DRAFT – do not distribute

The Incorporation of an Ecosystem Services Assessment into the Remediation of Contaminated Sites

August 2010

Prepared by

Sarah Slack
National Network for Environmental Management Studies Fellow
University of Connecticut

For

U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response Office of Superfund Remediation and Technology Innovation
Washington, D.C.
www.epa.gov
www.clu-in.org

NOTICE

This document was prepared by a National Network for Environmental Management Studies (NNEMS) grantee under a fellowship from the U.S. Environmental Protection Agency (EPA). This report was not subject to EPA peer review or technical review. The EPA makes no warranties, expressed or implied, including without limitation, warranty for completeness, accuracy, or usefulness of the information, warranties as to the merchantability, or fitness for a particular purpose. Moreover, the listing of any technology, corporation, company, person, or facility in this report does not constitute endorsement, approval, or recommendation by the EPA.

The report contains information attained from a wide variety of currently available sources, including project documents, reports, periodicals, Internet websites, and personal communication with both academically and commercially employed sources. No attempts were made to independently confirm the resources used. It has been reproduced to help provide federal agencies, states, consulting engineering firms, private industries, and technology developers with information on the current status of this project.

About the National Network for Environmental Management Studies

The NNEMS is a comprehensive fellowship program managed by the Environmental Education Division of EPA. The purpose of the NNEMS Program is to provide students with practical research opportunities and experiences.

Each participating headquarters or regional office develops and sponsors projects for student research. The projects are narrow in scope to allow the student to complete the research by working full-time during the summer or part-time during the school year. Research fellowships are available in Environmental Policy, Regulations and Law; Environmental Management and Administration; Environmental Science; Public Relations and Communications; and Computer Programming and Development.

NNEMS fellows receive a stipend determined by the student's level of education and the duration of the research project. Fellowships are offered to undergraduate and graduate students. Students must meet certain eligibility criteria.

ACKNOWLEDGEMENTS

This project was supported by a National Network of Environmental Management Studies fellowship from the U.S. Environmental Protection Agency. The author would like to acknowledge the U.S. EPA Office of Solid Waste and Emergency Response, Office of Superfund Remediation and Technology Innovation, and Carlos Pachon in the Technology Innovation and Field Services Division for supervision, guidance, and editorial review of this report. The author would also like to thank all of the remedial project managers who supplied information and support for this project, as well as the individuals who reviewed and provided feedback on the paper.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
GIS	Geographic information systems
MEA	Millennium Ecosystem Assessment
NPL	National Priorities List
PRA	Participatory Rural Appraisal
OSWER	Office of Solid Waste and Emergency Response
RCRA	Resource Conservation and Recovery Act
UST	Underground Storage Tanks

EXECUTIVE SUMMARY

Green remediation, the incorporation of techniques to reduce the environmental footprint of remediation, is a relatively new and growing practice. There are opportunities to reduce negative impacts on ecosystems which may occur from the remediation process at contaminated waste sites, as well as opportunities to reduce energy consumption and greenhouse gas emissions. This report outlines an approach to assess a site's ecosystem services, the benefits humans derive from ecosystems. Through a combination of literature research and personal correspondences, the report presents background information on the concept of ecosystem services, as well as steps interested parties can take to mitigate or avoid impacts to ecosystem services at a site level throughout the remediation process. The report also outlines replicable practices that remedial project managers can utilize when attempting to mitigate impacts on the ecosystem. Included is the current state of data collection methods, as well as issues and concerns to consider when undertaking this type of assessment. The target audience includes remedial project managers, potentially responsible parties, regulators, operators, and other stakeholders with an interest in the remediation of contaminated sites. The concept of evaluating and mitigating impacts to ecosystem services at a site level prior to and throughout the remediation process is a rather recent consideration, so the intended result of this report is to foster the production of a replicable methodology to identify & mitigate impacts to ecosystem services at contaminated sites.

1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) works to preserve and restore land by promoting protective waste management practices and by assessing and cleaning up contaminated sites. The remediation of contaminated land protects human health and the environment and enables communities and other stakeholders to pursue future use or reuse of the land and its resources for economic, environmental, and societal purposes. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) provide the legal authority for these actions. Cleanup projects are required to comply with a number of state and federal statutes as well. OSWER cleanup programs address contaminated soil, groundwater, surface water, sediments, air, and other environmental media. The cleanup programs in the United States can be broken down into seven market segments:

- National Priorities List (NPL) or Superfund
- Resource Conservation and Recovery Act Corrective Action
- Underground Storage Tanks (UST)
- Department of Defense (DOD)
- Department of Energy (DOE)
- Other federal agencies
- States and private parties (including brownfields)

These programs all include common elements such as initial site assessment, site stabilization when needed to protect against imminent threats, site characterization, remedy evaluation and selection, implementation, and when applicable, long-term management (EPA 2004).

1.1 Green Remediation

Green remediation is the practice of considering all environmental effects of remediation and incorporating changes to remedial operations to minimize the environmental footprint of cleanup actions. The remediation of contaminated waste sites is an action undertaken to protect human health and the environment, however impacts from the cleanup process need to be taken into account, such as energy use, greenhouse gas emissions, and disruptions to the water cycle. The practice of green remediation would reduce the demands placed on the environment, also known as the footprint of remediation. Green remediation involves more than merely adopting a specific technology or technique, it is a compilation of practices, which will help reduce negative impacts on the environment, therefore maximizing the net environmental benefits of cleanup. There are key opportunities for green practices to be utilized during all phases of remediation from site assessment to remedy implementation to long-term management. At each stage, as well as in the day to day management of onsite activities, there are opportunities to improve upon traditional remedial methods. However, since all sites are unique, project managers will need to take into account challenges and characteristics specific to the site and tailor their plans to achieve green remediation objectives. The EPA has identified five core elements of green remediation, which include energy, air, water, land & ecosystems, and materials & waste (EPA 2008). This report will focus on the land and ecosystems core element, which fosters ideas of land management and ecosystem protection. There is a significant collection of data on energy and air quality green remediation practices, so this report is meant to move forward the utilization of best management practices regarding ecosystem protection.

There is a growing recognition of the significance of ecosystem services, as well as the dramatic impact human activities can have on these essential services. Ecosystem services are the benefits human populations derive from ecosystems and identifying the services existing at a contaminated site prior to the remediation process is a necessary component of reducing the impacts that remediation may have. This type of assessment would provide project managers with the knowledge necessary to limit impacts on ecosystems and the services they provide from remediation and daily activities at the site. An ecosystem services assessment would also develop a baseline that would assist project managers and stakeholders in the creation of a revitalization or reuse plan. This type of assessment, as well as other green remediation strategies, can be applied to each of the cleanup market segments. In a recent publication, the Science Advisory Board highly recommended the evaluation of ecosystem services and their contributions to human well-being from the earliest stages of remediation (EPA 2009a).

The purpose of this report is to foster the development of a replicable methodology to indentify and evaluate ecosystem services prior to remedial planning and cleanup of a contaminated site. Such a methodology will provide technical guidance to project managers and other cleanup program stakeholders on approaches to identify, map and mitigate impacts to ecosystem services at a site level. The intended result is to prompt project managers to evaluate and revise their remedial operations in order to minimize remedial impacts on ecosystem services.

2. OVERVIEW OF ECOSYSTEM SERVICES

Ecosystems are dynamic, complex systems of plant, animal, and microorganism communities and the nonliving environment, interacting as functional units (Millennium 2005a). An ecosystem involves physical, chemical and biological activities that influence the flows, storage and transformation of energy and materials through the environment. Through these functions and processes, ecosystems provide services that contribute to the well-being of human populations. "Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. They maintain biodiversity and the production of ecosystem goods…(Committee 2005)."

Ecosystem services can be categorized by how human populations benefit from them. Ecosystems provide services that human populations directly consume or benefit from such as timber, water and food. These services are often the most readily identifiable and can often be managed in a sustainable manner. In addition, ecosystems provide services from which humans benefit from indirectly, also known as intermediate services. These services do not provide a direct good or opportunity to society; however they support ecological resources or maintain biological processes required by the ecosystem. Examples include services such as pollination, nutrient cycling, and climate regulation. Each ecosystem will provide a variety of both direct and indirect services. For example, a terrestrial forest ecosystem may provide services directly to human populations such as recreation through hiking trails, medicinal and genetic resources through native plant species, and raw materials from the sustainable production of lumber. In addition, it may also provide services such as climate regulation through carbon sequestration, water regulation, and the formation of soil, all from which humans benefit from indirectly.

Humans have had dramatic impacts on the provision of ecosystem services. Impacts include such things as traditional air and water pollution, global warming, pervasiveness of invasive species, and land conversions. Contaminated sites are excellent examples of the profound impacts that humans have enacted on ecosystems. It is important to realize that changes in the quantity or quality of ecosystem services will affect human populations. Considering the vital role that ecosystem services play, even small-scale changes to ecosystem services, which may occur at contaminated sites, can alter the current benefits and potential future benefits humans may derive from the regional environment. For example, if the remedy selected will require heavy vehicular traffic then there is a potential for wide scale soil compaction at the site. This compaction will reduce the soil's ability to absorb rainwater, thereby increasing runoff and soil erosion. This may result in a reduction in vegetation growth and subsequently wildlife habitat. Due to the high volume of traffic through the site, there is the potential that society may lose services such as erosion control, recreational opportunities, habitat for wildlife, aesthetics, and water regulation. Depending on the level of contamination and degradation at a site, all of these services may not be provided, however this is just an example of how one cleanup activity can have dramatic effects on a variety of ecosystem services.

However, if ecosystem services are taken into account prior to remediation, there is an opportunity that some of the site's services could be preserved and remedial impacts could be avoided or reduced. "Humans depend on ecosystem properties and on the network of interactions among organisms and within and among ecosystems for sustenance, just like all other species (Millennium 2005a)." Contaminated waste sites extend from urban to rural settings and encompass ecosystems of all kinds including forests, estuaries, rivers, wetlands, grasslands, mountain ranges, and coastal areas. These sites have the potential to provide significant services to society and their value needs to be recognized prior to remediation. This report will assist in the assessment of contaminated site's ecosystem services and outline simple practices and techniques to help project managers circumvent these preventable impacts.

2.1 Millennium Ecosystem Assessment

When undertaking an ecosystem services assessment, project managers can chose whether to follow the Millennium Ecosystem Assessment (MEA) approach to ecosystem services or the final ecosystem services approach. The United Nations' sponsored MEA program breaks ecosystem services down into four categories: provisioning, regulating, supporting and cultural services. Provisioning services are physical materials or products obtained from ecosystems. This includes things like fresh water, food derived from wild sources, and medicinal resources. Provisioning services are all services from which humans benefit from directly. Regulating and supporting services are often least recognized and appreciated by society. Regulating services are the benefits humans obtain from the regulation of ecosystem processes. Examples include waste treatment, disturbance regulation, and climate regulation. Supporting services are those functions that are necessary for the production of all other services. Supporting services include nutrient cycling, pollination, soil formation, and habitat. Lastly, cultural services are the non-material or the intangible benefits humans receive from ecosystems. This includes such things as recreational opportunities like bird watching, hiking, and eco-tourism, as well as religious, educational, and existence values (Millennium 2005a). See Table 1 for a comprehensive list of ecosystem services and their corresponding role they hold in the ecosystem.

Ecosystem Service	Ecosystem Function	Examples
Regulating Services: benefits obtained from the regulation of ecosystem processes		
Gas regulation	Regulation of atmospheric chemical composition	Ozone for UVB protection, carbon dioxide and oxygen balance
Climate regulation	Regulation of favorable climatic conditions such as temperature and precipitation at local and global levels	Greenhouse gas regulation
Disturbance regulation	The ability of ecosystems to dampen impacts from environmental fluctuations	Storm protection, flood control, drought recovery and other aspects of environmental variability mainly controlled by vegetation structure
Water regulation	Regulation of hydrological flows	Timing and magnitude of water transportation, recharge and precipitation
Biological control	Trophic-dynamic regulations of populations	Predator control of prey species, pest and disease regulation
Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of loss of soil by wind, runoff, or other removal processes, landslide prevention
Waste treatment	The storage & recycling of nutrients through dilution, assimilation and chemical re-composition	Waste treatment, pollution control, detoxification
Supporting Services: functions necessary for the production of other ecosystem services		
Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation
Pollination	Animal-assisted pollen transfer between plants, without which many plants cannot reproduce	Native bees pollinate crops
Soil formation	Soil formation and fertility processes	Weathering of rock and the accumulation of organic material
Habitat	Habitat for resident and transient populations	Nurseries, habitat for migratory species, habitats for local plant & animal species
Provisioning Services: physical materials obtained from ecosystems		
Water supply	Storage and retention of water	Provisioning of water by watersheds, surface waters and aquifers
Food production	That portion of gross primary production extractable as food	Production of fish, game, wild foods
Raw materials	That portion of gross primary production extractable as raw materials	The production of lumber, fuel, fiber
Genetic resources	Sources of unique biological materials and products	Products for materials science, genes for resistance to pathogens and crop pests
Medicinal resources	Natural biota with a variety of medicinal uses	Drugs and pharmaceuticals derived for commercial or domestic use
Cultural Services: nonmaterial services rendered from ecosystems		
Recreation	Providing opportunities for recreational activities	Eco-tourism, sport fishing, bird watching, hiking
Aesthetic	Sensory enjoyment of the environment	Open space, scenic views
Science, Education	Use of natural areas for scientific and educational enhancement	Historical sites, field laboratories and experiments
Cultural, Spiritual, Religious	Value environment due to belief system	Religious and ceremonial sites, national symbols, heritage value
Existence	Value placed on a resource knowing it exists, even if no benefits are accumulated	Preservation of species, overall biodiversity

Table 1: Ecosystems Services in MEA Format
Adapted from Millennium Ecosystem Assessment

2.2 Final Ecosystem Services

The MEA's categorization structure is helpful in understanding the numerous roles that ecosystem services play and the diversified benefits that they provide to human populations. It conveys the idea that ecosystems are socially, economically and environmentally valuable in ways that are not always intuitive. However, this report will recommend that project managers focus on final ecosystem services (with a couple of exceptions). The final ecosystem services approach is a different categorization method than the one taken by the MEA. This approach draws services from each of the four MEA categories described, but it only addresses services that are directly enjoyed, consumed, or used by society (Resources 2006). Final ecosystem services can also be thought of as the end-products of nature. Final ecosystem services which should be considered by project managers conducting ecosystem service assessments are discussed in more detail beginning in Section 2.2.1. By reducing the focus on indirect services, this approach will simplify the process and allow project managers to more readily identify ecosystem services and assess potential impacts from remedial actions. This recommendation will assist project managers, the community and other interested stakeholders in understanding the direct connection between the protection of ecosystem services and the preservation of human well being. Figure 1 represents an example of the final ecosystem services approach regarding the services that suitable soil and native vegetation provide and regulate. This is a simplified representation and does not emphasize the connections between the ecosystem services; however it clarifies the relationship between final ecosystem services and the benefits humans receive.

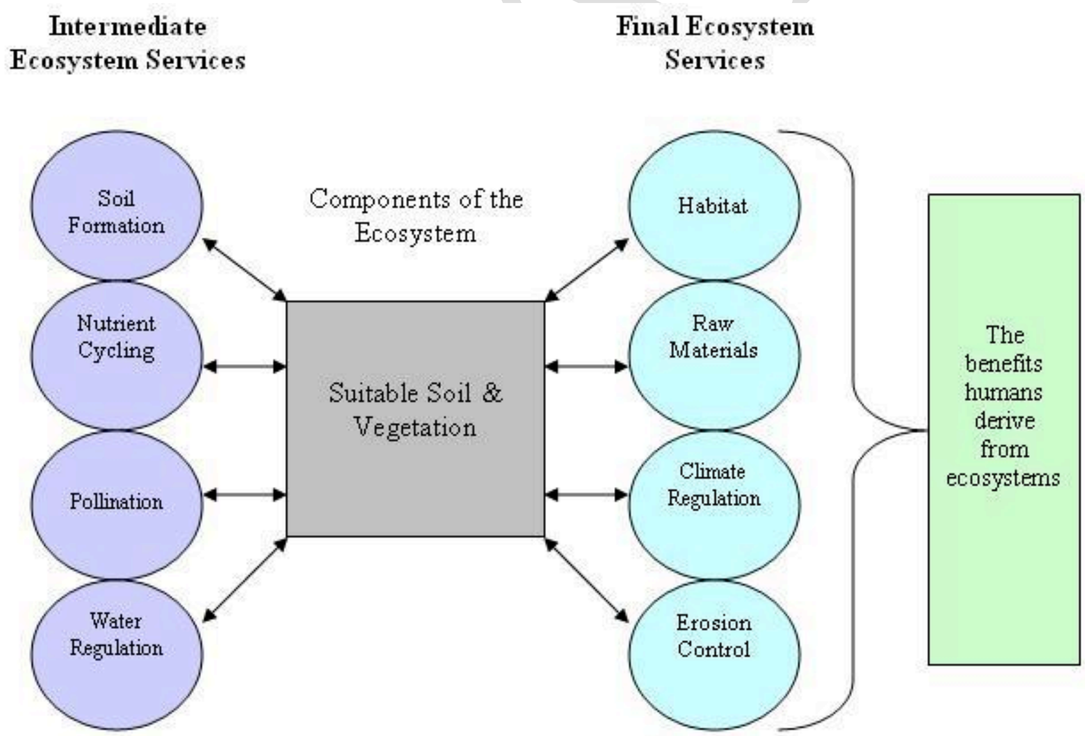

Figure 1: Final Ecosystem Services Regarding Soil & Vegetation

2.2.1 Disturbance Regulation

Ecosystems alleviate the impacts from natural events such as hurricanes, floods and droughts. For instance, coral reefs and mangrove forests act as buffers for waves and protect the coastline from storm damage. Vegetation can increase the soils absorption capacity, thereby reducing the potential for and intensity of flooding.

2.2.2 Water Supply

Water supply refers to the filtering, storage and retention of water in streams, lakes, aquifers and watersheds. Soil and vegetation assist in the filtration process and the delivery of water to groundwater sources. This service refers to the water processes which support the consumption of water by households, industry and agriculture.

2.2.3 Food Production

Food production refers to the provision of wild food sources such as fish, game, natural plants and fungi. Forms of subsistence agriculture and aquaculture have been considered by some as part of this category. This does not include food derived from cultivated land or domesticated animals. Suitable habitat for vegetation and wildlife is necessary for the provision of most wild food sources.

2.2.4 Raw Materials

Raw materials include renewable sources of materials such as lumber, fuel, and fiber. These materials come from a variety of ecosystems and support the production of private and public goods.

2.2.5 Genetic & Medicinal Resources

Genetic resources refers to the use of natural materials for scientific purposes. The use of wild genes is essential for the productivity of cultivated plant species and the continuation of critical processes such as resistance to pathogens and deadly crop diseases. Natural vegetation is also used for a variety of medicinal processes such as in the production of pharmaceuticals derived for commercial use.

2.2.6 Cultural Services

Cultural services refer to the benefits humans derive from recreation, aesthetics, scientific, and cultural experiences with nature. Humans also place an existence value on the environment or value in knowing that a resource exists such as the preservation of species.

2.3 Intermediate Services Added to the Final Ecosystem Services Approach

For the purposes of an ecosystem services assessment at a contaminated site, a certain number of intermediate services have been added to the traditional final ecosystem services approach. This has been done because project managers may have an influence over and an opportunity to identify and limit impacts to the services discussed below.

2.3.1 Climate Regulation

The climate regulation service refers to the regulation of favorable climatic conditions such as temperature and precipitation at local and global levels. Vegetation as well as surface waters such as lakes and rivers assist in the moderation of climate as they absorb and release carbon dioxide.

2.3.2 Erosion Control and Sediment Retention

Erosion control is the reduction or prevention of soil loss by wind, runoff and other removal processes. Soil retention is essential in the provision of other services such as water supply, raw materials, and disturbance and climate regulation. Suitable vegetative cover is often critical to the prevention of soil erosion because it increases soil infiltration capacity and reduces runoff.

2.3.3 Waste Treatment

Waste treatment refers to an ecosystem's ability to store and recycle organic and inorganic nutrients through dilution, assimilation and chemical re-composition. Wetlands and other aquatic ecosystems play a key role in this process, acting similarly to water purification systems.

2.3.4 Habitat

As previously mentioned, humans often value the existence of animal species. The provision of available habitat is critical for the continued existence of local and transient animal populations. This includes regular habitat areas, as well as breeding and nursery areas (de Groot 2002).

3. IMPLEMENTATION OF AN ECOSYSTEM SERVICES ASSESSMENT

In order to combat unnecessary negative impacts on ecosystems, it would be extremely beneficial to identify and evaluate ecosystem services at a site level, prior to and throughout remedial planning and remedy implementation. "In the traditional approach, the data collection for site characterization captures the degree and pattern of chemical contamination but does not collect information about the ecological condition of the site… (EPA 2009a)." As a result, replicable steps need to be constructed for remedial project managers to utilize when undertaking an assessment of a site's ecosystem services. A model assessment process is outlined below. An ecosystem services assessment includes four major steps:

- Service identification
- Site prioritization
- Impact identification
- Mitigation

The service identification and site prioritization phases should take place during site characterization or the initial stages of remedial planning. Whereas impact identification and mitigation should take place during remedy evaluation and selection. This will allow for a data collection period and upfront assessment of the site's services, which can be applied during the following decision-making processes. Figure 2 represents when the ecosystem services assessment phases would occur during a standard remediation procedure. "Identifying these (ecosystem services) up-front will enable decision makers to proactively manage any associated risk and opportunities (WRI 2008)."

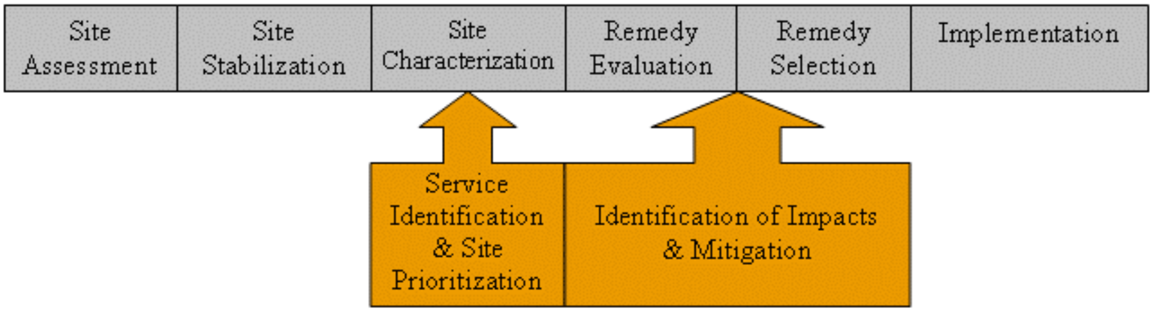

Figure 2: Ecosystem Service Assessment Placement

Evaluating the ecosystem and the services it provides prior to implementation may also present valuable insight and opportunities to project managers and the community. This information could be an invaluable tool to utilize during the creation of revitalization and reuse plans. Revitalization refers to the process of returning land from a contaminated state to one that supports a functioning and sustainable habitat. Reuse refers to the outcome of the cleanup process where measures have been implemented to create, restore, protect or enhance the site. Reuse can result in the creation of parks, playgrounds, and low-impact recreational opportunities such as hiking and bird watching (EPA 2009b). If ecosystem services are identified prior to the remediation process, project managers will be aware of and can use the existing services as a starting point in these plans.

It must be stressed that in no way should this process degrade the level of cleanup necessary to protect human health and the environment. Information collected while assessing ecosystem services should not be used to compromise the protectiveness of the cleanup. There are a multitude of opportunities for reducing negative impacts on services while maintaining a high remediation standard. For example, at the Myers Property Superfund Site, the existing ecosystem was taken into account while maintaining a necessary level of remediation. This seven acre site is located in a rural, residential area of western New Jersey and had contaminated soil, buildings and shallow groundwater. The site runs adjacent to a creek used for recreational fishing and contains a wetland area with trails for the local community. Keeping this information in mind, project managers chose to hand dig the contaminated soil and sediments out from around the roots of trees. This process allowed approximately 30 trees to remain in place throughout the wetland area (Vaughn, Stephanie). As a result, the local community continued to benefit from services such as better aesthetics, climate regulation, erosion control, and habitat for local wildlife and vegetation. Not only was this remedy protective of the site's ecosystem, it also offered the shortest remediation timeframe.

3.1 Service Identification

To partake in this type of assessment, the first step would be to identify what services the site provides. Currently, the best method to approach this would be to utilize a comprehensive list of ecosystem services. An example of this occurs on page 3, Table 1. Only a subset of the services on the overall list will apply to any one site. As a result, it will be necessary to methodically evaluate the list and ascertain which services apply. Depending on how large the site is this process may be relatively simple or intricately complex. This is why it is helpful to strictly focus on final ecosystem services. It would become difficult to assess the elaborate ecosystem components which support ecosystem services such as nutrient cycling and gas regulation. It may also be helpful to garner support from an ecologist or other applicable parties during this phase to reduce uncertainty and hasten the process.

Another way to approach the identification process would be to initially define the type of ecosystem involved. When the type of ecosystem is identified, it may help narrow down the applicable services which need to be considered. For example, a drylands or desert ecosystem will probably not provide an ecosystem service such as erosion control. When taking this type of approach, project managers should be aware that ecosystem services are site specific. So even though it would be unlikely to find sources of erosion control in a desert ecosystem, it is not impossible. This type of approach should be used as guidance only, not a comprehensive solution. It is also important to note that the site may contain different types of ecosystems. Project managers can delineate the site on those ecosystem lines and assess the areas individually. The development of a tool which would assist in the process would be extremely helpful. Table 2 is an example of what this type of tool may look like and address. It is a tool that can be used as a initial gauge for what services may be at a site and can be utilized for final and intermediate service identification, depending on the project's needs. The cultural services section of the table is listed as potentially provided by each ecosystem, since they are often determined by individual preferences.

Since this assessment is strictly dealing with contaminated sites, it is very likely that project managers will come across services which have been contaminated or degraded due to the history of the site. However, these services should still be identified and kept in consideration. There is the potential that these services could be addressed during the remediation process and their contributions to human well being can be restored.

		Marine	Coastal	Wetlands	Inland Water	Forest & Woodlands	Grasslands & Drylands	Mountain	Urban
Regulating Services	**Gas regulation**								
	Climate regulation								
	Disturbance regulation								
	Water regulation								
	Biological control								
	Erosion control								
	Waste treatment								

Supporting Services	Nutrient cycling	■	■	■	■	■			
	Pollination					■	■		■
	Soil formation					■	■	■	
	Habitat	■	■	■	■	■	■	■	
Provisioning Services	Water supply		■	■	■				
	Food production	■	■		■	■	■	■	
	Raw materials		■			■		■	
	Genetic resources			■		■			
	Medicinal resources	■		■		■		■	
Cultural Services	Recreation	■	■	■	■	■	■	■	■
	Aesthetic	■	■	■	■	■	■	■	■
	Science, education	■	■	■	■	■	■	■	■
	Cultural, Spiritual, Religious	■	■	■	■	■	■	■	■
	Existence	■	■	■	■	■	■	■	■

Table 2: Ecosystem Services Defined by Ecosystem
Adapted from *Ecosystem Services: A Guide for Decision Makers*

3.2 Setting site priorities

Since there may be a multitude of services provided by one site, it may not be possible to evaluate and mitigate remedial impacts on each service due to circumstantial constraints such as lack of time or funding. This may especially be the situation in a larger site or a site that encompasses multiple ecosystem types. If this is the case, decisions will need to be made to determine which services are priorities to preserve or reduce impacts to. This process will involve evaluating the identified services and determining if they are relevant to the remediation process or to the community. Figure 3 is a simplified representation of relationship between site priorities and services provided by the site. The site's priorities will be a subset of all the services provided by a specific site, which in turn are a subset of all possible ecosystem services. At this point, it may be beneficial to separate services that are intact from services which have been degraded from contamination. If the degraded service is being remediated during the cleanup process, then by design it is a site priority and will not need to be separately addressed during this process.

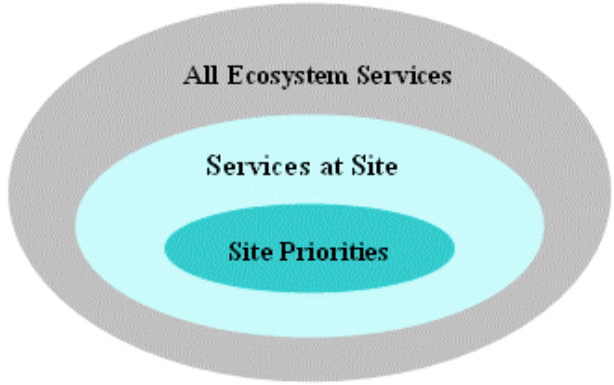

Figure 3: Service Identification & Prioritization

This is an area of the assessment process that project managers can decide how comprehensive an assessment they want to complete and how accurately they measure the condition of the site's services. There are some specific questions and conditions to consider which will be beneficial when setting site priorities. They are listed below:

- Scarcity: Is the service in short supply relative to demand? What are the quantity and the quality of the service? Would the impact push the service across a threshold that leads to a shortage in production? If a service is degraded or has low production levels naturally, then even a mild impact may result in a dramatic decrease in the service's ability to continue functioning. For example, if the site houses an endangered species, it would be necessary to mitigate impacts to any applicable habitat since there are a limited number of the species left.
- Vulnerability: How sensitive is the service to a disturbance? Is the production of the service likely to be affected in a minor or serious manner? For instance, if the site contains a grove of young trees, they may be providing services such as erosion control and habitat. However, since they are young their ability to withstand disturbance will not be as affective as a grove of mature trees, with stronger root structures.
- Substitutes: Are there any other areas or ecosystems in the region which provide the service? Are there any manmade substitutes? "A substitute for an ecosystem service could include a manufactured product or physical structure that provides a similar service (WRI)." For example, in the early 1990's New York City debated whether they should install a water filtration plant or if they should take further measures to protect the watershed from which they receive 1.3 billion gallons of drinking water per day. This may not always be the case, but NYC found it was more cost-effective to protect the ecosystem instead of constructing the manmade substitute. The World Resources Institute states that regulating and cultural services are more likely to be site specific so substitutes are not likely to be found. Whereas provisioning services such as raw materials or food production are more likely to have substitutes.
- Reversibility: If the service is impacted, will there be opportunities for the environment to naturally restore itself? Is this a service that will be addressed during the revitalization process? For example, if some of a site's vegetation is going to be removed, will this vegetation grow back? Will habitable soil and sediments remain? Or will plans be put in place that once remediation is completed, natural plant species will be replanted in a suitable

environment? For example, at the Barker Chemical Site, project managers graded and reseeded native vegetation in order to stabilize and revitalize the land, as shown in Figure 4.

Figure 4: Reseeding the Barker Chemical Site

These considerations are suggestions which may provide guidance and assist project managers in making tough decisions. Setting site priorities can be done in terms of trade-offs as well. When looking at it from this perspective, you assess what can be gained by protecting one service versus what you would lose by not protecting a different service (WRI 2008). Project managers can evaluate what sectors of the community or of the ecosystem will benefit from the provision of a service and what sectors will lose out from the decrease of another service. Again, this process may be relatively easy if there are a limited number of services provided, although this is not always the case. If these considerations have not aided the decision-making process, then project managers can move on to other tools such as community involvement and economic valuation to assist in setting site priorities.

3.2.1 Community Involvement

Ecosystem service priorities will often vary according to user. For instance, community members, local businesses and indigenous populations may all value different services that the site provides. Or they may all value the same services, but for different reasons. Depending on the level of community involvement in the remediation process, this would be an appropriate time to garner their input on what ecosystem services are significant to them. Recognition of the ecosystem services that are most valuable to the local or regional community may provide considerable insight and assist in the process of setting site priorities for ecosystem services, as well as the remedy selection and revitalization processes.

One way to garner input from the surrounding community is through small group deliberations. The basic idea is that small groups of the general public can be brought together to deliberate about the necessity of each service. So in this way project managers can not only hear what the community's priorities are, but also the reasons behind their opinions. "The purpose of deliberation is to 'reach agreement on what should be done by or on the behalf of society as a whole (Farber 2002)." This type of involvement will provide project managers with a more complete picture of the values the local populations derive from the ecosystems services.

3.2.2 Economic Valuation

Another option to assist in the prioritization of ecosystem services would be to conduct an economic valuation of the services. Market and non-market valuation methods could be utilized in an attempt to allocate quantitative values to ecosystem services. The results of this type of assessment can draw attention to the value of ecosystem services as if they were traded in markets. Economic valuation attempts to apply a monetary value to services, in order to provide a common measurement to compare them by. Some services, such as food production and raw materials are physically traded in markets, so economic valuation for these services will be more readily available. However, other services such as pollination and erosion control can be extremely difficult to valuate. Nevertheless, their valuation is equally important, if not more so since their critical role is often overlooked. There are a variety of valuation techniques available for this type of assessment; some are shown in Table 3.

Method	Background	Examples of applicable services
Benefits transfer	Uses estimations of benefits obtained from a service in one context, to estimate values of service in a different context or site.	Recreation, disturbance regulation, aesthetics, water supply
Choice modeling	A survey approach in which respondents are asked to choose their preferred option for a set of alternative scenarios.	Habitat, recreation, raw materials, biological control, climate & gas regulation, water supply
Contingent valuation	Hypothetical scenarios are posed to the public which involve some valuation of alternatives. They are responses are elicited based on their willingness to pay for each alternative scenario.	Climate & gas regulation, erosion control, disturbance regulation, existence value, water supply
Travel cost	For society to utilize a service, it may require travel. The service is valued based on society's willingness to pay to utilize the resource.	Recreation, aesthetics, medicinal & genetic resources, cultural/religious, science/education
Replacement cost	Services may be replaced by a manufactured product or physical structure. The cost to produce the manmade substitute represents the value of the service provided.	Can only be utilized when replacement options exist - water supply, waste treatment, disturbance regulation, science/educational opportunities
Avoided cost	When services are functioning properly, it allows society to avoid certain costs. The service is valued based on this cost.	Disturbance regulation, waste treatment, biological control
Factor income	Values services based on their impact and enhancement of salaries. For example, commercial fisheries will have an increased catch and therefore income when there are available services such as fish habitat and clean water.	Recreation, aesthetic, science/education, medicinal & genetic resources, raw materials, food production, water supply, habitat, pollination
Hedonic pricing	The value of a service is derived from its presence / effect on market-priced goods. For example, aesthetic values can be derived from the real estate market by comparing similar properties with and without good views.	Aesthetics, water supply, waste treatment
Conjoint evaluation	The public is asked to make choices between alternative scenarios with different attributes and prices, in order to derive the marginal value of a service instead of the total value.	Climate, water & gas regulation, disturbance regulation, habitat, pollination

Table 3: Economic Valuation Methods

Many valuation techniques are founded on the ideas of willingness to pay or willingness to accept (Farber 2002). Willingness to pay is based upon how much people are willing to spend to preserve a resource. Whereas willingness to accept is based upon how much people would need to be paid in order to accept a change in the condition of the resource. These measures may seem similar but they are usually used in different circumstances. Willingness to pay is often utilized when society does not own the resource or control access to the service. This is also used to measure increases in ecosystem quality, whereas willingness to accept is used when measuring decreases in ecosystem quality. Willingness to accept is also utilized when society does own access to the resource; however these estimates tend to be higher than data collected using the willingness to pay approach so it is not used as often.

Each of these methods has been subject to various levels of scrutiny and has their own set of strengths and weakness. In some scenarios, there may not be an applicable valuation method, however in other cases there may be multiple options. This process can help develop a more tangible representation of the contributions that ecosystems services provide to human well-being and may provide guidance in setting site priorities.

3.3 Identification of impacts

At this point in the assessment process, the site's ecosystem services have been identified and it has been determined what services are site priorities through evaluating the circumstances, community involvement, and/or economic valuation techniques. The next step for project managers will be to identify potential impacts on the selected ecosystem services. There are two types of impacts which may occur from the remediation process. The first are any impacts from the remedy implementation phase of a cleanup. An example of an impact from remedy implementation includes the removal of onsite vegetation in order to reach the contaminated media. The second are the impacts from the day to day activities that take place around the site during the cleanup process. Day to day activities include such things as heavy vehicle traffic, the use of sanitation facilities, and construction activities.

Impacts on ecosystem services are any actions that alter the quality and/or quantity of a service (WRI 2008). For instance, going back to the example of heavy vehicle use and soil compaction, if this did occur the vehicles would be causing a decrease in the area of available habitat for vegetation. This is an alteration of the quantity of a service produced. This soil compaction may also result in an increase in runoff, due to a decrease in the infiltration capacity of the soil. This runoff can carry particles of sediment and organic matter into a nearby surface water. These particles will result in decreased water quality. In this example, the use of vehicles throughout the site results in quality and quantity impacts on ecosystem services. However, this may not always be the case, an impact may only result in changes of one or the other, quality or quantity.

This example highlights another important aspect of this assessment that project managers must keep in mind. Ecosystems are complex and intricate interacting systems. One single action may have an obvious direct impact on the ecosystem; however it may also have one or more not-so-obvious indirect effects. Going back to the previous example, the direct impact of heavy site traffic is the compaction of soil. Whereas, the indirect effects are the soil erosion, runoff and potential decreases in water quality. It can be difficult to correctly identify and address indirect impacts, because the relationships between ecosystem functions can be difficult to discern. If the project manager wants to do a more in-depth assessment and evaluate the indirect impacts more completely, this might be another step in which it would be beneficial to garner the input from an ecologist.

Another thing to consider is the probability that an identified impact will occur. For instance, the further away a body of water is to a contaminated site, the lower the probability is that any action will affect the water supply. When the probability of occurrence cannot be identified or is difficult to ascertain, it is best to err on the side of caution and assume that impacts will occur.

3.3.1 Services impacting one another

As previously mentioned ecosystems are complex systems and cannot be looked at as independent, operating parts. The use or degradation of one ecosystem service may influence the availability or the functionality of other ecosystem services at the site. For example, increasing the use of raw materials, such as timber, may decrease the provision of other services such as local climate regulation and habitat. Some of the occurrences where one service is impacting the provision of another may overlap with previously discussed indirect impacts. However, this can be a different way to assess the situation and may uncover impacts that were previously missed. This can often make the identification and evaluation process even more complex. Nonetheless, this consideration is essential to completing a realistic assessment of ecosystem services.

3.3.2 Evaluation of impacts on the provision of services

The important question to ask here is what are the relationships between the identified impacts and the provision of ecosystem services? Project managers will need to determine if impacts are going to be negative, neutral or even positive. Impacts should be considered negative if they decrease the available quality or quantity of a service. A neutral impact may affect how the service is produced, but it will not affect the rate of production. For example, at the French Limited Superfund Site in Crosby, Texas, project managers reduced food supply to local animal populations of alligators and beavers in the remediation area and increased their food supply in other more suitable areas that would not be disrupted during the remediation process. In this case, the animals were affected because they were moved out of their initial habitat; however they were relocated to an area where they could find appropriate habitat and food sources. Positive impacts will also occur. Throughout the process of a remediation project, the removal of contaminated waste will result in cleaner soil, water, and/or air, which will positively impact the provision of ecosystem services. This may be another opportunity to consider revitalization and reuse plans. When positive impacts are identified during this process, then revitalization plans could be created to continue to build on these benefits.

3.4 Mitigation of Impacts

At this stage in the process, the impacts on ecosystem services have been identified and their probability of occurrence and effects on the provision of services has been assessed. Now, project managers need to identify what can be done to avoid the impacts altogether or at least mitigate their affects on the provision of services throughout the site. If there are multiple remedy options available, then project managers have the opportunity to consider the results of the ecosystem services assessment during the remedy selection process if this is a priority.

However, the focus of green remediation is not on remedy selection. The objective is to build and operate current technologies and methods in a way that limits negative impacts on the environment. As a result, if project managers are interested in mitigating impacts from remedy implementation, it will require an investigation into how they can operate necessary technologies while limiting harm to ecosystem services. This will be an on-going process, which can lead to the compilation of replicable best management practices regarding ecosystem protection. When project managers are striving to mitigate the impacts from day to day procedures around the site, this will require analysis of site activities and the identification of measures and practices which will reduce effects as well. This process will benefit from the utilization of basic practices which limit ecological damage to a site. These are discussed below.

3.5 Practices to minimize ecological damage

Various levels of an ecosystem services assessment can be completed depending on available time, funding, and expertise. If a complete assessment is not applicable or there is limited flexibility in the remedy selection, then there are a variety of actions, which can be incorporated into any site cleanup, that minimize the damage inflicted upon ecosystem services. These practices were taken from EPA's "Ecological Revitalization: Turning Contaminated Properties into Community Assets" publication and are listed below (EPA 2009b).

- Work zones & traffic plans: Designating specific areas where site traffic is and is not allowed through the utilization of a traffic plan will reduce impacts on ecosystem services, like the ones in the previously used soil compaction example. As you can see in Figure 5, project managers can even construct compacted roadways in order to facilitate transportation and reduce erosion. Plans should be made not only for onsite traffic, but also designating where site workers and equipment can and cannot be utilized. This will minimize unnecessary disruptions to sensitive areas and existing habitat.
- Minimizing excavation & retaining existing vegetation: When large scale excavations are done onsite, it can disrupt roots of trees and other vegetation, as well as uncontaminated soil and wildlife. Excavation should be minimized and the utilization of in situ technologies should be encouraged, as long as they retain the necessary level of protection.

Figure 5: Roadway at Barker Chemical Site

- Phase site work: Project managers can create remediation plans in which they phase site work. Phasing site work involves remediating one area at a time and ensuring that the area is stabilized before disrupting another. This practice can reduce erosion by allowing revegetation to occur as soon as possible. Site work can also be planned around seasons with frequent, heavy rain in order to avoid substantial erosion. Another issue to consider when

constructing site work plans are local animal populations and any sensitive periods, such as nesting or breeding for certain species.
- Location of contaminated waste & soil: During the remediation process, excess waste or soil may need to be stored prior to or after treatment onsite. These should be located away from slopes, wetlands, surface water bodies and other sensitive areas to avoid contamination from runoff. Further steps can be taken such as placing a medium between the storage piles and clean soil and/or constructing an overhang or utilizing a cover to reduce water infiltration and runoff.
- Reusing indigenous materials whenever practical: If needed, onsite materials, such as rocks, brush, felled trees and roots can be reused at the site, sometimes offering a cost savings. These materials can be used to create new habitats, reduce erosion, or added to soil amendments.
- Avoiding introducing new sources of contamination: Cleanup activities may introduce additional sources of contamination to the site if involved parties are not aware of the dangers. Sources of further contamination can come from sanitation facilities, fertilizers, pesticides, petroleum products and solid wastes. It is necessary to carefully handle and store such sources of contamination to avoid contact with the environment. Project managers should also avoid the introduction of non-native plant and animal species that can invade a site and destroy existing vegetation and populations.
- Developing and communicating ecology awareness: If project managers are taking an ecosystem services approach, then they should inform everyone involved in the site's remediation, such as contractors, construction leaders, and community involvement coordinators. If these steps are taken, it will lay out a site-wide policy standard and allow project managers to gather support and ideas from other involved parties. During this process, project managers should inform the involved parties of the actions that they will be taking such as work zone traffic plans to increase awareness and participation.

These types of practices can be used at a variety of sites to reduce impacts on ecosystem services. The Rocky Mountain Arsenal site, a 27 acre project in Colorado, is an excellent example of the utilization of minimization techniques. Site-wide traffic and work plans were put in place to reduce disruption of sensitive areas and existing habitat and minimize soil erosion and disturbance. A permit system was also created, which monitored activities ongoing at the site to assess if any activities were in conflict with each other. A bald eagle management area was located at the site so remediation and construction activities were restricted during a period of the year to avoid disrupting sensitive nesting and breeding times. Site managers adopted an awareness of the environment while planning and implementing this site cleanup, phasing the site work in 88 stages. Minimally invasive remediation techniques were also selected. Excavation occurred up to the drip line, the outer circumference of tree branches, so that existing trees could remain intact (Williams, Laura). This site was remediation in a way that minimized impacts on the natural systems existing there while keeping the standard of cleanup necessary to protect human health and the environment.

Whether project managers conduct a thorough step-by-step ecosystem services assessment or they follow applicable minimization techniques, their actions will often positively influence the remediation and redevelopment process, potentially leading to increased net environmental benefits.

4. DATA COLLECTION

Depending on the circumstances, an ecosystem services assessment can be done in a qualitative or quantitative manner. The assessment that has been laid out in this report has had a qualitative focus. The site's services and remedial impacts are identified and mitigation measures are evaluated however there is no quantitative evaluation of the services or the level of impact remedial actions may have. Quantitative evaluations can be beneficial because they provide a more detailed and accurate assessment of site conditions. It is recommended that if project managers have access to the necessary funds and time to undertake a thorough quantitative assessment that they do so. However, since ecosystem services are not the primary focus of the remediation process it may not be applicable or realistic to undertake more quantitative measures. If project managers are interested, quantitative measures can come from utilizing models, as well as laboratory and field studies. Since there will most likely be multiple ecosystem services provided by one site, project managers will need to utilize a variety of data collection techniques as various services must be assessed using different methods and scales. Other applicable sources of data include the use of indicators, remote sensing techniques, and local knowledge. Data from other assessment procedures has the potential to become a resourceful tool, as well as a way to expedite an ecosystem services assessment, see Figure 6.

Ecological risk assessments (ERA) evaluate the likelihood that adverse ecological effects will occur due to hazardous contaminants at a site. Since ERAs usually only require basic information about the site's ecosystem, they will not be particularly helpful in assessing ecosystem services. However, if generic ecosystem service endpoints (ecological entities & their characteristics) were developed, they could assist the ERA and Natural Resource Damage Assessment (NRDA) processes, as well as facilitate an ecosystem service site assessment (Munns 2009). NRDAs are not conducted on every contaminated site, however they estimate the value of lost resources due to contamination and remediation. If NRDAs are completed then there is the potential that project managers can pull data from them regarding the site's ecosystem and the services it provides. If generic endpoints were developed and employed or NRDAs were utilized for data, they could become excellent data collection tools to utilize during an assessment of ecosystem services.

Figure 6: Potential for Utilizing Assessment Data

Models are simplified representations which can simulate the dynamics of interacting plant and animal species as well as other physical and biological ecosystem processes. They can be applied at the site, regional or global level. There are models that can assess watershed and hydrology, population, climate, ecosystem processes, food webs and entire terrestrial ecosystems, which may be applicable to evaluating the ecosystem services at a site (Millennium 2005b). Models can often be particularly useful when attempting to assess services which humans benefit from indirectly such as nutrient cycling, pollination, and gas and water regulation.

Laboratory studies on ecosystems services and their responses to various impacts can be informative on response mechanisms and temporal scales. Conditions can be controlled in laboratory studies, so specific actions and associated responses can be assessed. However, since it is a controlled environment the wide range of responses and functions of an ecosystem may not be replicated. This concern is reduced when completing field observational studies from which ecologists observe ecosystem functions and processes in relation to disturbances. Although, this brings up another complication, that since there are multiple variables in place, it may be difficult to make a direct correlation between the disturbances and the ecosystem fluctuations. Laboratory studies and field studies can be excellent sources of information; however they are probably not experiments in which project managers will have the time or funding to become involved in. The principal point here is that there will likely be applicable studies already completed from which data and information can be pulled to inform project managers interested in a more detailed assessment.

Indicators are defined as "something that provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately dectectable (King 1997)." Indicators could potentially become a helpful tool when assessing ecosystems and the condition of services. Indicators take a quantifiable measurement of the environment, which represents the overall condition of the ecosystem or a specific service. For example, mean temperatures and carbon dioxide concentrations are now accepted as indicators for climate change. It is important to choose indicators which can be measured quantifiably and represent the true condition of the ecosystem service. For example, wildlife population data will be informative when identifying habitats on the site and water quality sampling will provide information on erosion control capabilities and the availability of clean water. These methods would benefit from further development and standardization; however they may be applicable to this type of assessment.

Remote sensing and geographic information systems (GIS) can also be utilized to identify ecosystem services and assess their condition. Ground-based mapping and sensing surveys can be informative for identifying biophysical characteristics of the site; although it is important to keep in mind that this type of technique will be most applicable to smaller scale sites. If a site is on the larger side, it will often times be more beneficial to utilize remote sensing techniques. This can be done by aircraft, satellite, or ship depending on the circumstances. This type of data can be utilized to assess current ecosystem condition and if done repeatedly, can be used to evaluate changes or trends in ecosystem condition over time. It may also be beneficial to combine ground-based and remote sensing data in order to aid in the interpretation of site conditions and fill any information gaps that may exist. Models can also be combined with the use of remote sensing data to assess factors that may influence ecosystem service production, such as evapotranspiration, primary productivity and species distribution (Millennium 2005b).

GIS can allow for the assessment of various data sets on the same spatial scale. For example, a map could be created to compare areas of vegetation to wildlife habitat in order to highlight which areas of a site, project managers should avoid disrupting if possible. In the past GIS has been utilized to assess humans impacts on ecosystems. It uses information on factors such as roads, land use and human population densities to assess their relation to ecosystem health. Information could potentially be pulled from these types of assessments and applied to site evaluations. GIS has been used at a site level to assess and compare data collected on contaminated ground and surface water and soils (Gustavson, Karl). Utilizing GIS for this type of application could be coupled with an assessment of the site's ecosystem and services in order to benefit the overall remediation project.

Local or indigenous knowledge and expertise regarding the existence and condition of ecosystem services may also be extremely helpful and can often times be an excellent resource. As previously mentioned, the surrounding community may provide critical insight into an ecosystem services assessment, however in this scenario they would be assisting project managers in identifying ecosystem services and providing information on the condition and history of a site, not just providing feedback on site priorities. If the community is involved in the initial identification phases of an ecosystem services assessment, it would set up a greater understanding and foster a feeling of involvement, which would be beneficial during the selection of site priorities as well. It is important to note that local knowledge should be supplemented by other sources of data, to ensure that a complete and accurate evaluation of the site is made. Another key consideration is that local and indigenous knowledge will be site-specific and may not be a valid option at all cleanup sites. There are a variety of methods to involve the community and collect data through their participation, such as town hall style meetings, surveys and Participatory Rural Appraisal (PRA). PRA can be done through interviews, mapping, measuring, analysis and planning done jointly with the local community (Millennium 2005b). This type of data collection can be informative; however it has its own set of limitations as well, which are discussed in the next section.

5. ISSUES & CONCERNS

Depending on the level of assessment, evaluating ecosystem services can be a difficult and time consuming process due to the complexity of ecosystem services and limited availability of data. Problems can arise when carrying out community involvement plans and economic valuations as well.

As previously mentioned, ecosystems are made up of complex, interweaving components. As a result, knowledge about the intricate processes and connections between various components may be limited and uncertain. There is variability in how ecosystems function, which may make it difficult to predict how remedial actions will impact the provision of ecosystem services. In addition, a number of services will be more readily identifiable compared to others. For instance, the identification of wildlife habitat will most likely be a relatively easy process compared with the identification of ecosystem components which provide services such as gas regulation and nutrient cycling. Services which are more difficult to identify include soil formation, pollination, biological control, and the previously mentioned gas regulation and nutrient cycling. However, these services are all considered to benefit human populations indirectly, so if project managers choose to follow the final ecosystem services approach, then these complexities might not concern them.

Another factor to consider is that services could be provided on varying temporal scales. Production of a certain service may take place year round, such as disturbance regulation, whereas the production of other services may be limited to a certain season, such as the production of certain raw materials or genetic resources. This complication may make it difficult to identify services if the identification phase of the assessment takes place during a service's off season. As a result, certain services could be overlooked and unintended impacts may occur. Varying temporal scales may also affect how accurately impacts are assessed. Certain services may respond to disturbances on different time scales, so it is important to assess the impacts considering the long term implications that may occur as well as any immediate effects.

Data sources and methods of assessment for ecosystem services are unevenly distributed and vary between the type of ecosystem and the service in question. When necessary information and data is hard to come by, it can be difficult to assess the services at a site uniformly. In a number of studies, certain services and ecosystems have been evaluated multiple times. For example, there have been several studies done on wetland and forest ecosystems and the benefits humans derive from them (Bridgespan 2009). In terms of specific services, most research has been done on provisioning services because those services are directly linked to the functioning of the economy. This is not the case for a long list of supporting or regulating services including soil formation and biological control. The one exception is that recently there has been an increase in research done on climate regulation due to concerns of global climate change. Without equivalent knowledge of all the ecosystem services available at a site, there is the potential for unwanted, unknown trade-offs and missed opportunities. However, as the concept of ecosystem services spreads, it is likely to drive increased research from academic and government sectors, alleviating this concern.

Community involvement and economic valuation can be extremely helpful tools; however both come with their own set of limitations. Issues regarding community participation may stem from a lack of background knowledge on the concept of ecosystem services. When tapping into the local community to garner their input, it is critical that time is taken to explain exactly what ecosystem services are. If the involved individuals have skewed perceptions of ecosystems and their importance, it may result in slanted opinions and priorities. This is why it is essential for project managers to follow up on any information provided by the local community that they plan to utilize while assessing ecosystem services. Information collected during a community involvement initiative may also reflect people's own priorities rather than the actual condition of the site. So it is important that community involvement is carefully planned and implemented to avoid bias.

There are concerns over the use of market and non-market economic valuation techniques as well. Valuation techniques that utilize market data for services such as raw materials like timber usually do not represent the total value of that service. The market price represents the trees utilization as timber; it does not represent the other services that the tree provides such as erosion control and habitat. Market data can also be affected when the government controls or raises the price of certain goods, changing their market value. In this case, the service's value should be calculated based off of its initial, actual value, not the altered market one. Several of the non-market valuation techniques involve surveying the community to derive the value they place on a service. If one of these methods is chosen, it will call for a conversation with the community on the concept of ecosystem services, as previously mentioned is required. These methods can also be plagued by bias if not carefully compiled and applied. Due to these issues and concerns, there may be a certain level of uncertainty as ecosystem services assessments are carried out. However, in the future this may become a standardized practice and these types of uncertainties and issues will be resolved.

6. CONCLUSIONS

The idea of including an ecosystem services assessment into the remediation process at contaminated sites is a relatively new concept. The sites mentioned in this report such as the Rocky Mountain Arsenal and Myers Property Superfund site have not completed an ecosystem services assessment such as the one described here. However they have taken steps to alleviate impacts on the ecosystems and essential services that they provide. It is critical that project managers continue remediation projects with ecosystem services in mind. A series of pilot projects containing an ecosystem services assessment will also assist in the development of a standardized approach and facilitate the necessary data gathering and research on the intricate functions of ecosystem services. Further research needs to be done on ecosystem dynamics and feedbacks to reduce the uncertainty of this type of assessment, specifically when identifying potential impacts and their effects on the provision of ecosystem services. This process has the potential to facilitate the use of existing conditions as a baseline for revitalization and reuse plans. In addition, OSWER could potentially utilize results from ecosystem service assessments from across the nation to monitor and record the environmental benefits that accumulate from remediation and revitalization of the nation's contaminated waste sites. It is important to keep in mind that once remediated every site has the potential to provide increased benefits to society. A recent study on biodiversity and ecosystem services found that ecological restoration increased the provision of ecosystem services by 25% (Benayas 2009). At times contaminated sites are seen as problems, but they are also opportunities to increase ecological benefits for society.