-578-1745, e-mail: cramcha @lsu.edu, LSU) will look at the acute effects of oil development in a freshwater lake, since these environments preserve a history of their past physical, chemical, biological, and even climatological environments in their sediments. Using a variety of sensitive and sophisticated techniques for chemical analyses, the residues of these past environments can be detected in sediment cores. This project will attempt to determine the chronic effects of oil development in the food web of Caddo Lake. The data collected may also aid in monitoring oil spill remediation efforts.

"Revegetation of oil brine spill sites" (Dr. Milan Vavrek) requires a compound analysis. The approach involves a detailed literature review and experimental components. The objectives are to: (1) identify plant species capable of growing in contaminated sites by cross-referencing species

tolerance to oil, saline and sodic soils and by reviewing successful restoration techniques; (2) quantify survival, growth and fecundity of identified species when grown in saline, oil and oil brine-contaminated soils to test whether these species are candidates for restoration schemes; (3) quantify the benefits of a calcium amendment to plant and fungal growth; (4) quantify the benefits of amending arbuscular-mycorrhizal fungi to re-establishment of plant species; and (5) quantify the salinity, sodium, oil, and the structure of vegetated and unvegetated oil brine-contaminated soils to test whether plants and fungi contribute to reduction of oil and salt.

SUMMARY

It is critical that the science developed with OSRADP support is incorporated into the Oil and Gas Industry's planning and response strategies. These projects are only useful when they are implemented. We are convinced the goals and objectives of the OSRADP are compatible with industry. We must work together to see these research efforts, and others, are approved and utilized by all parties involved in an oil spill cleanup operation. On the shelf, the research initiatives are not meeting the program's applied mandate. If not approved, they will have at least been assessed. Regardless, questions will be answered. Rejection is not necessarily bad, if that rejection leads to better science. Acceptance by the regulatory community can lead to better response in the future. Therefore, expectations are kept within the context of the research, so the best efforts are used to limit an oil spill's environmental impacts.