A Benefit Transfer Approach to the Estimation of Agro-Ecosystems Services Benefits: A Case Study of Kern County, California

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1. Introduction

Agro-ecosystem functions support not only the production of food and fiber but a variety of non-market goods and services that are socially valuable. Examples of those non-market goods and services include aesthetic experiences, wildlife habitat, carbon sequestration, and recreation to name a few. There is a growing awareness of the importance that provision of these non-market goods and services has to the long-run sustainability of agriculture in general and California agriculture in particular. This awareness has led to an increasing interest in the estimation of the economic value of agro-ecosystem functions non-market goods and services. This increased awareness can be seen by the growing body of work dealing with economic valuation of these non-market services and the contribution of various agricultural practices to the provision of those services (Dale, Sandu, Goldman, Baumberger)

The purpose of this paper is to demonstrate the use of benefit transfer as methodology for measuring baseline and marginal value (loss) estimates of agro-ecosystem non-market goods and services. The benefit transfer methodology is used to estimate the agro-ecosystem non-market goods and services values in Kern County, California. We conclude by suggesting that some estimate of the value of the non-market good and services provided by agro-ecosystem functions is important to the determination of either public policy prescriptions or market-based incentive programs that have as their objective maintaining or increasing those agro-ecosystem function non-market goods and services.

The paper begins with an introduction to ecosystem functions and services. This is followed by development of an agro-ecosystem economic valuation framework that is used to aid in the discussion of the importance of estimating agro-ecosystem non-markets goods and services baseline and marginal values. That section is followed by a review of ecosystems services economic valuation methodologies. A case is made for the use of benefit transfer as an appropriate agro-ecosystem non-market goods and services valuation methodology. The forth section presents the results of utilizing benefit transfer methodology to estimate the agro-ecosystem services values in Kern County. The final section provides a summary.

Ecosystem Functions and Services

An ecological system or ecosystem is any area of nature that includes living organisms and non-living substances that interact to produce an exchange of materials between the living and non-living parts (Odum). Like all systems, they are a combination of interacting, interrelated parts that form a unitary whole.

Economic theory identifies four kinds of capital: human, financial, manufactured and natural. Developed economies have focused primarily on using the first three (which were considered limiting factors to development) to transform natural capital (which was considered ‘free’ and abundant) into consumer products and services (Hawken et al., 1999). Ecosystem services are the equivalent of 'natural capital'. The concept of ecosystem services refers to the set of ecosystem functions that are useful to humans (Kremen). It encompasses the delivery, provision, production, protection or maintenance of a set of goods and services that people perceive to be important (Chee). These services impart to society a variety of benefits, many of which are critical to the survival of the society (Kremen). The list of services is long, and includes benefits such as the purification of our water by forest ecosystems, control of flooding by wetland ecosystems, crop pollination, and aesthetic and cultural benefits (Daily, 1997).

Ecosystem services can be defined in myriad ways dependant on scale and perspective (Daily, 1997). One widely used classification of ecosystem functions and a description of the service provided by those functions has been developed by De Groot, et al (2002) Table 1 shows that classification[1].

Table 1: A Classification of Ecosystem Functions

Ecosystem Functions	Description
1. *Regulation functions*	This group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. In addition to maintaining ecosystem (and biosphere) health, these regulation functions provide many services that have direct and indirect benefits to humans (such as clean air, water and soil, and biological control services). Natural ecosystems play an essential role in the regulation and maintenance of ecological processes and life support systems on earth.
2. *Habitat functions*	Natural ecosystems provide refuge and reproduction habitat to wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes.
3. *Production functions*	Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass. This broad diversity in carbohydrate structures provides many ecosystem goods for human consumption, ranging from food and raw materials to energy resources and genetic material.
4. *Information functions*	Because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.

Agro-ecosystem functions can encompass the definition of all the ecosystems functions discussed in table 1 and would provide many of the services that those individual functions provide. It is relatively straight-forward to measure and value the goods and services provided by the production function component of agro-ecosystem functions. It is less straight-forward to measure and value the goods and services provided by the regulatory, habitat, and information functions since they don't have easily observable market prices. However, not valuing those social goods and services provided by agro-

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[1] It should be noted that while the ecosystems functions are classified and discussed as individual functions that these biophysical functions are interrelated with each other and thus to some extend the good and services they generate are interrelated.

ecosystem functions can result in significant undervaluation of the true contribution that agricultural production makes to society. This is especially true in California where a number of economic and social pressures are being exerted on agricultural land use decisions that affect the long-run sustainability and competitiveness of the California agriculture sector. The economic valuation of California agro-ecosystem function social goods and services value is critical to effectively managing California agricultural lands as public policy officials make policy decision that affect those lands.

III. Agro-Ecosystem Goods and Services Valuation Framework[2].

A major issue in the estimation of agro-ecosystem services values is the complexity and interrelationship between those functions and human-decision-making Antle and Capalbo (2002) argue that agro-ecosystems can be represented by loosely or closely coupled ecosystem and economic models. Their hypothesis is that "agriculture is best understood by representing it as a complex, dynamic system with spatially varying inputs and outputs which are the result of interrelated physical and biological processes and human decision making processes." That is, as the authors note "agriculture is a managed ecosystem because is encompasses ecological processes, i.e. processes governing the relationship between organisms and their environment."

This concept that agro-ecosystem can be represented as loosely or closely couple ecosystem and economic models leads to three basic research questions: (1) the relationship between agro-ecosystem functions and production of agro-ecosystem services, (2) techniques for measuring and valuation of agro-ecosystem services, and (3) design of effective policies and incentives for the maintenance and increased supply of those services (Swinton, et al, 2006)

The above questions provide the context in which a complete study of the agro-ecosystems services and their values should be viewed. Such a study would require an interdisciplinary modeling approach that would attempt to capture the interrelated complexities and dynamics associated with agro-ecosystems. Such a modeling approach is beyond the scope of this study. However, an attempt will be made to provide a framework from which a discussion of economic valuation of agro-ecosystems values can occur. The intent is to construct a framework that can be used to discuss economic valuation issues associated with the flow of agro-ecosystem services over time.

The basic units of the economic valuation framework are:

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[2] Although more accurately production function services are part of the agro-ecosystem goods and services produced by agro-ecosystem functions for brevity we will refer to the non-market goods and services provided by agro-ecosystems functions as agro-ecosystem services in the remainder of the paper.

z Defined as a set of agro-ecosystem functions; and

x a set of economic and social variables.

$V_t^i(z,x)$. Is the value of the agro-ecosystems services at time t for agro-ecosystem service i. The value of agro-ecosystem service i is dependent on the existence and quality of agro-ecosystem functions (z) that provide the agro-ecosystem goods and serviceservice and economic and social variables (x). The value of agro-ecosystem service will change as the agro-ecosystem functions change and/or economic and social variables change.

$$\sum_{t=1}^{i} V_i(z_1, x_1) \qquad (1)$$

Is the total value of agro-ecosystem services at some initial time period t for a specific site, area, or region given agro-ecosystem functions z_t and economic and social variables x_t. This is the agro-ecosystem services baseline value for a specific site, area, or region,

$$\sum_{t+n}^{i} V_i(z_{t+n}, x_{t+n}) \qquad (2)$$

Is the total value of agro-ecosystem services at some future period t + n (n = 1, m) for a specific site, area, or region given agro-ecosystem functions z_{t+n} and economic and social variables x_{t+n}.

$$\sum_{t+n}^{i} I_i(z_{t+n}, x_{t+n}) \qquad (3)$$

Is the marginal value gain due to improvement in agro-ecosystem services in some time period t + n (n = 1, m) at a specific site, area or region. The improvement can be due to newly created agro-ecosystem services, restored agro-ecosystem services, or enhanced agro-ecosystem services and/or changes in economic and social variables.

$$\sum_{t+n}^{i} D_i(z_{t+n}, x_{t+n}) \qquad (4)$$

Is the marginal value loss due to degraded or lost agro-ecosystem services at any future time period t + n (n = 1, m) for a specific site, area or region. The degradation or loss in agro-ecosystem services can be due to natural disaster such as flood, drought, fire, biological factors such as invasive pests, conversion of the agricultural lands to alternative uses, and/or changes in economic and social variables.

The agro-ecosystem services value framework for a specific site, area, or region can be written as:

$$\sum_{t+n}^{i} V_i(u_{t+n}, x_{t+n}) = \sum_{t=1}^{i} V_i(u_1, x_1) + \sum_{t+n}^{i} I_i(z_{t+n}, x_{t+n}) - \sum_{t+n}^{i} D_i(z_{t+n}, x_{t+n}) \qquad (5)$$

Equation 5 states that the sum of a specific site, area, or regions agro-ecosystem services value at some future time period is the sum of the baseline agro-ecosystem values plus the sum of the marginal value gain of improved agro-ecosystem services less the marginal value loss of degraded or lost agro-ecosystem services.

The framework described above contains two states. The first is the baseline value of currently provided agro-ecosystem services values which is a function of existing agro-ecosystem functions and economic and social variables. The second is the future value of agro-ecosystem services which can identical to the baseline value or have increased or decreased in value as changes in the agro-ecosystem function or the economic and social variables occur.

The following example attempts to illustrate how the two states are related. Suppose agricultural producers in a specific region change their agricultural production technologies resulting in a change in the agro-ecosystem biophysical functions that affect air quality and a change in those functions result in a reduction of air pollution thereby increasing visibility (esthetic value) and a reducing air pollution related public health costs. The exact measure of social value of the improvement in air quality can be difficult to measure but it is at least partly dependent on a set of economic and social factors among which are the number and proximity of individuals who benefit from the region’s improved air quality.

The example above allows for some examination of the agro-ecosystem services valuation issues. First, knowledge of the baseline agro-ecosystem services values is important. It is difficult to access whether there has been an improvement or loss of agro-ecosystem value if one doesn’t have a starting value. For example, conversion of agricultural land to residential housing could entail the loss of agro-ecosystem services.

That loss should be compared to the economic gain that would be attained by increased availability of residential housing. This necessitates knowledge of the baseline agro-ecosystem services value of maintaining the land in agricultural production and the consequent loss in agro-ecosystem service if the land is converted. If the loss in agricultural production value plus agro-ecosystem services value is determined to be greater than the economic gain from more residential housing than policy instruments should be used or devised to maintain the land in agricultural production.

Second, the magnitude of the marginal value gain or marginal value lost provides some gauge as to whether it is appropriate to implement public policy actions that would provide incentives or penalties that would cause human decision making actions that would result in either an increase in agro-ecosystem services value or reduce loss in agro-ecosystem services value[3]. For example, Antle (2006) argues that an efficient agricultural policy could be implemented using a mechanism he call "payments for ecosystem services," or PES. He defines a PES system as one that rewards farms for increasing the quantity of ecosystem services they supply above and beyond the amount that would have been provided without such rewards. Note that the PES implicitly assumes knowledge of the baseline ecosystems services value and the marginal gain for supplying additional agro-ecosystem services.

Marginal analysis is fundamental to agro-ecosystem valuation because it examines the way in which a service's benefits vary with the aggregate level of the service available. This is not to say that marginal analysis is easy to do, particularly when complex biological and economic relationships are involved. Nevertheless, it provides a necessary discipline to the valuation process.

III. A Review of Ecosystem Services Economic Valuation Methodologies

Ecosystem services are typically not traded in markets and therefore do not carry an explicit market value. Costanza et al.'s (1997) in their seminal paper call attention to the fact that due to the public nature, ecosystem services are inadequately quantified and often given too little weight in policy decisions. Evaluating the actual value associated with ecosystems is a complex undertaking. Farber et al, (2002) define ecosystem valuation as the process of expressing a value for ecosystem goods and services to facilitate scientific observation and measurement.

Valuation has been described as trying to find an integrative metric, one that can indisputably link ecosystem services to human welfare (Pattanyak). Proponents of ecosystem service valuation believe that valuations can: (i) improve understanding of problems and trade-offs, by estimating the relative importance of various ecosystems; (ii) to justify or evaluate decisions in particular places; (iii) identify and illustrate the distribution of benefits and thus facilitate cost-sharing for management initiatives and (iv) spur the creation of innovative institutional and market instruments that promote sustainable ecosystem management (Chee, Pagiola et al. 2004).

Literature attributes four value types to ecosystem services: direct use values, indirect use values, option values and non-use values. Direct use values arise from human direct utilization of ecosystems such as, through the sale or consumption of a piece of fruit. All production services and some cultural services have direct use value. Indirect use values stem from the indirect utilization of ecosystems, and reflect the type of benefits that regulation services provide to society, such as pollination. Because people are unsure about their future demand for a service, they are willing to pay to keep open the option of

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[3] The policy action can take the form of government regulation (e.g. land preservation policies, zoning) or compensation policies. Both impact human-decision making and consequently impact on agro-economic services and values. Kuminoff(2006) discusses the currently regulatory environment that is in place to achieve agro-ecosystem environmental goals and suggests possible changes to Farm Bill conservation programs to achieve those goals more efficiently.

using a resource in the future—insofar as they are, to some extent, risk averse. Option values may be attributed to all services supplied by an ecosystem.

Various authors also distinguish quasi-option value, which represents the value of avoiding irreversible decisions until new information reveals whether certain ecosystems have values we are not currently aware of. Although theoretically correct, the quasi-option value is in practice very difficult to assess. Non-use values are derived from attributes inherent to the ecosystem itself. Three types of non-use value are recognized: existence value (based on utility derived from knowing that something exists), altruistic value (based on utility derived from knowing that somebody else benefits) and bequest value (based on utility gained from future improvements in the well-being of one's descendants).

Though difficult to separate, both conceptually and empirically these different categories, they help to recognize the fact that there are different motives to attach non-use value to an ecosystem service; these motives depend upon the moral, aesthetic and other cultural perspectives of the stakeholders involved. In principle, the four value types are exclusive and may be added. The sum of the direct use, indirect use and option values equals the total use value of the system; the sum of the use value and the non-use value is the total value of the ecosystem (Hein). If the value of those services can be revealed and expressed in a common metric (such as monetary estimates) then that metric can be used to evaluate and rank the value of different ecosystems (Boyd & Wainger). By quantifying the contributions of ecosystem services to human welfare, ecosystem valuation has become a valuable tool in public policy (Carson&Bergstrom**).**

Estimates of the monetary of ecosystem goods and services can be obtained by either of the following two approaches. One approach consists of pricing them according to their provision costs, through cost-side based methods, such as replacement cost, restoration cost, and relocation cost and government payments. However, the monetary estimates created by these methods do not give information about individual demand regarding the goods and services available. To know the economic value that consumers assign to non-marketed goods, demand-side valuation methods are needed. These methods generate estimates of the willingness to pay or the consumer surplus related to a change in the provision level of a given non-marketed good, based on two alternative approaches: the revealed preference methods and the stated preference methods (Madureira et al). Table 2 summarizes the methods for cost-side based and demand-side valuation approaches used in the ecosystem valuation literature.

Table 2: Approaches and Methods for Environmental Economic Valuation

Valuation Approach	Valuation Methods	Description
Cost-side	Replacement cost	Costs of replacing environmental assets and related goods and services (e.g. replace soil fertility due to soil contamination)
	Restoration cost	Costs of restoring environmental assets and related goods and services (e.g. restore soil fertility through soil decontamination)
	Relocation cost	Costs of relocating environmental assets and related goods and services (e.g. moving existing habitats to alternative sites)
	Government payments	Government payments for the provision of environmental goods and services (e.g. agri-environmental measures)
Demand-side Revealed preference Methods	Travel cost method (TCM)	Estimates the demand for a recreational site using travels costs as a proxy to the individual price for visiting the site
	Hedonic Price Method (HPM)	Estimates the implicit price for environmental attributes through the individuals choices for market goods which incorporate such attributes (e.g. estimate implicit price for air quality in the price of a house)
	Averting Behavior (AB)	Estimates the monetary value for an environmental good or service observing the costs individuals incur to avoid its loss (e.g. buying water filters to assure safe drinking water)
Demand-side Stated Preference Methods	Contingent Valuation (CVM)	Hypothetical markets are constructed to allow individuals to state their willingness to pay for changes in the quantity or quality of environmental goods and services
	Conjoint Analysis	Hypothetical markets are constructed to allow individuals to state their preferences for attributes entangled in goods or services present to them
	Choice Experiments	Hypothetical markets are constructed to allow individuals to choose their most preferred option from a set with more than two choice options, defined as attribute bundles where the price is included
	Contingent Ranking	Hypothetical markets are constructed to allow individuals to rank alternative options from a set with more than two alternatives, defined as attribute bundles where the price is included
	Contingent Rating	Hypothetical markets are constructed to allow individuals to rate alternative options using a rating scale; the alternatives defined as attribute bundles where the price is included

Source: Madureira *et al.*

Despite the relevancy of ecosystem evaluation, as Pattanayak and Butry (2005) and Pagiola et al. (2004) indicate there is a need for more eco-valuation studies. The existing empirical literature on this topic is thin and shallow, limited to a countable few studies for each type of ecosystem or service. Economic valuation methods through primary research methods presented in Table 2 are a desirable approach to ecosystem evaluation, because the econometric tools employed are objective and have been extensively tested, criticized, and improved over a period of decades (Boyd and Wainger, 2003).

Unfortunately, the application of these methods is costly in terms time and financial resources. One way to harness the benefits of primary research, while minimizing the use of resources is to rely on the benefit transfer method.

Benefit transfer is a formal process whereby the stock of knowledge, rather than original research, is used to inform decisions (Loomis). Benefit transfer method uses economic information from one place and time to make inferences about the economic value of environmental goods and services at another place and time (Wilson and Hoen, 2006). According to Rosenberger and Loomis (2000) the benefit transfer approach is the application of values and other information from a ‘study’ site where data are collected to a ‘policy’ site with little or no data. The site with data is typically called the “study” site, while the site to which data are transferred is called the “policy” site. The estimated value of a non-market resource is not known with certainty, even if it was obtained from a carefully performed original study.

Benefit transfers serve as indicators of the likely magnitude of this value (Loomis). In practice, four benefit transfer approaches have been developed. They are: (1) benefit estimate transfer, (2) benefit function transfer, (3) meta-analysis, and (4) preference calibration. Benefit estimate transfer obtains a benefit estimate from one study and applies the estimate directly to the policy site. Benefit function, which uses only one study, and meta-analysis, which uses multiple studies, employ statistical models from existing studies while using policy information to control differences between the study site and the policy site (Voorthui).

Necessary conditions of the benefit transfer method to be valid are that: (a) the primary valuation from the study site is carried out properly, (b) the goods and services considered are similar at both locations, (c) the locations have similar populations, and (d) the hypothetical markets are the same at each location (Desvousges et al., 1992).

Benefit transfer took form as a separate method once the non-market valuation literature grew large enough to allow comprehensive synthesis and cross-study comparisons. In the last two decades environmental benefit transfer has matured into a viable approach for estimating the value of environmental goods and services. The method ultimately remains dependent on the quality of original benefit estimation (W&H, 2006). Benefit transfer is a growth area of environmental economics research, which has been, and is being, encouraged by the demands of policy makers and natural resource managers for estimates of nonmarket environmental values in a world of scarce time and limited research budgets. Benefit transfer applications have been used more and more frequently in the last decade (Colombo et al., 2006). Despite the recognized limitations of benefits transfer, the technique is widely used in the United States by government agencies to facilitate benefit-cost analysis of public policies and projects affecting natural resources such as water, forest and rangeland, etc[4].

Ecosystem services are supplied at various spatial scales, and this characteristic has a direct effect on the value placed by society. Many of these services are best thought of as differentiated goods with important place-based quality differences. Ecosystem services' scarcity, substitutes, and complements likewise are spatially differentiated. This property is important to their economic measurement. This means that the benefit of the service is spatially explicit. If the benefit is to be measured and is spatially explicit, the service's units must be spatially explicit (Boyd and Banzhaf). (There are exceptions to such requirement, for example carbon sequestration service does not require spatially explicit assessment as the value of the carbon storage does not depend upon where it is sequestered). To this end, Geographical Information Systems (GIS) techniques have offered great possibilities for incorporating the spatial dimension into applied studies.

This new avenue enhances the ability of economists to successfully incorporate the complexity of the environment within their empirical analyses. Bateman *et al* examine the contribution that GIS may provide in incorporating the complexities of the spatial dimension within analyses undertaken by environmental and resource economists. Lately, a continuous stream of economic valuation analysis has been enhanced by using GIS data and technology (see Lant et al, Bateman et al, Bastich, Ready and Abdalla, 2005; Troy and Wilson,2006; Boyd and Waigner, 2003; Boyd and Banzhaf, 2007; Sandhu,).

IV. Economic Valuation of Agro-Ecosystem Services in Kern County, California

The site selected for this analysis is Kern County, California. This county was selected due to its geographic diversity and available data sources. Kern County is located in the southern Central Valley of California. Kern County encompasses an area of about 8,171 square miles or 5,229,440 acres, making it the third-largest county in terms of area in California. The county is well-endowed with mineral resources and fertile land. Agriculture is the County's most significant economic activity.

Kern County now has a population approaching 800,000 and is expected to have an increase in population growth over the next 20 years. This increase in population is expected to exert pressure to convert agricultural land to housing, industrial, and commercial uses. Thus, it is increasingly important to determine the value of the agro-ecosystem services provided by agricultural land, in order to determine appropriate use policies. If this is not done, then it is possible that a significant yet, currently unaccountable and non-quantified portion of the total economic value of Kern County agricultural land base will not be considered in land use planning.

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[4] See Bergstrom and DeCivita for a comprehensive list of benefits transfer applications by government agencies in the United States and Canada.

The benefit transfer method that is being used in this study starts with the GIS mapping of 13 land cover types. The data on the land categories used in this study were obtained from California Spatial Information Library (Casil),; ; ;;; ;.

Table 3 present data on the 13 land categories and acreage in Kern County as determined by the GIS analysis[5].

Table 3: Land Cover Typology for Kern County, California

GIS CODE	Land Type	Area (Acres)
AGR	*Agriculture*	1,209,465
CON	*Forest-Conifer*	176,688
DSHB	*Desert Shrub*	1,338,701
DWLD	*Desert Woodland*	7,141
FWET	*Fresh wetland*	52,265
HDW	*Hardwood oak woodland*	334,417
HEB	*Herbaceous*	1,254,210
MIX	Mixed hardwood, conifer	61,936
RIPF	*Riparian Forest*	151,051
SHRB	*Shrubs*	381,174
URB	*Urban and Barren*	218,278
URBG	*Urban Green*	94,143
WAT	*Open Fresh Water*	41,729

Equation 6 is the agro-ecosystems services valuation function. The total ecosystem service value of a given cover type is calculated by adding up the individual, non-substitutable ecosystem service values associated with that cover type and multiplying by area as follows:

$$TV(ESS) = \sum_{i=1}^{13} A(LCT_i) * V(LCT_{k,i}) \qquad (6)$$

Where: $TV(ESS)$ represents the total value provided by ecosystem services of the entire area, $A(LCT_i)$ denotes the area of a specific land cover type, and $i = 1...13$ as there are 13 land cover types present in the study area, and $V(LCT_{k,i})$ represents the annual value per unit for ecosystem service type k, associated with land cover type $i.$, and $k = 1...13$, representing 13 ecosystem services considered.

We use data from a benefit transfer valuation study of ecosystem services in three California counties to determine the $V(LCT_{k,i})$. The study by Troy and Wilson (2006) and TSS Consulting (2005) report estimate the benefits from the ecosystem services for three counties namely, Napa, Humboldt and San Bernardino, in California. Based on

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[5] Appendix A describes the GIS process used to provide the land type covers necessary to estimate the ecosystem services value associated with each.

preexisting studies published in peer reviewed journals, focused on temperate regions in either, North America, Canada or Europe and dealing with non-consumptive uses of natural resources, they provide a set of unique standardized ecosystem service value coefficients broken down by land cover class and service type. The counties included in Troy and Wilson (2006) studies were selected based on the rich landscape heterogeneity that allowed transferability of results to other parts of the state. Namely, these counties' land cover types are sufficiently representative of most of California's major biomes to allow for the transfer of ecosystem service values by land cover type.

These value estimates are based on data combined through a compilation of two literature reviews conducted in the Web of Science and other databases. This compilation generated 84 useful studies with a total of 205 individual point estimates for reviewed land cover types. However, the available literature still lacks studies and estimates for certain functions and services provided by ecosystems, therefore the values reported associated with specific land covers will tend to underestimate the real value of the services.

An additional literature search of ecosystem valuation studies was conducted by the authors of this study. The focus of this additional literature search was the identification of the recent additions in the ecosystem valuation literature (specifically, studies published since year 2005), with the intent of merging the new results with those reported in Troy and Wilson (2006). This would have enhanced the accuracy of the value estimates, by filling in the gaps in the existing value estimates found by Troy and Wilson (2006) and would have enriched the dataset with most up-to-date estimates. A thorough review of the environmental databases of EVRI and ESV however, produced no new estimates.

A possible explanation for this might be that many original valuation studies are not designed for application purpose in the comparative framework that is inherent to the value transfer method, making the identification and recovery of suitable empirical studies for transfer difficult. In fact, in many cases valuation estimates are generated as a by-product of efforts to clarify research methods (McConnell, 1992). This has resulted in a somewhat paradoxical situation in the peer-reviewed economic valuation literature that when a methodology is well understood and achieves reasonably high levels of professional acceptance, the attention of editors and readers shifts to new issues. As a result, peer-reviewed publications often serve merely as a vehicle for illustrating the most recent valuation method (Costanza et al, 2006).

Table 4 reports on the available estimates from the literature for each land cover type and ecosystem service. The data reported in white cells show that 205 individual ecosystem value estimates were able to be obtained from the peer-reviewed empirical valuation literature for the land cover types included in this study. Areas shaded in grey represent cells where a service is anticipated to be provided by a land cover type, but for which there is currently no empirical research available.

Table 4: Gap of Estimates Matrix

ESS\LAND COVER TYPE	AGR	CON	DSHB	DWLD	FWET	HDW	HEB	MIX	RIPF	SHRB	URB	URBG	WAT
Gas & Climate Regulation		1				1		1				3	
Disturbance Prevention									2				
Water Regulation	1				1							1	1
Water Supply					2				5				7
Soil Retention & Formation	1								1				
Nutrient Regulation													
Waste Treatment					3				1				
Pollination	2												
Biological Control													
Refugium Function	1	4			1	4		4	2				
Aesthetic & Recreation	2	12			7	1		12	8			4	17
Cultural& Spiritual	2												

The values used in this study were inflated to 2007 US dollar values using the CPI (BLS).

The categories of ecosystem services considered in this study are reported in Table 5.

Table 5: List of Ecosystem Services Included in the Study

Ecosystem Services	Explanation
Climate Regulation	Capture and storage of carbon dioxide by forest and other plant cover, reducing global warming
Freshwater Regulation and Supply	Storage, control, and release of water by forests and wetlands, providing local supply of water.
Waste Assimilation	Filtering of pathogens and nutrients from runoff by forests and wetlands, reducing the need for water-treatment systems
Nutrient Regulation	Cycling of nutrients, such as nitrogen, through ecosystem for usage by plants, reducing need to apply fertilizers
Habitat Refugium	Value of contiguous patches of forest and wetland in supporting a diversity of plant and animal life
Soil Retention and Formation	Creation of new soils and prevention of erosion, reducing need for dredging and mitigation of damage due to siltation of rivers and streams
Disturbance Prevention	Mitigation of flooding and coastal damage by natural wetlands and floodplains
Pollination	Services provided by natural pollinators such as bees, moths, butterflies, and birds, avoiding need for farmers to import bees for crop pollination
Recreation and Aesthetics	Recreational value of natural places as well as positive impact on nearby property values

Source: TSS Consulting.

The standardized value estimates associated with each ecosystem services are reported in Table 6.

Table 6: Ecosystem Service Value Estimates in 2007 US $/acre by Land Cover[♣]

Land Cover	Ecosystem Service	Average Value ($/acre/year)
Agricultural Land	Water Regulation	111.57
	Soil Formation	6.35
	Habitat Refugium	13.97
	Pollination	8.98
	Cultural and Spiritual	797.52
	Aesthetic and Recreational	28.08
	Totals	**966.46**
Forest Conifers	Gas and Climate Regulation (CO2)	32.86
	Habitat Refugium	127.68
	Aesthetic and Recreational	201.56
	Totals	**362.10**
Fresh Wetland	Water Regulation	503.73
	Waste Treatment	1,853.47
	Habitat Refugium	5.49
	Aesthetic and Recreational	2,475.51
	Totals	**4,838.23**
Harwood oak woodlan	Gas and Climate Regulation (CO2)	36.87
	Habitat Refugium	127.68
	Aesthetic and Recreational	29.19
	Totals	**193.74**
Mixed Hardwood Conifer	Gas and Climate Regulation (CO2)	34.86
	Habitat Refugium	127.68
	Aesthetic and Recreational	201.56
	Totals	**364.10**
Riparian Forest	Water Supply	456.63
	Water Treatment	4.79
	Habitat Refugium	970.03
	Soil Retention	134.20
	Disturbance Prevention	1,073.66
	Aesthetic and Recreational	1,237.22
	Totals	**3,876.53**
Urban Green	Water Regulation	6.13
	Gas and Climate Regulation	366.48
	Aesthetic and Recreational	2,098.63
	Totals	**2,471.24**
Open Fresh Water	Water Supply	2,708.11
	Water Regulation	30.02
	Aesthetic and Recreational	452.75
	Totals	**3,190.88**

[♣] The conversion factor used to calculate CPI is 1.0895.

All the values presented represent the statistical mean for each combination of land cover and agro-ecosystem service. Value estimates of ecosystems services considered in this study are derived by studies that employ a variety of estimation methods, such as contingent valuation, travel cost, etc.

Results

Table 7 presents results of the estimated values of the agro-ecosystem services for Kern County.

Table 7: Total Value Estimates of Ecosystem Services by Land Cover

Land Class	Area (Acres)	Ecosystem Value ($/Acre/Year)	Total ESV ($)
Agriculture	1,209,465	$966.46	**$1,168,899,543.90**
Forest-Conifer	176,638	$362.10	$63,960,619.80
Desert Shrub	1,338,701	Unknown	
Desert Woodland	7,141	Unknown	
Fresh Wetland	51,828	$4,838.23	**$250,755,784.44**
Hardwood Oak Woodland	334,265	$193.74	$64,760,501.10
Herbaceous	1,252,913	Unknown	
Mixed Hardwood Conifer	61,930	$364.10	$22,548,713.00
Riparian Forest	151,005	$3,876.52	**$585,373,902.60**
Shrubs	381,010	Unknown	
Urban and Barren	2,182,267	Unknown	
Urban Green	94,069	$2,471.24	$232,467,075.56
Open Fresh Water	41,689	$3,190.88	$133,024,596.32
Total Value of ESS			**$2,521,790,736.72**

Results reported here represent the agro-ecosystem services value for differing land types expressed in 2007 dollars[6]. These figures are the values generated by agro-ecosystem habitat, information, and the regulatory functions (Footnote 2). As mentioned earlier, this evaluation of agro-ecosystem services includes value estimates only for those services that have been quantified in the peer-reviewed literature, which by no means is exhaustive of all of the services provided by the Kern County agro-ecosystem functions. The land classes, for which the literature provides no transferable value information, are shown as unknown in Table 7.

Results show that ecosystems services provide a relatively large stream of benefits to Kern County, with a total value of more than $2.5 billion per year. Agricultural land provides $1.2 billion per year, or approximately 50% of the estimated benefits from those land types for which estimated ecosystem service values exist. This is primarily due to the size of the agricultural land base, relative to the other considered land types. Cultural and spiritual and water regulation are the most valuable services provided by agricultural land.

Riparian forests contribute more than $585 million, mainly through the aesthetic and recreational and disturbance prevention functions. Fresh Wetlands provide by far the highest agro-ecosystem services value per acre and even though they cover relatively a small area in Kern County, they do provide the third highest value of ecosystem services, with a total value of more than $250 million per year. The most valuable services are the aesthetic and recreational functions and waste treatment services.

Each of the remaining categories contribute to the total value of ecosystem services as follows: urban green area provides more than $232 million per year, open freshwater provides about $133 million per year, followed by hardwood and conifers which contribute respectively $64 million and $63 million per year. Desert shrub is the most predominant land cover type in Kern County. However, there are no studies available in the literature that estimate economic values for desert cover types and thus their ecosystem services value is unknown.

The Kern County agro-ecosystem services value of $1.2 billion when combined with Kern County agro-ecosystem production function's food and fiber output of $3.2 billion (2005) totals $4.4 billion. Thus, if the value of Kern County agricultural is simply measured by the market value of agricultural production then the actual agro-ecosystem functions services provided by Kern County agriculture would be undervalued by approximately 27%. Additionally, since several agro-ecosystem services were not estimated due to a lack of known values the actual undervaluation is likely to be greater than 27%.

The agro-ecosystem services values can be broken done by crop as shown in Table 8.

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[6] A visual display shown as a series of maps of the spatial distribution of ecosystem values as reported in contained in Appendices B-G. These maps show substantial differences in the total ecosystem service value by land cover (Figure 6), by zip code (Figure 7) and type of crop (Figure 8).

Table 8: Ecosystem Service Value Estimates for the Top Five Agricultural Crops

Top Five Cultivated Crops	Area Cultivated (Acres)	ESS Values (000 $)
Almond	165,831.8	$160,270
Alfalfa	69,532.3	$67,200
Grape	58,887.8	$56,913
Pistachio	57,195.2	$55,277
Cotton	52,591.9	$50,828

It should be noted that the agro-ecosystem services values for each crop represent that crops proportion contribution based on acreage. These five crops account for approximately 33% of the value of the agro-ecosystem services in Kern County with almond cropland accounting for approximately half of that five crop value. These values should be considered carefully. It is quite possible that the actual contribution to the total agro-ecosystem service value made by each of crops would differ based on its individual agro-ecosystem functions. However, the figures shown in table 8 are at least first approximation of the crops agro-ecosystem services value.

Earlier it was suggested that some estimate of the baseline value of agro-ecosystem services is important for informed agriculture land-use decision- making. It becomes more problematic to determine appropriate policy prescriptions or market incentives to create an environment that is supportive of maintaining or improving the quantity and quality of agro-ecosystem services without some estimate of the baseline agro-ecosystem services value.

It is also useful to have a baseline value from which to evaluation the impact of changes in agro-ecosystem functions and their services from either a marginal value gained or loss perspective. For example, it is projected that by 2040 Kern County will have 147,142 acres of farmland to convert to alternative uses (AFT, 2006). Using the information reported in Table 3, this conversion would result in a marginal value loss of agro-ecosystem services of more than $142 million per year thus reducing Kern County agro-ecosystem service value by approximately 14%. The marginal value loss of agro-ecosystem services plus the loss in agricultural production value plus the loss in agricultural production multiplier value sum to the marginal agricultural land conversion cost against which the net marginal benefit of conversion should be compared. Thus, with out estimating the marginal value loss of agro-ecosystem services, the marginal cost of conversion would be understated and could result in poor land-use decision-making.

Measuring the total economic value of an agricultural system is useful and worthwhile, as it can be used to leverage public support for ecosystem protection and convince policymakers to make more informed decisions on the natural environment. Additionally, a further benefit from estimating baseline and marginal value (loss) for converting agricultural land and thus changing agro-ecosystems functions and the services they provide is the gained knowledge and awareness about the ecological and economic parameters that determine agro-ecosystem services value. Well-managed agricultural landscapes supply important non-marketed goods and services to society and this ability and stream of benefits should be explicitly considered in crafting public policies and or market-based incentive programs.

Summary

Agro-ecosystem functions provide both market and non-market good and services to society. It has been increasing more important to learn more about the functioning of agro-ecosystem functions and the services that those functions provide.

An agro-ecosystem goods and services valuation framework was specified to discuss various economic principles that would impact the determination of agro-ecosystem values. The framework underscores the idea that agricultural systems are complex and dynamic with spatially varying inputs and outputs which are the result of interrelated physical and biological processes and human decision making processes. It was concluded that an estimate of baseline and marginal value gain (loss) of agro-ecosystems service is important to development of policy instruments and market based incentive programs that have as their purpose the maintenance or improvement in agro-ecosystem services.

The paper reviews the various economic valuation methodologies for estimating non-market agro-ecosystem goods and services values and lays a foundation for the use of benefit transfer methodology as a second-best approximation to alternative valuation methodologies given that it has the advantage of being less costly and time consuming to use than alternative non-market valuation approaches.

A benefit transfer methodology is used to estimate the non-market agro-ecosystem good and services values for Kern County. We conservatively estimate that total Kern County ecosystems services value is approximately $2.5 billion in 2007 dollars. The main land type contributor to ecosystem services value in Kern County is agriculture which has an estimated agro-ecosystem services value of $1.2 billion or about 48% of the total. Almond cropland makes a $160 million contribution to Kern County non-market agro-ecosystem value. The contribution is due to the size of almond acreage in Kern County compared to other crops grown in the county.

The study concludes with an example that demonstrates the worth of using agro-ecosystem services marginality principles in evaluating the cost and benefits of agricultural land conversion. We estimate converting 147,142 acres of Kern County agricultural land would result in a marginal value loss of agro-ecosystem services of more than $142 million per year thus reducing Kern County agro-ecosystem service value by approximately 14%. If this information were not available the marginal cost of agricultural land conversion would be understated and could result in poor land-use decision-making.

We conclude by noting the measuring the total economic value of an agricultural system is useful and worthwhile, as it can be used to leverage public support for ecosystem protection and convince policymakers to make more informed decisions on the natural environment. Additionally, a further benefit from estimating baseline and marginal value (loss) for converting agricultural land and thus changing agro-ecosystems functions and the services they provide is the gained knowledge and awareness about the ecological and economic parameters that determine agro-ecosystem services value. Well-managed agricultural landscapes supply important non-marketed goods and services to society and this ability and stream of benefits should be explicitly considered in crafting public policies and or market-based incentive programs.

Appendix A

Below we describe the process of merging and combining the data from various sources.

The California Spatial Information Library (CaSIL) is maintained by the State of California as a repository of GIS information from state agencies and other sources. It acts as a data storage site as well as having links to other state agencies data servers. It replaced the Teale Data Center in 2001 and has actively searched for updated GIS and Remote Sensing information for the State of California. It has a large variety of information available, including high resolution (1 meter) imagery of the whole state of California. For this study it was used to obtain some basic geopolitical and highway layers. In addition the base vegetation / land use data was obtained from CaSIL. The data is in the form of GIS layers which provides georeferenced shapes and underlying tabular data relating to the shapes.

The base layer was based on vegetation layers of the bioregions of California. The bioregion layers used for this project were San Joaquin, Sierra, Mojave, and just a small part of Central. This vegetation layer was compiled from data created for the Land Cover Mapping and Monitoring Program (LCMMP) Vegetation information from the California Department of Forestry and Fire protection and the United States Forest Service. It was published in 2005 but has data only current to 2002. The vegetation shapes were derived from LANDSAT TM satellite imagery and has a minimum resolution of 2.5 acres. The layers were geo-referenced to the California (Teale) Albers projection. This projection had been established to provide a single low precision projection that covered all of California. It is common for most of the State GIS layers to be based on this projection. The datum that was used for the vegetation projections was North American Datum of 1927 (NAD27). The current projection used is North American Datum of 1983 (NAD83). It was determined to do a transformation of the underlying vegetation data to Teale Albers NAD83. This would provide better correlation to the additional data that was going to be used.

Each of the bioregion layers were clipped along the Kern County Boundary, which came from the geopolitical layers extracted from the CaSIL site. Once the layers were clipped, they were then merged into a single layer for all the vegetation in Kern County. We used the “WHR13Name” field as our basis for Land use. WHR Stands for California Wildlife Habitat[♦] Relationships System. The number 13 indicates there are 13 classifications, which is a hierarchical reclassification of WHR types into 13 "Land cover Subclasses" classes. The classification names were coded according the categories reported in Table 2.

[♦] http://www.dfg.ca.gov/bdb/html/wildlife_habitats.html

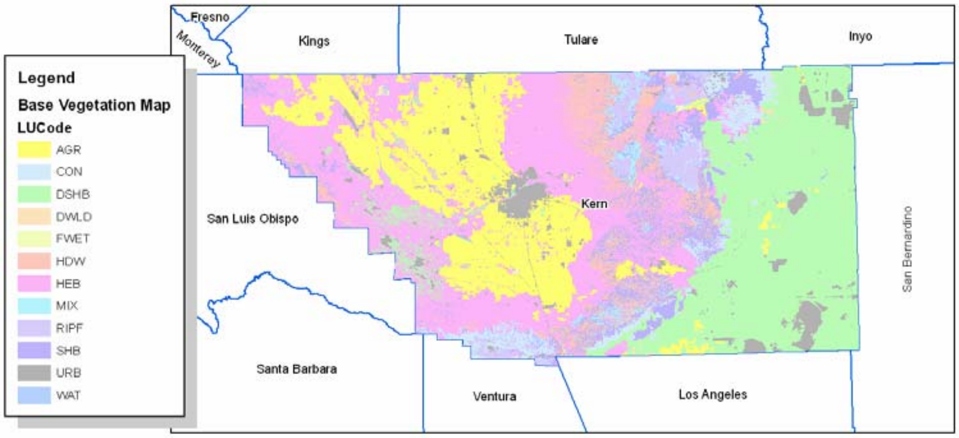

Figure 1-Base Vegetation Map

The total area per this layer equals approximately 8160 square miles. The U.S. Census Bureau notes the area of Kern as 8140 square miles[♥].

Next, to update the Wetlands areas, the U.S. Fish and Wildlife's National Wetlands Inventory (NWI). The goal of the NWI is to provide geospatially referenced information on the status, extent, characteristics and functions of wetland, riparian, deepwater and related aquatic habitats in priority areas to promote the understanding and conservation of these resources. NWI provides current data available for download. The layers are referenced using the USGS 1:100,000 scale mapping. The maps that cover Kern County were Cuddleback Lake, Cuyama, Delano, Isabella Lake, Lancaster, Ridgecrest, Taft, Tehachapi and Victorville. These layers were downloaded and then combined and finally clipped to the boundary of Kern County[♠].

Once the wetland layer was updated, we determined which polygons within the wetlands were to be classified as Open Water "WAT" and which were to be classified as Wetlands "FWET". All the Polygons are classified using the Wetlands and Deepwater Habitats Classification scheme. One of the Modifiers within the classification scheme for Water Regime is "H" indicating permanently flooded. This modifier would be in position 5 of the attribute code. It was determined that this was the best indicator of open water. Therefore, all polygons having position 5 as "H" were classified as water and all others were classified as Wetlands.

[♥] Source: http://quickfacts.census.gov/qfd/states/06/06029.html

[♠] Note: there is data based on the 1:24000 maps which would provide better resolution. However, It would significantly increase the number of files to work with (9 to over 100), as well as the fact that our vegetation scheme is based on low resolution Satellite imagery, it was determined that the increase resolution was not warranted.

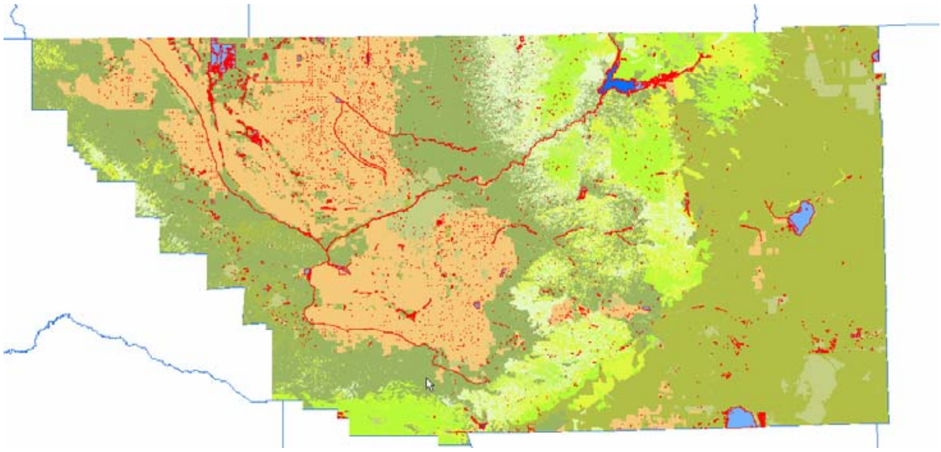

Figure 2-Wetlands data overlaid onto vegetation base layer

Next, the vegetation base layer was modified such that all areas coincident with the wetlands polygons were erased and the 33 layer was merged into the base layer. This significantly increased the amount of lands considered wetlands.

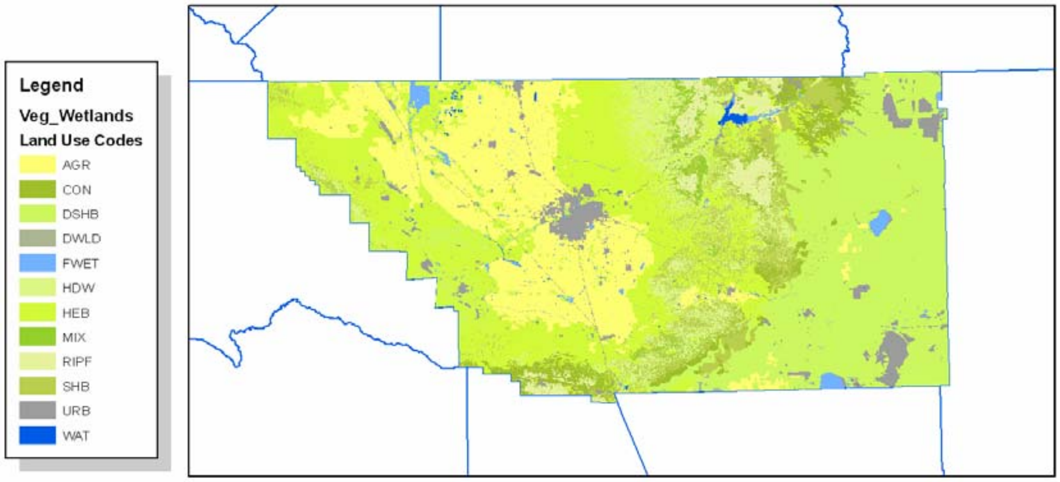

Figure 3 - Resultant Classifications

Next, we worked with data provided by the Kern County. The County's department of Agriculture/Measurement Standards began developing a Geographic Information System in 1997. This program also builds a history of land use in Kern County, and allows for rapid and accurate analysis of cropping patterns at the individual field level. It has the most detailed information for Kern County Crops. This data is not available online; however Kern County was willing to provide the data for our use. Two layers were integrated into the project, the agriculture commodities layer for 2007 and the sensitive habitat layer. With the agricultural commodities layer, all the polygons were considered Agricultural "AGR" land use; however, we added a "b" at the end to distinguish between the original and the Kern County data. This layer was added into the vegetation/wetland layer with the same process as for the Wetlands. After reviewing the layer to compare Agricultural land use "AGR" that was not from the Kern data set "AGRb" it was found that most of the "AGR" was surrounded by the Kern data. Therefore all the Agricultural land uses were combined as one.

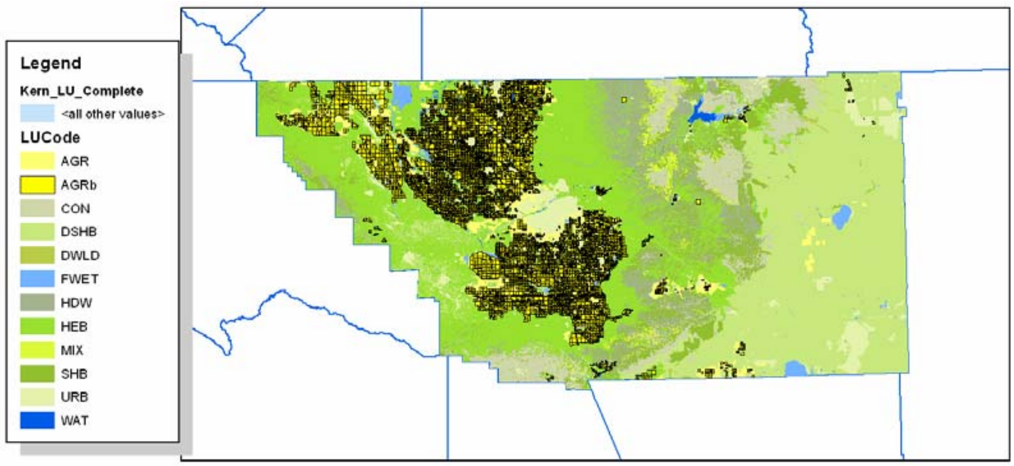

Figure 4-Classifications showing added Ag "AGRb"

The last layer added was the Kern County Sensitive Habitat layer. The layer covered selected areas within Kern County and consisted of polygons defined by classes which were converted then to the land use codes. The layer consisted of 94,479 polygons defining the land use codes for Kern County. The final version of data by land categories and acreage is reported in Table 4.

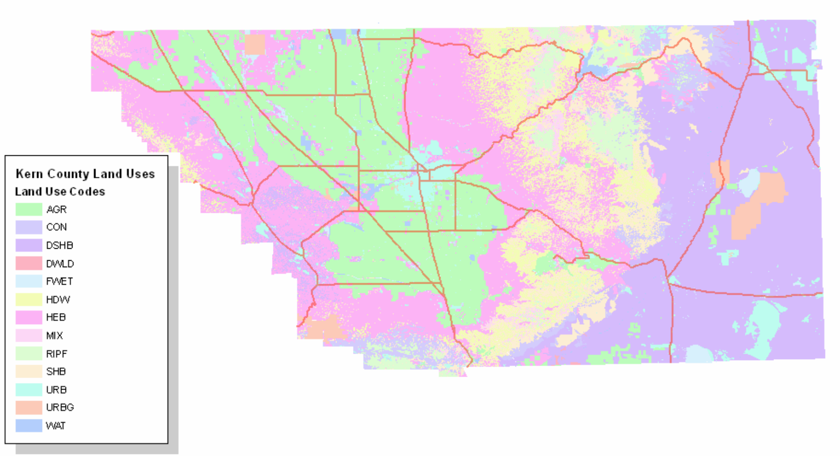

Figure 5-Completed Land Use map

Determination of Values within Zip Code Boundaries

In determining a specific unit of measurement, it was decided that regions defined by zip code boundaries would be appropriate. The US Postal Service does not define zip codes areas by boundaries, but by linear limits along streets. Therefore any zip code boundary is an interpretation of the parcels affected by the linear limits. This means that there can be variations in a boundary shown as a zip code boundary. The zip code boundaries used in this study came from the CaSIL database and were trimmed to Kern County for use in this project. For each zip code the Land Uses were extracted so that we could look at each area. This process required to clip the overall Land Use layer to each of the Zip code boundaries. This was done to ensure that Land Use polygons would not be counted twice.

The process was to select a zip code boundary, clip the land use data to that boundary. Then a new field with the zip code value was added to these new clipped layers. Once all the zip code layers were created, all the layers were merged back into a single layer. Then within each zip code boundary the total acres and total value were computed.

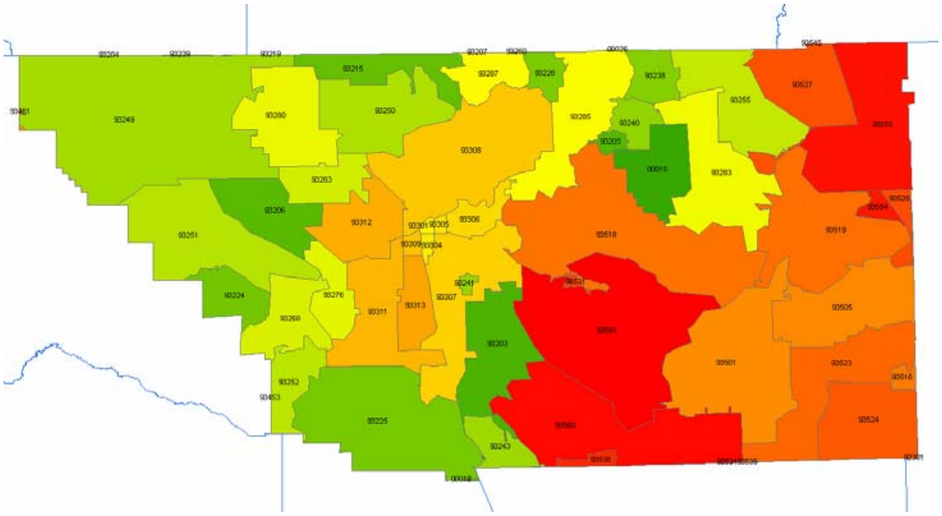

Figure 6-Zip codes of Kern County

Table 8: Ecosystem Value Estimates in ($US) by Land Cover and Zip Code

Zip Code Area	Community Name	Count of Parcels	Total Area	Total ESS Value ($)	Average Value ($/Acre)
00016	SEQUOIA NATIONAL FOREST	1287	79,839.5	$170,651,532	$2,137.43
00018	LOS PADRES NTL FOREST	18	456.4	$813,799	$1,783.05
00026	EAST TULARE COUNTY	8	49.9	$1,735	$34.75
92301	ADELANTO	1	3.3	$0	$0.00
93203	ARVIN	1955	127,338.0	$87,018,798	$683.37
93204	AVENAL	9	34.2	$4,732	$138.45
93205	BODFISH	757	9,631.4	$915,730	$95.08
93206	BUTTONWILLOW	1691	90,358.4	$80,991,370	$896.33
93207	CALIFORNIA HOT SPRINGS	6	2.0	$106	$54.51
93215	DELANO	740	73,270.3	$59,951,059	$818.22
93219	EARLIMART	6	22.4	$15,074	$674.25
93224	FELLOWS	1859	50,721.9	$1,792,271	$35.34
93225	FRAZIER PARK	3160	246,495.2	$164,261,421	$666.39
93226	GLENNVILLE	1446	24,258.8	$5,960,856	$245.72
93238	KERNVILLE	211	39,861.9	$85,169,215	$2,136.60
93239	KETTLEMAN CITY	35	369.0	$338,985	$918.68
93240	LAKE ISABELLA	1742	30,943.2	$25,258,992	$816.30
93241	LAMONT	110	4,662.9	$3,443,959	$738.58
93243	LEBEC	1794	39,037.8	$8,972,943	$229.85
93249	LOST HILLS	6954	496,637.6	$279,107,206	$561.99
93250	MC FARLAND	1745	133,721.0	$101,122,880	$756.22
93251	MC KITTRICK	5659	187,651.4	$22,511,387	$119.96
93252	MARICOPA	1722	53,930.8	$22,155,452	$410.81
93255	ONYX	767	126,723.8	$64,192,544	$506.55
93260	POSEY	2	1.1	$185	$175.16
93263	SHAFTER	1237	59,133.0	$54,619,638	$923.68
93268	TAFT	2653	75,605.8	$10,837,260	$143.34
93276	TUPMAN	843	63,428.0	$58,656,415	$924.77
93280	WASCO	2275	132,241.7	$123,360,697	$932.84
93283	WELDON	1668	155,498.2	$34,430,570	$221.42
93285	WOFFORD HEIGHTS	4313	136,807.5	$148,755,881	$1,087.34
93287	WOODY	1630	48,910.0	$4,566,185	$93.36
93301	BAKERSFIELD	29	2,960.4	$535,127	$180.76
93304	BAKERSFIELD	11	4,736.4	$98,057	$20.70
93305	BAKERSFIELD	6	3,579.4	$93,593	$26.15
93306	BAKERSFIELD	386	31,458.9	$4,947,426	$157.27
93307	BAKERSFIELD	2768	168,883.2	$134,456,963	$796.15

93308	BAKERSFIELD	5654	247,942.3	$38,322,670	$154.56
93309	BAKERSFIELD	33	6,734.5	$1,222,749	$181.57
93311	BAKERSFIELD	1989	123,254.9	$110,436,205	$896.00
93312	BAKERSFIELD	1378	90,524.1	$93,869,233	$1,036.95
93313	BAKERSFIELD	934	57,281.9	$56,198,129	$981.08
93453	SANTA MARGARITA	54	42.4	$12,621	$297.83
93461	SHANDON	83	822.5	$5,034	$6.12
93501	MOJAVE	670	231,046.6	$11,306,005	$48.93
93505	CALIFORNIA CITY	41	141,094.0	$29,765,307	$210.96
93516	BORON	20	9,215.8	$361,185	$39.19
93518	CALIENTE	14020	317,010.4	$61,272,298	$193.28
93519	CANTIL	123	194,410.4	$158,182,393	$813.65
93523	EDWARDS	436	152,378.8	$48,671,278	$319.41
93524	EDWARDS	100	117,962.5	$868,586	$7.36
93527	INYOKERN	116	114,653.8	$11,790,197	$102.83
93528	JOHANNESBURG	6	18,374.4	$5,136	$0.28
93531	KEENE	249	2,984.7	$119,192	$39.93
93534	LANCASTER	1	5.7	$0	$0.00
93535	LANCASTER	2	6.4	$19,692	$3,067.51
93536	LANCASTER	24	10,206.8	$1,250,028	$122.47
93545	LONE PINE	2	5.3	$191	$35.85
93554	RANDSBURG	6	13,206.8	$356,271	$26.98
93555	RIDGECREST	125	199,992.7	$7,784,562	$38.92
93560	ROSAMOND	5523	241,101.3	$60,003,843	$248.87
93561	TEHACHAPI	14722	329,117.9	$69,935,823	$212.49

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County of Kern Department of Agriculture/Measurement Standards	http://www.kernag.com/