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BENEFITS AND COSTS OF RESOURCES POLICIES AFFECTING
PUBLIC AND PRIVATE LAND

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INTRODUCTION

This volume contains the proceedings of the 1999 W-133 Western Regional Project Technical Meeting on "Benefits and Costs of Resource Policies Affecting Public and Private Land." Some papers from W-133 members and friends who could not attend the meeting are also included. The meeting took place February 24th - 26th at the Starr Pass Lodge in Tucson, Arizona. Approximately 50 participants attended the 1999 meeting, are listed on the following page, and came from as far away as Oslo, Norway.

The W-133 regional research project was rechartered in October, 1997. The current project objectives encourage members to address problems associated with: 1.) Benefits and Costs of Agro-environmental Policies; 2.) Benefits Transfer for Groundwater Quality Programs; 3.) Valuing Ecosystem Managment of Forests and Watersheds; and 4.) Valuing Changes in Recreational Access.

Experiment station members at most national land-grant academic institutions constitute the official W-133 project participants. North Dakota State, North Carolina State, and the University of Kentucky proposed joining the group at this year's meeting. W-133's list of academic and other "Friends" has grown, and the Universities of New Mexico and Colorado were particularly well represented at the 1999 W-133 Technical Meeting. The meeting also benefitted from the expertise and participation of scientists from many state and federal agencies including California Fish and Game, the U.S. Department of Agriculture's Economic Research and Forest Services, the U.S. Department of Interior's Fish and Wildlife Service, and the Bureau of Reclamation. In addition, a number of representatives from the nation's top environmental and resource consulting firms attended, some presenting papers at this year's meeting.

This volume is organized around the goals and objectives of the project, but organizing the papers is difficult because of overlapping themes. The last section includes papers that are very important to the methodological work done by W-133 participants, but do not exactly fit one of the objectives. -- I apologize for the lack of consistent pagination in this volume.

On A Personal Note... Any meeting or conference is successful (and fun!) only because of its participants, so I would first like to thank all the people who came and participated in 1999 - listed below. I also want to thank Jerry Fletcher for all his help at this meeting and prior to it, and John Loomis who passed on his knowledge of how to get a meeting like this to work, and who continues to have the funniest little comments to lighten the meetings up. I especially thank Paul Jakus, who helped me to organize this conference and have a lot of fun during it and afterward. Finally, I want to thank Nicki Wieseke for all her help in preparing this volume, and Billye French for administrative support on conference matters.

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June, 1999

P.S. P.F. and J.C. - As far as I can tell, that darn scorpion is still dead!

Welfare Losses Due to Livestock Grazing on Public Lands:
Some Evidence from the Hoover Wilderness

by

J. S. Shonkwiler
and
Jeffrey Englin

Abstract:

Backcountry hikers' willingness to pay for removing grazing from trails in the Hoover Wilderness is analyzed by linking a multinomial logit model of trip allocation with a Dirichlet distribution so that seasonal trips can be properly aggregated. Seasonal welfare measures are derived from an incomplete demand specification. Results show that hikers' welfare losses do not everywhere exceed agency revenues and producers' surpluses. Prioritization of activities is indicated on a trail by trail basis.

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Welfare Losses Due to Grazing on Public Lands

...in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands..., it is hereby ordered as follows:
Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities... (Ex. Ord. No. 11990, May 24, 1977, 42 F.R. 26961)

Federal agencies are required under the National Environmental Policy Act to consider the economic impacts of their management decisions. Economic impacts are broadly construed to include the non-market values assigned to recreational activities on public lands. Under the above referenced Executive Order these agencies additionally must manage their operations to preserve and enhance the beneficial values of wetlands. Again there is the implication that these values need not be market based. Conflicts can arise when public lands serve multiple types of users—particularly when some use is economic and some recreational. Clearly benefits accrue to both types of users, but the difficulty is quantifying these benefits. We illustrate an approach to benefit estimation using as our example the Hoover Wilderness of eastern California. Here both grazing and back country hiking activities occur on certain trails in the wilderness; and both some hiking and some grazing take place in riparian areas.

While multiple use of public lands has been the philosophical approach used by public land managers its application has proven difficult. One reason for this is that choosing how much of each use should be allowed is usually based upon economic criteria. Unfortunately, that presupposes enough information about prices and quantities is known so as to allow management using traditional economic principles. In the case of public lands many of the alternative uses are non-market uses. As a result, managers are hampered in their efforts.

A pressing public issue in the United States is the competition between grazing and other uses for public lands. While the price of grazing permits is an administrative decision, the value of the public lands in other uses is a non-market issue. One of the competing recreational uses is backcountry hiking. Backcountry hiking is an especially interesting competing use because the conflict is so direct. The issue is that people are viewing cattle or sheep and sharing the ecosystems with these animals.

Examining the relationship between grazing and backcountry hiking is facilitated by the fact that both grazing and backcountry hiking activities are permitted in the Hoover Wilderness Area. When the Hoover Wilderness was created grazing rights were grandfathered into the enabling legislative act. While hiking had been going on for some time, in this area the designation as wilderness brought with it an administrative structure that now accounted for hiking as well as grazing. This analysis utilizes data from this wilderness to estimate the willingness-to-pay by backcountry hikers to reduce grazing and to provide estimates of the value of several ecosystems and other trail characteristics.

Non-Market Valuation Methods

Recreation demand modeling is an important element of natural resource planning. Recreational trip data constitute the primary source of information for revealed preference methods. Recreation visitation data are, however, subject to the fact that each respondent will report a discrete number of trips to a site. Yet a single, independent recreational site rarely exists. The proper evaluation of policy changes may require a systems approach if several sites are impacted simultaneously. Or if similar recreational experiences can be obtained at places near a single recreation site of interest, there may be a high degree of substitutability among such sites. Although most travel cost studies to date have assumed independence in order to estimate demand, researchers recognize the probable important interdependencies of demands for sites due to the pioneering work of Burt and Brewer. Subsequent studies by Cicchetti et al.

and Sellar et al. have provided additional evidence to justify a systems approach. Unfortunately, travel cost analyses of household (or individual) demands for multiple recreational goods typically have not accounted for the discrete, non-negative integer characterization of trip data. Or in the case where the count nature of the data was accommodated, restrictions consistent with rational behavior were not imposed (Ozuna and Gomez). The published exceptions are recent studies by Englin et al. and Shonkwiler which employ an incomplete demand specification for non-negative integer data. Yet these papers do not fully develop the proper use of the incomplete demand model when valuing environmental goods.

A conventional recreation site choice model is the multinomial logit model of McFadden. McFadden's multinomial logit model possesses useful properties for analyzing the site allocation problem because visitation data are discrete and the model can be easily used to estimate exact per-trip welfare measures for site quality changes (we ignore the additional and tangential issue of allowance for income effects here). This model, while quite popular because of its attractive features in dealing with multiple sites, limits consideration of seasonal welfare changes due to the fact that the multinomial logit's site-specific demands are estimated conditional on total demand for all sites. Many recreation modelers have raised the point that consumer's surplus measures should come from some aggregate or unconditional demand function rather than from the site-specific conditional demands, because the former allows total seasonal consumption to change in response to site quality and price changes and the latter does not.

Intuitively, when one only has per-trip welfare measures, some assumption must be made about whether and how these can be added together to arrive at a welfare measure that can be interpreted as an annual (seasonal) maximum willingness to pay (WTP) to bring about some change. One line of research has sought to link the RUM with an aggregate demand quantity (Bockstael et al., Feather et al., Parsons and Kealy, Hausman et al.). Substantial attention has been devoted to determining the appropriate aggregate price to use in the aggregate demand equation when site-specific demands have been modeled using the multinomial logit specification. However, recent work by Shaw and Shonkwiler, Smith, and Smith and Von Haefen suggests the aggregate price indexes being proposed do not provide a utility theoretic link between the RUM and the aggregate demand equation.

The foregoing discussion leads to recognition of the fact that the data necessary to specify a random utility model are typically detailed enough to provide information on site-specific demands. In this situation the data are rich enough to allow calculation of a travel cost model to each individual recreation site, and it seems logical that this information should be exploited when developing models for multiple sites. The necessary techniques to accomplish such modeling consist of a demand system that allows calculation of unconditional welfare measures and a proper econometric technique to accommodate the discrete nature of the demand quantities.

This study attempts to synthesize the elements necessary to appropriately treat multiple site travel cost models of recreation demand when the decision variables are measured as trip counts. A multivariate count data probability model is shown to provide a link between conventional logit models of trip allocation and count data models of trip demand. Because this model generates conditional demands with exponential form, a proper incomplete demand structure (LaFrance and Hanemann) will be imposed to insure that exact welfare analysis can be performed. In general it is easier and less demanding of the data to develop quasi-indirect utility functions as opposed to a complete preference function. Such an approach adopts the general framework of Hausman's approach to derive the incomplete preference relationships and provide expressions for the welfare effects of variations in non-market goods.

Incomplete Demand Systems

Specification of a system of demand equations naturally leads to the implications of consumer choice theory for assessing the structure imposed. As LaFrance has pointed out, three practical approaches can be considered for the demand system specification. First, broad aggregates of all goods available to the consumer can be used to reflect all choices in the consumption set. Second, separability can be imposed so that conditional demand equations involving a subset of commodities can be estimated. Third, an incomplete system of demand equations can be specified. Obviously, the first approach is unsatisfactory because interest is focused on individual commodities. The second approach suffers from i) uncertainty as to the true nature of separability, ii) not identifying the overall utility function but only a subutility function, and iii) the interdependence between quantities demanded and group expenditure. This latter condition is exacerbated when many households have zero demands and consequently zero groupwise expenditure. Thus, substantial simultaneous equations bias would likely be encountered.

The incomplete demand system specification is an attractive alternative only if the preference structure it identifies is consistent with rational models of consumer behavior. Incomplete demand models can be related to an underlying utility maximization subject to a linear budget constraint and can be used to conduct proper welfare analysis (LaFrance and Hanemann, 1989). The incomplete demand structures that are consistent with such maximizing behavior were first catalogued in LaFrance and Hanemann (1984) for some common functional forms of demand equations. In the case of linear expected demands, the restrictions required for integrability are zero (or essentially zero) income effects and a symmetric negative definite cross price matrix. Burt and Brewer as well as Seller et al. imposed cross equation symmetry of the price coefficients. Hence both studies imposed restrictions generally consistent with those suggested by a linear incomplete demand system. However, because both studies modeled discrete household demand data with linear models, their welfare calculations were compromised by their assumption that demands were continuously distributed.

As mentioned, demand models which are based on an optimization hypothesis and which are applied to a subset of goods typically assume preferences are separable—thus allowing the analysis to focus on demand models for the goods of interest apart from other goods. The budget allocated to this group of separable goods is assumed known and the system yields only partial welfare measures. This can be contrasted with the key assumption of an incomplete demand system: prices outside the set of goods of interest do not vary. If this maintained hypothesis is reasonable, then unconditional welfare measures can be computed from a properly specified incomplete demand system. Given that prices of other goods are constant, the utility maximization problem under a linear budget constraint yields a system of incomplete demands which satisfy Slutsky symmetry and provide exact welfare measures for price changes of the goods of interest.

The functional form assumed for modeling the relationship between expected demands and conditioning variables will dictate the restrictions necessary to assure that the incomplete demand system satisfies proper integrability conditions. Fortunately, LaFrance and Hanemann(1984) have considered a number of functional forms and have detailed the restrictions consistent with integrability. In the empirical example which follows, their Log I specification is adopted. Consequently this particular functional form will be used to illustrate the incomplete demand system approach.

Assume that site-specific expected demands for j=1, 2, ..., J sites take the form

$$E(y_j) = \alpha_j \exp(\sum_{k=1}^{J}\beta_{jk}p_k + \theta_j I) = \gamma_j \qquad (1)$$

where p_k represents the price of the k^{th} (k=1, 2, ..., J) site, I denotes household income and the observational index has been suppressed. One set of restrictions consistent with an incomplete demand system of this form is (LaFrance and Hanemann, 1984): $\alpha_j > 0$ and $\beta_{jj} < 0 \ \forall j$, $\beta_{jk} = 0 \ \forall j \neq k$, and $\theta_j = \theta \ \forall j$. These restrictions result in this Log I incomplete demand system having J free own-price parameters and one income coefficient. Therefore there are (1 + ½ J)*(J-1) price and income parameter restrictions implied by this functional form if it is to be consistent with the optimizing behavior underlying the incomplete demands. Although the restrictions imposed on this incomplete demand system appear severe, the requirement of zero Marshallian cross price effects is largely unavoidable when adopting a model of expected demand that yields non-negative predicted demands. In contrast, linear specification of expected demand with symmetric cross price coefficients and no income effects would result in a properly specified incomplete system—but at the cost of ignoring the discrete nature of the observed demand data and possibly predicting negative expected demand. Clearly this is a trade off that the analyst needs to consider.

Individual-specific factors can enter the incomplete demand model and still satisfy the integrability restriction that $\alpha_j > 0$ by recognizing that we can specify $\alpha_j = \exp(a_j)$ where a_j is itself a function of conditioning variables which may correspond to an individual or household. Note that the Log I specification may be restricted to reproduce the basic form of the standard conditional multinomial logit model which does not admit different own price coefficients, income, or other individual-specific shifters. This is easily accomplished by requiring that: $\beta_{jj} = \beta$ and $\theta_j = 0 \ \forall j$. These additional restrictions result in the model

$$E(y_j) = \alpha_j \exp(\beta p_j) = \gamma_j \tag{2}$$

These restrictions imply a quasi-indirect utility function and expenditure function associated with this demand system which are (LaFrance and Hanemann,1984) respectively

$$v(p, I) = I - \beta^{-1} \sum_{j=1}^{J} \alpha_j \exp(\beta p_j) \tag{3}$$

$$e(p, u) = u + \beta^{-1} \sum_{j=1}^{J} \alpha_j \exp(\beta p_j) \tag{4}$$

Now these expressions can be used to estimate the welfare effects of changes in prices and, under certain circumstances, changes in environmental goods. Of course this leads to consideration of the comparison of these welfare measures to those obtained from the logit model. To illustrate this, assume some or all of the α_j include an environmental amenity which when increased yields a new level $\alpha_j^* \geq \alpha_j$. The change in consumer's surplus under the incomplete demand specification is

$$S_1 = \beta^{-1} \left(\sum_{j=1}^{J} \alpha_j \exp(\beta p_j) - \sum_{j=1}^{J} \alpha_j^* \exp(\beta p_j) \right) = \beta^{-1} \left(\sum_{j=1}^{J} E(y_j) - E(y_j^*) \right) = \beta^{-1} \left(\sum \gamma_j - \sum \gamma_j^* \right)$$

The logit model may be parameterized so that

$$E(\pi_j) = \frac{\alpha_j \exp(\beta p_j)}{\sum_{j=1}^{J} \alpha_j \exp(\beta p_j)} = \frac{\gamma_j}{\sum_{j=1}^{J} \gamma_j} \tag{6}$$

with the $E(\pi_j^*)$ defined analogously. This formulation leads to the per-trip surplus measure

$$S_t = \beta^{-1} \left(\ln \sum_{j=1}^{J} \alpha_j \exp(\beta p_j) - \ln \sum_{j=1}^{J} \alpha_j^* \exp(\beta p_j) \right) = \beta^{-1} \left(\ln \sum \gamma_j - \ln \sum \gamma_j^* \right)$$

Two choices exist for scaling up the per-trip surplus measure S_t. They are i)multiply S_t by total expected trips before the amenity change or ii)multiply by total trips after the amenity change. Define these measures as $S_0 = S_t \sum_{j=1}^{J} E(y_j) = \sum \gamma_j$ and $S_2 = S_t \sum_{j=1}^{J} E(y_j^*)) = \sum \gamma_j^*$. Note that the γ_j have been scaled such that the expected value of their sum equals the sum of the y_j.

Proposition: Given that $\gamma_j > 0$ and $\gamma_j^* \geq \gamma_j \quad \forall j$ then $S_0 \leq S_1 \leq S_2$

Proof: $\beta^{-1}\sum \gamma_j (\ln \sum \gamma_j - \ln \sum \gamma_j^*) \leq \beta^{-1}(\sum \gamma_j - \sum \gamma_j^*) \leq \beta^{-1} \sum \gamma_j^* (\ln \sum \gamma_j - \ln \sum \gamma_j^*)$

define $V = \sum \gamma_j^* / \sum \gamma_j \geq 1$ then by multiplying both sides by the positive quantity $-\beta/\Sigma\gamma_j$ yields $\ln V \leq V - 1 \leq V \ln V$ which holds for all $V \geq 1$ (Jeffrey, p.132).

Thus scaling up the per-trip consumers surplus measure from the random utility model by expected demand either before or after the amenity change provides bounds to the surplus measure obtained from a certain restricted incomplete demand system. Of course these results may be applied to the valuation of nonmarket goods only if the welfare effects of amenity changes can be completely recovered from the site specific demands (LaFrance, 1994). This notion if further developed by Ebert who shows that if the marginal willingness to pay functions for the environmental goods can be inferred from the specification of the incomplete demand system then unambiguous welfare measures can be determined for these environmental goods.

Econometric Approach

Let y_{nj} denote the number of trips from the n^{th} (n=1, 2, …, N) origin to the j_{th} (j=1, 2, …, J) individual site. Let $Y_n = \sum_{j=1}^{J} y_{nj}$ denote aggregate trips to the wilderness area from the n^{th} origin. Now suppressing the origin index, if the $y_1, y_2, \ldots, y_J$ are independently distributed as

Poisson: $y_j \sim Po(\mu_j)$, then:

i) Y is distributed $Po(\mu = \Sigma\mu_j)$

ii) $$P(Y_1 = y_1, Y_2 = y2, \ldots, Y_J = y_J | Y) = \prod_{j=1}^{J} \mu_j^{y_j} e^{-\mu_j} (y_j!)^{-1} \Big/ \mu^Y e^{-\mu} (Y!)^{-1}$$

$$= \frac{Y!}{y_1! y_2! \ldots y_J!} \left(\frac{\mu_1}{\mu}\right)^{y_1} \left(\frac{\mu_2}{\mu}\right)^{y_2} \ldots \left(\frac{\mu_J}{\mu}\right)^{y_J}$$

$$= \frac{Y!}{y_1! y_2! \ldots y_J!} \pi_1^{y_1} \pi_2^{y_2} \ldots \pi_J^{y_J} = Mn(\pi_1, \pi_2, \ldots, \pi_J | Y)$$

where $Mn(\bullet|Y)$ denotes the multinomial distribution.

iii) Conversely, the independent, non-negative, integer valued variables $y_1, y_2, \ldots, y_J$ have Poisson distributions if and only if the conditional distribution of these variables for the fixed sum $\sum_{j=1}^{J} y_j = Y$ is a multinomial distribution (Johnson et al. p.65).

It is obvious that the unconditional distribution is

$$Mn(\pi_1, \pi_2, \ldots, \pi_J | Y) \bullet P(Y) = P(Y_1 = y_1, Y_2 = y2, \ldots, Y_J = y_J | Y) \bullet P(Y)$$

$$= \prod_{j=1}^{J} \mu_j^{y_j} e^{-\mu_j} (y_j!)^{-1} = \prod_{j=1}^{J} Po(\mu_j)$$

This result was suggested by Terza and Wilson. Yet they and others have failed to recognize that if P(Y) is not specified to be $Po(\mu)$ as in (i) above, then there can be no claim that the conditional distribution is indeed multinomial. For example if the distribution of Y is $Nb(\mu,\theta)$, i.e. negative binomial, such that $V(Y)=\mu(1+\mu\theta)$ and the joint conditional distribution for the $y_1, y_2, \ldots, y_J$ is taken to be $Mn(\pi_1, \pi_2, \ldots, \pi_J | Y)$, then the unconditional results that $E(y_j) = \mu_j$, $V(y_j) = \mu_j(1+\mu_j\theta)$, and $Cov(y_i, y_j) = \theta\mu_i\mu_j$ can be obtained. This will be termed the multinomial-negative binomial model (Mn-Nb). However, we have shown that the marginal distributions of the counts should be Poisson distributed under the multinomial model. Yet if the sum of the y_j, Y, is specified to be $Nb(\mu,\theta)$ then the marginal distributions of its components, the y_j, are consequently Nb.

To derive a conditional distribution of the y_j consider that they are independently distributed with probability generating function

$\text{pgf}_j = (1+\rho-\rho t)^{-\gamma_j}$ then $\sum y_j$ has $\text{pgf} = (1+\rho-\rho t)^{\Sigma\gamma_j}$. The marginal probability mass function is $P(Y_j = y_j) = \dfrac{\Gamma(\gamma_j + y_j)}{\Gamma(\gamma_j)\Gamma(y_j+1)} q^{y_j}(1-q)^{\gamma_j}$ where $q = \rho/(1+\rho)$.

Thus $y_j \sim Nb(\gamma_j, \rho)$ and $E(Y_j) = \gamma_j\rho$ and $V(Y_j) = \gamma_j\rho(1+\rho)$. The joint conditional distribution $P(Y_1 = y_1, Y_2 = y2, \ldots, Y_J = y_J| Y)$ is

$$\prod_{j=1}^{J} \frac{\Gamma(\gamma_j + y_j)}{\Gamma(\gamma_j)\Gamma(y_j+1)} q^{y_j}(1-q)^{\gamma_j} \Bigg/ \frac{\Gamma(\Sigma\gamma_j + \Sigma y_j)}{\Gamma(\Sigma\gamma_j)\Gamma(\Sigma y_j + 1)} q^{\Sigma y_j}(1-q)^{\Sigma\gamma_j}$$

or simply

$\dfrac{Y!\Gamma(\Sigma\gamma_j)}{\Gamma(Y+\Sigma\gamma_j)} \prod_{j=1}^{J} \dfrac{\Gamma(\gamma_j + y_j)}{\Gamma(\gamma_j)\Gamma(y_j+1)}$. Termed the compound multinomial (Mosimann) or the fixed effects negative binomial (Hausman, Hall, and Griliches) or multinomial Dirichlet (MnD). Mosimann derives this distribution by assuming the multinomial probabilities $Mn(\pi_1, \pi_2, \ldots, \pi_J| Y)$ have Dirichlet distribution and notes that

$$E(\pi_j) = \gamma_j/\Sigma\gamma_j \text{ and } Cov(\pi_i\pi_j) = \gamma_i\gamma_j\left(\frac{1}{\Sigma\gamma_j + (\Sigma\gamma_j)^2} - \frac{1}{(\Sigma\gamma_j)^2}\right) < 0.$$

Woodland has recognized the ability of the Dirichlet distribution to limit shares to the unit simplex and gives several compelling arguments why the shares would likely be negatively correlated. Morey et al. have extended this discussion to the case where shares lie on the boundaries of the unit simplex and correctly noted that the Dirichlet cannot be applied to data where zero shares are observed. Although Morey et al. concluded that no multivariate density functions exist which have positive density over the entire unit simplex, boundaries included, and which are restricted to the unit simplex, the multivariate multinomial Dirichlet may properly be used in the boundary case problem because the multinomial parameters do not have a degenerate distribution in this situation.

The multinomial Dirichlet, MnD($\gamma_1, \gamma_2, \ldots \gamma_J|Y$), is a conditional distribution. Consider the unconditional distribution that results when $Y \sim Nb(\Sigma\gamma_j, \theta)$

$$\frac{\Gamma(Y+\theta^{-1})\Gamma(\Sigma\gamma_j)}{\Gamma(\theta^{-1})\Gamma(Y+\Sigma\gamma_j)}\left(\frac{\theta^{-1}}{\Sigma\gamma_j+\theta^{-1}}\right)^{\theta^{-1}}\left(\frac{\Sigma\gamma_j}{\Sigma\gamma_j+\theta^{-1}}\right)^{Y}\prod_{j=1}^{J}\frac{\Gamma(\gamma_j+y_j)}{\Gamma(\gamma_j)\Gamma(y_j+1)}.$$

Finally for additional flexibility, consider modeling the $E(Y) = \delta\Sigma\gamma_j = \mu$, that is the hyperparameters are scaled by δ. This gives the multinomial Dirichlet-negative binomial, MnD-Nb, distribution

$$\frac{\Gamma(Y+\theta^{-1})\Gamma(\Sigma\gamma_j)}{\Gamma(\theta^{-1})\Gamma(Y+\Sigma\gamma_j)}\left(\frac{\theta^{-1}}{\mu+\theta^{-1}}\right)^{\theta^{-1}}\left(\frac{\mu}{\mu+\theta^{-1}}\right)^{Y}\prod_{j=1}^{J}\frac{\Gamma(\gamma_j+y_j)}{\Gamma(\gamma_j)\Gamma(y_j+1)}.$$

This distribution of both the allocation of trips and the sum of the trips across alternatives can be compared to the aforementioned multinomial-negative binomial model which has a scaled from as well. As seen in Table 1., the MnD-Nb has additional flexibility to model the variance within and covariance between equations due to the fact that the scale parameter enters these equations in a more complicated fashion. Note that for certain parametric combinations, the

MnD-Nb can allow for negative covariances across equations whereas the Mn-Nb restricts these to be everywhere positive.

Table 1. Some Moments of the MnD-Nb and the Mn-Nb with scale parameter

	MnD-Nb	Mn-Nb
$E(Y_j)$	$\delta\gamma_j$	$\delta\mu_j$
$V(Y_j)$	$\delta\gamma_j[1 + \delta(1+\theta)\omega(1+\gamma_j) - \delta\gamma_j]$	$\delta\mu_j[1 + \theta\delta\mu_j]$
$Cov(Y_iY_j)$	$\delta^2\gamma_i\gamma_j[(1+\theta)\omega - 1]$	$\theta\delta^2\mu_i\mu_j$

where $\omega = \Sigma\gamma_j/(1 + \Sigma\gamma_j)$

DATA

The study area is the Hoover Wilderness area. The Hoover Wilderness area is located on the east side of the Sierra Nevada Mountain range, close to the California-Nevada state borders. The primary wilderness recreation taking place in Hoover is backcountry hiking. One of the requirements for backcountry hiking is that a backcountry hiking permit be filled out. This analysis is based on permits for 1990, 1991, and 1992.

A total of 7,661 complete permits were submitted during these three years. Of these, 7,136 were for backcountry hiking, the activity under study here. The permits included the entry point of the hiking party and the originating zip code of the party. Using these pieces of information travel distances were calculated using both computer programs and US Forest Service maps. A total of 598 residential zip code origins in Nevada and California were used in this analysis in order to more reasonably infer that the main purpose of the trip to the wilderness area was for recreation there. This resulted in a sample of 5113 permitted trips to the 14 trails.

Trail characteristics were developed from US Forest Service geographic information system information (GIS) and US Forest Service and US Geological Survey maps. The maps primarily provided information about campgrounds in the area of the trailhead, grazing allotments and trail elevation. Vegetative characteristics were obtained from the timber inventory GIS. The ecosystems found in the Hoover Wilderness include Ponderosa/Jeffrey pine, mixed pine, riparian/meadow, and rocky alpine areas. These data were merged together by digitizing the trail maps and then laying the trail map layer onto the vegetative characteristics GIS layers. This allowed us to accurately calculate the number of acres of each ecosystem that were on each trail. Grazing allotments were then added to the data base by using a US Forest Service grazing allotment map in conjunction with historical grazing figures.

Since the analysis is based on permit data there is no individual travel cost information. (Hellerstein has discussed the rationale for using aggregate trip data.) Following Englin and Mendelsohn (1991) who also worked with permit data like these, travel costs were calculated at $0.25 per mile. While this is arbitrary, the welfare estimates can easily be converted using other numbers.

Results

The multinomial Dirichlet negative binomial model was estimated using a maximum likelihood routine programmed in GAUSS. Results are reported in Table 2. Note that the likelihood estimates are from a so-called penalized model. This likelihood includes a term to insure that the estimated aggregate average number of trips to the Hoover Wilderness closely matches that of the observed average (if this is not the case, subsequent welfare calculations will not be able to reflect the average visitation rates of the sample). This factor is necessitated by the consequence that the negative binomial model, while a member of the linear exponential family for fixed and known θ (Gourieroux et al.), will not necessarily reproduce the average count when θ is estimated simultaneously with the conditional mean. In the empirical model, it is seen that this penalty function only slightly decreases the likelihood from the unconstrained specification. Further, the impact of this penalty on the calculated robust (as per White) standard errors is investigated by also obtaining bootstrap standard errors. Table 2 indicates that both sets of standard errors correspond closely. In the one case where they differ substantially (the Mixed Pine variable), the calculated standard error suggests a more liberal confidence interval.

The multinomial Dirichlet negative binomial was compared to the corresponding multinomial negative binomial model with the identical number of parameters. This latter model's log likelihood value was –1351.92 at convergence. The models differ only in the distributional assumption underlying the conditional distribution of site specific trips and thus are non-nested. Vuong's test of the superiority of the multinomial Dirichlet versus the multinomial specification yielded at test statistic of 3.04 which is distributed as standard normal under the null of no difference between the models. Thus we conclude with greater than 99% confidence that the multinomial Dirichlet better represents the data generating process.

Most of the ecosystems are positively valued as are high trails and campgrounds near the trailhead. Both sheep and cattle grazing have a negative impact on the utility of a backcountry hiking trip. Because the unit of observation is the residential zip code, the logarithms of the populations of these zip codes entered the model and were assigned parameters which could vary by destination. The rationale for the inclusion of the populations centered on the idea that more metropolitan origins likely focused their trips on the more well known trails. The coefficients on the Pn(j) variables show a diverse pattern of preferences for trails based on population of the zip code origin and generally support the notion that those from more populated areas have the propensity to visit the better known trails.

A variety of grazing scenarios could be examined using this model. We chose to examine the impacts of grazing bans on a trail by trail basis looking at sheep and cattle both individually and together. The reason for analyzing the impacts on a trail by trail basis is that the impacts of grazing depend in part on what other characteristics are on the trail. It's not only how many animals but where they are grazed. Table 3a provides these results. The first two columns of Table 3a show the current level of grazing by trail. Trails not listed in the table currently do not allow grazing. Cattle grazing is limited to Burt Canyon, Molybdenite Creek and Buckeye Creek. A total of 1354.2 AUMs (animal unit months) per year were allowed in the early 1990's. Sheep are grazed on Burt Canyon (in addition to the cattle), Leavitt Meadows, Poore Lake, Emma Lake, and Tamarack Lake. A total of 4153.5 AUMs per year of sheep have grazed in the wilderness over the last three years. It should be noted that while a cattle AUM is usually about one animal a sheep AUM consists of *five* head of sheep. So the *total number of sheep* in the wilderness could approach 20,000 head depending on the number of days that animals are grazed.

As the third column of Table 3a shows clearly the willingness-to-pay by hikers to remove cattle from the wilderness varies widely by trail. Burt Canyon shows a loss of $7,316 for all hikers visiting the Hoover Wilderness Area. Cattle grazing at Molybdenite Creek, with same number of cattle AUMs, results in losses of over $14,542. The total losses from all cattle grazing is estimated to be about $30,000. Sheep pose a more extreme picture. Leavitt Meadows is currently grazed by 1189 AUMs of sheep each year (the number of animals present at any given time would depend on the number of months sheep are grazed). The total losses from Leavitt Meadows are almost $124,000 per year. The reason for this substantial loss, and probably the large number of sheep, is that Leavitt Meadows contains a 100 acre riparian/meadow. As will be shown below riparian areas are highly valued by hikers. Removing sheep from Leavitt Meadows results is a large increase in the value of Leavitt Meadows to hikers. Comparatively speaking, the other losses are small.

A final observation about the Burt Canyon trail is useful. The cattle and sheep estimates presented above were for removing one kind of grazing but leaving the other. The final column shows the value of removing both kinds of grazing simultaneously. As you can see the value is about $42,000. This is sharply higher than the combined individual cattle and sheep estimates. This result has a straightforward interpretation however. Given that 780 AUMs of sheep are still there, removing the cattle is only worth $10,975. The *marginal* effect of removing cattle alone is small. The same argument applies to sheep. If, however, all grazing is curtailed at this site, then the sum of the two effects dominates the welfare change since now there is a complete absence of grazing on the trail.

In order to attach any policy significance to the welfare measures associated with removing grazing at a subset of the trails in the Hoover Wilderness we require benchmarks against which to compare these values. Table 3 recognizes that removing grazing can generate direct economic losses to permit holders and government agencies. While the loss in agency revenue can be easily calculated, welfare losses of permit holders require special treatment. A recent paper by Lambert and Shonkwiler has estimated the surplus under the derived demand curves associated with grazing permits over the time period analyzed. Their methods implicitly account for the non-fee costs incurred by permit holders since these costs are typically substantial relative to the grazing fee. By comparing values between Tables 3a and 3b, it is seen that at just two sites do welfare losses of hikers much exceed the revenues of the agency and the surpluses of the livestock grazers. And of those two, only grazing at Leavitt Meadows results in statistically significant net welfare losses to hikers (i.e. the 95% confidence interval for hiker welfare losses does not include the estimated losses in agency revenues and producer surplus). This result is a consequence of the ecosystem components that comprise each of the trails.

The model can then be used to the value of the ecosystems. Like the grazing, the value of the ecosystems will depend on what other characteristics are on the trail. For ecosystem valuation, the value of the ecosystem across pertinent trails is calculated rather than the total value of the ecosystem on a given trail. The values are estimated by increasing the quantity of each ecosystem on trails where that ecosystem is present by one acre and calculating the change in aggregate willingness-to-pay. Table 4 shows the results. The surplus/acre measure represents an average (across trails) marginal value of a one acre increase in the ecosystem since as many acres are added as there are trails possessing that ecosystem. These results sharply illustrate the value of riperian or meadowland to back country hikers.

Table 4. Per-Season Surplus for One Acre Increases in Existing Ecosystems

	Jeffrey Pine	Riperian	Mixed Pine	Rocky Alpine
Total Surplus	$75.04	$869.90	$ -7.16	$60.78
Acres Added	3	5	5	12
Surplus/Acre	$25.01	$173.98	$ -1.43	$ 5.06

CONCLUSION

One of the issues facing public land managers is the prioritization of those activities which may simultaneously compete for the same public areas. A pressing issue today is the appropriate level of grazing on public lands, especially those that have alternative uses. This analysis has examined i) the willingness-to-pay by backcountry hikers in the Hoover Wilderness Area to remove grazing from hiking trails and ii) the value of some Sierra ecosystems to back country hikers. The results indicate that damages to hikers varies considerably from trail to trail in the wilderness. The differences are primarily driven by the other characteristics at the trail. High country grazing by either sheep or cattle causes much lower damages than competition in riparian areas. On the Leavitt Meadows trail losses from sheep grazing are estimated to be about $124,000 annually. This is the direct result of the high value that hikers place on the 100 acre Leavitt Meadow. Welfare losses due to sheep grazing in other areas, while certainly constituting statistically significant damages, are at least an order of magnitude smaller. The increase in hiking activity is generally modest except for the change forecasted for Leavitt Meadows.

At least several limitations to this study are important to note. One is that the model cannot identify the intra-seasonal timing and patterns of hiking activities at the various trails which may result from the physical presence of livestock grazing in the Hoover Wilderness. Secondly, because of the nature of the data available, the calculation of the travel cost variable is crude and welfare effects can not be ascribed to the individual or household level. And while Leavitt Meadows does possess a wetland area which is apparently highly valued by backcountry hikers, whether the Forest Service has the ability to shift grazing from this area as per Ex. Ord. No. 11990 is as of this time an unresolved issue. Finally the use of the incomplete demand system to value changes in site attributes is proper as long as the marginal willingness to pay for quality changes can be completely recovered from the incomplete system.

Table 2. Multinomial Dirichlet-Negative Binomial Model. Log likelihood: -1244.98[a]

Variable	Coefficient	Std.Error	"t-value"	Bootstrap Std.Error[b]
Travel cost	-0.0183	0.0016	-11.3865	0.0018
Jeffrey/Pond. Pine(100 ac.)	0.2653	0.0577	4.5953	0.0565
Cattle AUMs $(100)^{1/2}$	-0.8846	0.1766	-5.0083	0.1921
Sheep AUMs $(100)^{1/2}$	-0.5892	0.0756	-7.7886	0.0588
Riperian /Meadow(100 ac.)	2.0737	0.5422	3.8243	0.3559
Mixed Pine (100 ac.)	-0.0152	0.0163	-0.9316	0.0082
Rocky Alpine (100 ac.)	0.0672	0.0150	4.4648	0.0142
Highest Elev. (100 ft.)	0.0047	0.0026	1.7968	0.0025
Campground (yes=1)	0.2910	0.1907	1.5260	0.2192
Log of Scale(δ)	-1.0333	0.1641	-6.2982	0.1543
Variance(θ)	0.6318	0.0439	14.4029	0.0434
Pn1	0.6662	0.1399	4.7620	0.1245
Pn2	0.1020	0.1355	0.7524	0.1291
Pn3	0.1407	0.0964	1.4604	0.0973
Pn4	0.3399	0.0790	4.3007	0.0811
Pn5	-0.8110	0.1136	-7.1419	0.1256
Pn6	0.2998	0.0682	4.3937	0.0705
Pn7	0.2957	0.0697	4.2403	0.0731
Pn8	-0.3215	0.0868	-3.7057	0.0863
Pn9	-0.4241	0.1004	-4.2238	0.0993
Pn10	0.6216	0.0663	9.3749	0.0671
Pn11	0.3856	0.0793	4.8604	0.0842
Pn12	-0.4187	0.1983	-2.1118	0.2191
Pn13	-0.6127	0.1926	-3.1810	0.2203
Pn14	-0.4257	0.1212	-3.5133	0.1202

[a]Penalized estimator. Unpenalized log likelihood: -1243.86

[b]Based on 400 samples

Table 3a. Total Per-Season Welfare Gains for Hikers: MnD-Nb **Incomplete Demand System**

Trail Name	Current Cattle AUMs	Current Sheep AUMs	Remove Cattle	Remove Sheep	Remove Both Cattle and Sheep
Burt Canyon	**545.6**	**780.0**	**$7,316** (3097-2328)[b]	**$4,437** (2423-6847)	**$42,354**[a] (19703-147059)
Molybdenite Cr.	**545.6**		**14,542** (6511-45828)		**14,542**
Buckeye Creek	**263.0**		**8,306** (3999-20339)		**8,306**
Leavitt Meadows		**1189.0**		**123,862** (72658-200274)	**123,862**
Poore Lake		**780.0**		**353** (157-824)	**353**
Emma Lake		**780.0**		**360** (148-701)	**360**
Tamarack Lake		**624.5**		**1,055** (609-1750)	**1,055**
Wilderness Totals	**1354.2**	**4153.5**	**$30,164**[a] (14042-90380)	**$130,067**[a] (77727-209895)	**$190,832**[a] (115053-356910)

[a]Value reflects multiple amenity changes
[b]Bootstrap 95% confidence interval based on 200 samples

Table 3b. Revenues and Surplus Measures Accruing to Non-recreationists Per-Season

Trail Name	Current Cattle AUMs	Current Sheep AUMs	Agency Revenue[a]	Surplus of Producers[b]	Total
Burt Canyon	545.6	780.0	$2,651	$19,957	$ 22,608
Molybdenite Cr.	545.6		1,091	15,277	16,368
Buckeye Creek	263.0		526	7,364	7,890
Leavitt Meadows		1189.0	2,378	7,134	9,512
Poore Lake		780.0	1,560	4,680	6,240
Emma Lake		780.0	1,560	4,680	6,240
Tamarack Lake		624.5	1,249	3,747	4,996
Wilderness Totals	1354.2	4153.5	$11,015	$62,839	$73,854

[a]Computed at $2 per AUM
[b]Computed at $28 per AUM for cattle and $6 per AUM for sheep (Lambert and Shonkwiler)

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