Midpeninsula Regional Open Space District

R-16-06
Meeting 16-03
February 10, 2016

AGENDA ITEM 5

AGENDA ITEM

Sudden Oak Death-Ten-Year Update

GENERAL MANAGER'S RECOMMENDATIONS

1. Receive a presentation on the actions taken over the past ten years regarding Sudden Oak Death in the preserves and new information regarding related diseases.
2. Authorize the General Manager to pursue additional Sudden Oak Death and related research and management responses for a total amount of approximately $524,000 in the next ten years, with funding for future fiscal year expenditures to be considered for approval by the Board during the annual budget preparation process.

SUMMARY

Sudden Oak Death (SOD), a plant disease caused by the fungus-like pathogen *Phytophthora ramorum,* is responsible for killing millions of oaks and tanoaks throughout California's forests. On December 14, 2005, the Board of Directors adopted a ten-year plan at a total cost of $350,000 to address SOD on the preserves by treating specimen trees with preventative measures, mapping potentially resistant trees, and funding SOD research (R-05-122). Over the past decade, research on District preserves and other wildland areas indicates that removing bay trees from the vicinity of oak trees may protect them from SOD if undertaken early enough, however, several more years of testing this and other methods during wet years will be necessary to confirm their effectiveness. SOD research on District preserves is providing valuable information to the District and other land managers on how to slow the spread of SOD and otherwise respond to the changed conditions in California's forests. New related diseases were discovered in California's native plant nurseries last year and the effects on District preserves are being evaluated. This report provides the status of past SOD research and management actions and recommends future actions for a total amount of District funds of approximately $524,000 in the next ten years. Staff will seek matching funds and in-kind services from other agencies and researchers.

DISCUSSION

Since 2000, SOD has spread from what is believed to be its initial core in the Long Ridge, Saratoga Gap and Skyline Ridge Open Space Preserves in a northerly and easterly direction primarily as a result of weather conditions. District staff has implemented best management practices to control SOD infestations that might be caused by human activities. Per the ten-year SOD plan approved by the Board in 2005, the District's response to SOD has focused on three main areas: 1) protect individual, prominent specimen oak trees and stands of oaks from SOD through preventative treatment measures, 2) identify and support research to determine if some

tanoak trees are potentially resistant to SOD, and 3) collaborate on SOD research to help guide land management decisions. Attachment 1 provides detailed background information on this forest disease, SOD-related management actions the District has undertaken in the past decade, and recommended actions for the future.

Research results on District preserves and research otherwise partially funded by the District are providing guidelines on how to manage SOD areas to slow the spread of infestation and minimize hazardous conditions. Additionally, these research results are providing baseline information on the SOD pathogen and its host plants. However, as a cryptic forest disease, no cure to SOD has been discovered nor is one anticipated in the near future that can be quickly implemented across millions of acres of susceptible forests in California (and other states and countries). District supported research results have been published and are otherwise readily available to other park agencies on websites and through conferences and trainings due to our partnership with university researchers, forest agencies and the California Oak Mortality Task Force. The major results from the last 10 years of District and partner funded research are detailed within the report sections below.

SOD Infection of District Forests

District preserves are some of the most heavily SOD impacted areas in the state because the Santa Cruz Mountains along with Marin County are the original locations where SOD spread from infested commercial nurseries to wildland forests of California. SOD infestations have gradually spread after warm, wet springs which are the best conditions for the pathogen's spores to be blown to additional host plants in moist forests. Currently, SOD-infected trees have been confirmed by laboratory samples or probable SOD symptoms have been detected by aerial surveys and staff observations in all District preserves except Fremont Older, Loma Prieta, Pulgas Ridge, and St. Joseph's Hill. Ravenswood, Toto Ranch and Tunitas Open Space Preserves do not have SOD-susceptible vegetation. The core of the infestation continues to be in the South Skyline preserves. Overall, approximately 15,600 acres of tree mortality from SOD have been detected in 15 counties of the central California coast by the US Forest Service (USDA-FS).

Treatment of Specimen Oak Trees

The District is protecting approximately 461 oak trunks (either as individual large-sized and multi-trunked trees or collectively in forest stands) from SOD in eight preserves by two preventative measures: removal of bay trees in the vicinity of oak and tanoak trees; and annual application of a fungicide that helps oaks and tanoaks resist SOD infection if applied early enough. Drs. Ted Swiecki and Elizabeth Bernhardt of Phytosphere Research have provided professional expertise in designing research-based SOD preventative treatments, monitored the treatment methods, and are publishing and presenting their results.

SOD levels have been lower in most areas treated by bay removal compared to nearby control plots in the District preserves, but there has been no detectable level of difference in the fungicide-treated plots compared to nearby control plots. On a preliminary basis, the results of the research on these treatment methods indicates that 1) bay removal treatment may be effective, and 2) fungicide treatment may not provide enough protection for the level of effort expended. However, it will be necessary to continue the treatment methods and science-based monitoring for several wet years in order to determine if these preventative treatment methods

are effective because recent SOD disease pressure has been low due to low rainfall since 2011, delaying the spread of the disease statewide.

SOD-Resistant Trees

Tanoaks are the most susceptible host plant to SOD. Since 2006, the District has been working with USDA-FS and University of California Berkeley to conduct research on the resistance of tanoaks to the SOD pathogen. The goal is to identify individual trees that are genetically resistant to SOD to assist future replanting of heavily infested SOD forests. Acorn and leaf samples were collected from approximately 35 tanoak trees in the Santa Cruz Mountains by District staff and volunteers to assist in this study along with numerous other samples taken by others throughout California. On a preliminary basis, some tanoak saplings have shown high tolerance to SOD in both laboratory and field experiments, and tanoak genes have been identified that may be responsible for increased resistance to SOD. Additional years of testing saplings in the field, and additional genetic studies will be necessary to determine if a resistance strategy can be developed for tanoaks.

SOD Research

Most of the District-funded SOD research has occurred as an integral part of the treatment and resistance projects described above. In addition to these specific research projects, the District has also supported SOD research on District preserves in non-monetary ways, such as studying infection pathways, tanoak pollinators and mapping of infested forests. SOD research partially funded by the District and conducted on District preserves unexpectedly resulted in two major research findings in the last decade: canyon live oaks were discovered to be susceptible to SOD; and the legal pesticide label for fungicide treatment of oaks as a SOD preventative method was revised to prevent phytotoxic effects on large oak trees. As a result, the District and many other entities added canyon live oaks to their SOD management focus and changed the amount of fungicide they were injecting into oak trees.

In 2013, the USDA-FS published A Reference Manual for Managing Sudden Oak Death in California written by Drs. Swiecki and Bernhardt. SOD research on MROSD preserves provided information to produce this useful publication and one of the Ancient Oaks from Russian Ridge OSP is featured in a photograph on the cover. The manual is providing guidance to park agencies and land owners and is available on the internet at http://www.fs.fed.us/psw/publications/documents/psw_gtr242/ .

All the research conducted with District funds and on District preserves has been published and presented in professional SOD forums. There have been dozens of scientific publications and presentations which have included results from research conducted on District preserves.

By funding and otherwise supporting scientific research, we can project what changes SOD might cause in the preserves, test which management responses might most effectively protect preserve visitors and adjacent land owners, and protect and restore the natural biodiversity of some of the infected preserve forests despite the onslaught of large scale changes. The District has been one of several interest groups funding this research out of their mission to protect wildland areas. Major funds for SOD research and management have been provided by the USDA-FS, USDA Animal and Plant Health Inspection Service, California Department of Forestry and Fire Protection, California Department of Food & Agriculture, the Gordon and

Betty Moore Foundation, San Francisco Public Utilities Commission, Marin Municipal Water District, nonprofit partners of the National Parks Service, Cooperative Extension Services and California Universities in the approximate total amounts of five to twenty million dollars per year for the past 15 years.

Recommendations for Future SOD Actions

Understanding the possibility of managing a large-scale forest epidemic such as Sudden Oak Death is expected to take decades and require multiple approaches. Collaboration with scientific experts will be necessary to determine trends and the efficacy of different approaches.

Staff recommends that existing and new SOD research and management actions be funded over the next ten years as summarized below. Costs are estimates and would be augmented with matching funding or in-kind services from SOD partners.

1) SOD TREATMENT:

    a) Continued Preventative Treatments on Individual Specimen Oaks ($178,000)- Continue removal of bays and fungicide application at existing treatment sites protecting approximately 410 oak trunks in eight preserves until research results clearly determine the effectiveness of these methods during wet years. At that point a decision will be made whether to continue any of the treatment methods at these locations and whether to expand any treatment methods to other preserve locations.

    b) Preventative Treatment for Tanoak Stands ($60,500) - Identify tanoak forests in District preserves which do not currently show signs of SOD infestation and protect these with preventative measures.

    c) Bear Creek Redwoods SOD Response Plan ($40,000) - Design and implement a SOD response plan for Bear Creek Redwoods Open Space Preserve including restoration of disturbed hillsides and wildfire fuel reduction.

2) SOD-RESISTANT TANOAKS ($40,000): Support tanoak resistance studies by assessing the survival of prior study trees, collecting acorns from new study trees, and funding field experiments and genetic studies of the UC-Berkeley researchers.

3) BEST MANAGEMENT DISEASE PRACTICES ($20,000): Consistent with the District's new Integrated Pest Management Program, review District best management practices in light of new SOD research to ensure that staff, visitors, volunteers and contractors are avoiding the spread of SOD and other exotic diseases to and from the preserves.

Recommendations to Respond to New Root Disease Outbreak in Native Plant Nurseries

Additional exotic plant diseases have recently been identified in native plant nurseries in California that are caused by other non-native species of *Phytophthora*. These pathogens infect the roots and soil of nursery grown plants which then can be introduced to restoration sites through installation of infected nursery stock and can spread farther into adjacent natural areas. The long-term effect of these unintended introductions of plant diseases into developed landscapes and wildlands throughout the state are currently unknown. A wide range of native

California forest and brush plants are known to be susceptible to these root diseases and preliminary investigations have found numerous plants (including three rare species) dying at restoration sites and that the root pathogen has spread into adjacent undisturbed natural areas.

In response, the District cancelled all plant orders for one year and is working with its main nursery to provide disease-free plants for future projects. All restoration planting sites in the preserves need to be surveyed to determine if they have been contaminated and if any responses are warranted. Management of these root diseases has been added to the SOD program because they are related plant diseases that could substantially affect the health of forests on District preserves.

The General Manager recommends that the following management actions be funded to evaluate and respond to this new threat to forests on District preserves:

4) DISEASE-FREE RESTORATION PLANTS:

   a) Develop Clean Nursery Practices ($5,500) - Work with a native plant nursery to revise and test propagation practices in order to produce disease-free plants for restoration at Mt. Umunhum and other future projects.

   b) New Nursery Location ($75,000) - As necessary, investigate locations on District preserves to build a new nursery facility that can be efficiently operated in a sanitary manner.

5) INSPECT AND REMEDIATE PRIOR PLANTING SITES ($105,000): Inspect all planting sites on District preserves for root pathogens and develop a response plan as needed to cleanup or contain exotic destructive diseases.

FISCAL IMPACT

The District has spent a total of approximately $225,000 and averaged about 150 hours per year on SOD research and management over the past decade compared to the $350,000 projected ten years ago. Annual funding of SOD research was substantially reduced during the economic downturn starting in 2009. The District investment in the past ten years has been matched by approximately $390,000 of matching funds and in-kind contributions from other agencies, university researchers, and expert consultants.

The recommended future research and management actions to respond to both SOD and nursery diseases described above would cost approximately $524,000 over the next ten years. The Natural Resources Department expects to expend $20,000 in the remainder of FY2015-16 on continuing SOD research and treatment projects, an amount which is currently available in the FY2015-16 budget. Funding for future fiscal year expenditures will be reviewed and approved by the Board during the annual budget preparation process and contracts over $50,000 will be brought to the Board for approval. Staff will continue to seek matching funds and in-kind services from other agencies and researchers.

BOARD COMMITTEE REVIEW

Because of high interest of the entire Board in SOD management in previous years, this item has been brought to the entire Board.

PUBLIC NOTICE

Public notice was provided as required by the Brown Act. Additional public notices were sent to the Resource Management and Sudden Oak Death contact lists.

CEQA COMPLIANCE

The SOD research and treatment actions are included in the Final Environmental Impact Report for the Integrated Pest Management Program approved by the Board on December 10, 2014 (R-14-148). Any new activities associated with SOD or new nursery diseases will be evaluated to determine if new environmental reviews are required.

NEXT STEPS

Upon Board authorization, the General Manager will direct staff to continue existing SOD research and management measures, and will develop additional SOD research and management projects and nursery disease activities consistent with the recommendations outlined herein. Funding for future fiscal year expenditures will be considered by the Board during the annual budget approval process.

Attachment

1. Background Information on Sudden Oak Death and Past and Future Recommended Research and Management Actions

Responsible Department Head:
Kirk Lenington, Natural Resources

Prepared by:
Cindy Roessler, Senior Resource Management Specialist, Natural Resources

Midpeninsula Regional
Open Space District

Attachment 1: Background Information on Sudden Oak Death and Past and Future Recommended Research and Management Actions

This attachment provides background information on the forest pathogen Sudden Oak Death and a description of the broad range of SOD-related actions undertaken by Midpeninsula Regional Open Space District in the years 2005 to 2015 after preparing a Ten-Year SOD Plan. It also recommends future research and management actions to manage this and related forest diseases in District preserves.

Background Information on Sudden Oak Death

Sudden Oak Death was first recognized in 1995 by large-scale die-off of tanoak trees in Marin, Santa Cruz and Monterey Counties. By 2000, *Phytophthora ramorum*, a water mold introduced into California on contaminated nursery stock, was diagnosed as the pathogen causing these symptoms. Fourteen California counties along the north coast and around San Francisco Bay have confirmed SOD infestations along with one county in southern Oregon. SOD also has been found as a nonnative disease in nurseries in the US, Canada and Europe, and in European gardens, timber plantations and in a few wild European locations.

Many species of oaks become infected with SOD trunk cankers and die, whereas a few oak species are not affected (Table 1). In contrast, with California bay laurel, only the leaves become infected and SOD does not kill bay trees. Under moist warm conditions, large amounts of the pathogen's spores develop on bay leaves and blow or splash throughout the surrounding forest to infect many other types of plants common in California forests. Oak trees with trunks within five feet of bay leaves have the highest risk of SOD infection and mortality. Tanoak trees are especially susceptible to SOD with both their trunks and leaves becoming infected, and they are the tree that is most frequently dying from SOD in the preserves.

Table 1. Susceptibility of oak trees to Sudden Oak Death

OAK TREES WHICH DIE FROM SOD	OAK TREES WHICH ARE NOT SUSCEPTIBLE TO SOD
Coast live oak *Quercus agrifolia*	Valley oak *Quercus lobata*
California black oak *Quercus kelloggi*	Blue oak *Quercus douglasii*
Shreve oak *Quercus parvula* var. *shrevei*	
Interior live oak *Quercus wislizeni*	
Canyon live oak *Quercus chrysolepis*	
Tanoak *Notholithocarpus densiflorus*	

Treatment of Specimen Oak Trees

The District is protecting individual large-size oaks and stands of oaks from SOD in eight preserves (El Corte de Madera, Long Ridge, Los Trancos, Monte Bello, Rancho San Antonio, Russian Ridge, Saratoga Gap and Skyline Ridge) by two preventative measures: removal of California bay trees in the vicinity of oak and tanoak trees; and annual application of phosphite as a fungicide to the trunks of oaks and tanoaks to help them resist SOD infection if applied early enough.

Since 2007, Drs. Ted Swiecki and Elizabeth Bernhardt of Phytosphere Research have provided professional expertise in designing research-based SOD preventative treatments in District preserves. The initial research effort focused on treating stands of tanoak, Shreve oak and coast live oak in El Corte de Madera, Monte Bello, and Rancho San Antonio Open Space Preserves (OSPs) consisting of 318 total stems. (Note that researchers report their data on individual stems of multi-trunked trees.)

Research is included as part of the treatment program. Treated trees are compared to untreated trees. The bay removal and fungicide treatment methods are compared singularly and combined. Fungicide application has been tested with spray and injection methods, and several pieces of equipment have been tested for the injection method. Because of their careful observations over several years at Rancho San Antonio OSP and comparative forests on properties of the San Francisco Public Utilities Commission, Phytosphere Research determined that the concentration of the fungicide originally recommended for the injection method was harming the trees, and state regulators subsequently revised the fungicide label. As a result, land managers, private property owners and researchers throughout the state are now using lower concentrations of the phosphite fungicide when treating trees with the injection method for prevention of SOD.

In 2007, District staff, Phytosphere Research, and UC-Davis researchers were the first to discover that canyon live oaks are susceptible to SOD. These findings were published and announced at meetings to alert regulators, researchers and land managers. Subsequently, protection of specimen canyon live oaks in Los Trancos, Russian Ridge and Skyline Ridge OSPs was added to the District's SOD research program.

In 2009 and 2011, approximately 280 bay trees and numerous bay saplings were removed by the California Conservation Corps, field staff, volunteers and a contracting arborist around 78 large oak trees in Long Ridge, Los Trancos, Monte Bello, Russian Ridge, Saratoga Gap, and Skyline Ridge Open Space Preserves. Field staff and volunteers return to these sites every few years to remove any bay seedlings or resprouts on the cut bay stumps. An arborist contractor has applied fungicide on 190 stems in Los Trancos, El Corte de Madera and Rancho San Antonio OSPs on an annual basis for six years.

Because of low rainfall years, SOD disease pressure has been low for several years and this has delayed advancement of the disease and therefore treatment results in the research plots. SOD levels have been lower in most areas treated by bay removal in the District preserves, but there has been no detectable level of difference in the fungicide-treated plots compared to nearby control plots. Several wet and warm years in which the pathogen has suitable environmental conditions to reproduce and spread will be necessary to adequately test these preventative methods.

SOD-Resistant Trees

Tanoaks are the most susceptible host plant to SOD and 80 to 100 % mortality of tanoaks has been reported over time in many stands throughout California. Since 2006, the District has been working with the US Forest Service (USDA-FS) and University of California Berkeley to conduct research on the resistance of tanoaks to the SOD pathogen. The goal is to identify individual trees that are genetically resistant to SOD, and understand the genetic variation of tanoak populations to assist in future replanting of tanoaks in heavily infested SOD forests.

Staff and volunteers collected acorns and leaf samples from 35 tanoak trees throughout the Santa Cruz Mountains in 2006 and 2007 in concert with similar collections at four other locations in California and Oregon. University researchers subsequently tested samples from the collected leaves for genetic information. Leaves from 10,000 saplings sprouted from the collected acorns were inoculated with the SOD pathogen and their response was measured as an indication of resistance. In addition, 800 of the tanoak saplings were planted in a SOD-infested forest in Santa Lucia Preserve in Carmel Valley in 2008 and are being monitored for symptoms and survival over a multi-year period.

Important results of this long-term research to date include:

- Some tanoak saplings have shown high tolerance to SOD in both laboratory and field experiments, including some that germinated from acorns collected on District preserves. Additional years of testing saplings in the field will be necessary to determine their genetic resistance at all life stages and over the long term.
- A laboratory assay method has been developed that can identify tanoaks with high disease tolerance. This assay, which is currently undergoing another round of testing, takes two years to produce results on individual tanoak saplings.
- Tanoak genes have been preliminarily identified that may be responsible for increased resistance to SOD. Additional genetic studies will be necessary to determine if a resistance strategy can be further developed for tanoaks.
- Tanoaks in coastal California have similar genetic structure with some differences between populations north and south of San Francisco Bay. This similarity may make it easier to find resistant tanoaks that can be planted in many different areas throughout the state.

SOD Research

As indicated in the sections above, District staff has included research as essential elements of the preventative treatments and the search for resistant tanoaks. Funds provided by the District in the past ten years have been important in attracting academic and other professional researchers. SOD researchers have also been attracted by in-kind services provided by District biologists, field staff and volunteers; District-provided equipment and GIS mapping; and access to infested forests to conduct field experiments over multiple years. Additional SOD research which has occurred as a result of these in-kind services and did not require funding include studies on infection pathways, tanoak pollinators and mapping of infested forests.

All the research conducted with District funds and on District preserves have been published and presented in professional SOD forums. We know of dozens of scientific publications and presentations which have included results from research conducted on District preserves, often partially funded by the District.

In 2013, the US Forest Service published A Reference Manual for Managing Sudden Oak Death in California written by Drs. Swiecki and Bernhardt. The manual is providing guidance to other park agencies and land owners. SOD research on MROSD preserves provided information to produce this useful publication and one of the Ancient Oaks from Russian Ridge OSP is featured in a photograph on the cover.

Other SOD Actions in the Past Decade

District staff attends and presents at SOD science symposiums, and facilitates local trainings including sessions in the preserves to demonstrate SOD symptoms and treatment options. Informational signs are posted at preserves and staff implements best management practices to control the human spread of SOD. Boot and bike tire brushes have been installed at some trailheads.

Volunteers have collected symptomatic bay leaves in preserves as part of community-wide SOD Blitz events which map and track annual changes in infestation levels on a local level. District volunteers have also assisted researchers in monitoring insects on flowering tanoak trees to help determine how they are pollinated.

In June 2016, District staff will kick off the first day of the Sudden Oak Death Sixth Science Symposium with a field trip to Los Trancos OSP to feature SOD symptoms, research, and difficult management decisions in this busy preserve. SOD Science Symposiums are usually attended by hundreds of forest experts representing over two dozen states and over a dozen countries and is an excellent opportunity to recruit new researchers to study SOD on District preserves. Presenters at prior symposiums have frequently thanked the District for funding and otherwise supporting SOD research.

Root Disease Outbreak in Native Plant Nurseries

An outbreak of root diseases of other nonnative species of *Phytophthora* has been discovered in many California native plant nurseries in the past year including the nurseries which have supplied plants for District restoration projects over the past decade. In response, the District cancelled all plant orders for one year and is working with its main nursery, Acterra, to clean up the facilities and implement best management practices to prevent further disease outbreaks in the nursery. However, some steps are not completed yet and may not be practical in the long term at the existing facility in Palo Alto's Foothill Park. Furthermore, all restoration planting sites in the preserves need to be surveyed to determine if they have been contaminated and if remedial actions are required.

Recommendations for Future SOD and Nursery Disease Activities

Understanding and managing a novel and large-scale forest epidemic such as Sudden Oak Death is expected to take many decades and require multiple approaches. Collaboration with scientific experts will be necessary to determine trends and the efficacy of different approaches. Staff recommends that existing and new research and management actions be funded over the next ten years as summarized below.

- Continue removal of bays and fungicide application at existing treatment sites protecting approximately 410 oak trunks in eight preserves to determine which methods are most

effective. Continue researching effectiveness of these treatments for an additional five years of non-drought conditions.

- Identify tanoak populations which do not currently show signs of SOD infestation and protect these with preventative measures. Of particular note are the redwood-tanoak forests at the Galloway property of El Corte de Madera OSP.
- Support tanoak resistance studies by assessing the survival of prior study trees, collecting acorns from new study trees, and funding field experiments and genetic studies of the UC-Berkeley researchers. In 2016 and 2017, District staff, interns and volunteers should resurvey original acorn-donor tanoak trees to assess their health/survival and provide that information to the UC-Berkeley researchers. In fall 2016, District staff and volunteers should collect acorns from tanoak trees as part of the on-going UC-Berkeley research project to identify tanoak trees potentially resistant to SOD. As directed by the researchers, these surveys and acorn collection may be repeated in future years and expanded to new locations. Fund UC Berkeley in their common garden tanoak research and assessment of genetic markers that indicate genetic resistance to SOD. Along with other park agencies, the District could fund the continued monitoring of tanoak saplings planted in the Santa Lucia Reserve.
- Design and implement a SOD response plan for Bear Creek Redwoods OSP including the restoration of areas currently invaded by invasive broom shrubs with native species and wildfire fuel reduction in forests where many oaks have died from SOD. Some of these areas could be experimentally planted with potentially resistant tanoak trees. This would not be additional costs to the District since these areas were going to be restored as a result of opening the preserve and trails to the public. The research on planted tanoak trees and other techniques for restoring forests in SOD-infested areas could be guided by the USDA-FS with partial funding provided by the District.
- Work with the Acterra native plant nursery to revise and test propagation practices in order to produce disease-free plants for restoration at Mt. Umunhum and other future projects. If necessary, investigate locations on District preserves to build a new nursery facility that can be efficiently operated in a sanitary manner. A consultant will be hired to inspect all restoration sites that have been planted with susceptible plants in the last 15 years for these root pathogens and develop a response plan as needed to cleanup or contain any such diseases. Many details will need to be worked out with these nursery and restoration actions, and staff will return to the Board or committees to obtain necessary direction and funding.

COSTS

The District has spent a total of approximately $225,000 (not including staff time) on SOD research and management over the past decade compared to the $350,000 projected ten years ago. Annual funding of SOD research was substantially reduced during the economic downturn starting in 2007. The District investment in the past ten years has been matched by approximately $390,000 of matching funds and in-kind contributions, primarily by the US Forest Service.