Estimating Recreation Visitation Response to Forest Management Alternatives in the Columbia River Basin

Donald B.K. English
USDA- Forest Service
Athens, GA

Amy Home
USDA- Forest Service
Portland, OR

Abstract. To evaluate how forest management alternatives affect recreation visitation, managers need to know both the changes in demand for the sites being altered and the general changes in regional recreation trip production. This paper shows one way to obtain that information. Trip-generation models developed for the United States Forest Service's national assessments of recreation are combined with site-demand models to create a two-equation system. The system predicts visitation changes stemming from changes in resource management. Empirical application is made to levels of road closure on Federal lands in the Columbia River Basin (U.S.A.). Acres of roaded National Forests affect both visitation to that forest and regional supply of recreation opportunities, which affects recreation trip generation.

Keywords. recreation demand, ecosystem management, visitation model

Résumé. Afin d'évaluer comment différentes alternatives de gestion des forêts touchent l'usage récréatif, il faut à la fois determiner comment changent la demande des sites et la production régionale de visites récréatives. Cet article montre comment obtenir cette information. Des modèles créés pour l'estimation des visites récréatives par le United States Forest Service sont combines à des modtles de demande de site pour créer un système à deux equations. Le système prédit que des changements dans la demande sont issus de changements dans la gestion des forêts. La fermeture de routes sur des terres fédérales dans le Columbia River Basin (U.S.A.) constitue une application empirique du modèle. L'accés à des hectares de forêts nationales par la route

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a un effet sur la visite de ces forêts et sur l'offre d'opportunitts récréatives qui, à leur tour, touchent la production de voyages récréatifs.

Mots clefs. la demande récréative, gestion d'ecosystème, modèle d'usage

Implementing a new management philosophy on a large land base will likely change the amounts of most outputs produced thereon, including timber, wildlife, minerals, and recreation. Economic evaluations of proposed management changes are often based on estimated changes in net economic value and/or regional economic impacts, summed across all affected outputs. Thus, accurate evaluations require linking management of resource attributes to production of each output. One prime example of such a management shift in the United States is the implementation of Ecosystem Management (EM) on National Forest (NF) and Bureau of Land Management (BLM) lands. The goal of EM is to maintain and restore ecological processes needed to sustain ecosystem composition, structure, and function while providing goods and services to people (Christensen et al., 1995). It may entail a variety of management changes, including closing roads to protect aquatic and wildlife habitats, altering timber harvest regimes, and restricting recreation use (Jensen & Everett, 1993).

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) is an effort which is intended to develop an EM plan for 58 million hectares (144 million acres) of Forest Service (FS) and BLM lands. The study area covers essentially all of Idaho, western Montana, eastern Oregon, and Washington to the Cascade Mountains' crest, and some ecologically related portions of Nevada, Utah, and Wyoming (Figure 1). Over half of the area is administered by 35 National Forests and 17 BLM districts. State governments, 13 National Park Service units, 15 National Wildlife Refuges, and other federal agencies manage 5% of the area. Private landowners hold 38% of the land area and Native American Tribes control 4%.

It is difficult to quantify the effects of instituting EM at this scale on recreation visitation and the associated economic benefits. The primary barrier lies in estimating the effects of management shifts at a regional scale on recreation visitation at each of the many sites in the area. Most models of recreation-site demand or of recreation participation are alone only partially suited to this type of application.

Figure 1
Counties in the United States within the Interior Columbia River Basin

Regional and national efforts to project recreation participation, such as the FS Resource Planning Act (RPA) Assessment for Outdoor Recreation and Wilderness (Cordell, Bergstrom, Hartmann, & English, 1990; English, Betz, Young, Bergstrom, & Cordell, 1993), are generally designed to estimate total recreation by origin. These aggregate models estimate either total recreation demand, i.e., the number of trips taken to all available recreation sites (Cordell & Bergstrom, 1991), or participation, i.e., the number of participants in the activity (Flather & Hoekstra, 1989; Hof & Kaiser, 1983; Walsh, John, McKean, & Hof, 1992). In either case, predictor variables include the size or characteristics of the general population and the amount of recreation resources available to the population centres. However, these types of models generally have not attempted to explain the distribution of recreation activity across sites.

Recreation-site demand models are often formulated as single-site travel-cost models. Most of these are developed for the primary purpose of estimating the net economic values for visitation at a single site such as a lake, a park, or a wilderness area (Kealy & Bishop, 1986; Ward & Loomis, 1986). Only as a secondary goal do these models predict the number of trips taken to the target site, and then only if surrounding population characteristics are known (Fletcher, Adamowicz, & Graham-Tomasi, 1990). Further, since data are collected at only one site, variations in site quality or management characteristics cannot be evaluated.

In contrast, multiple-site travel-cost models can be used to predict changes in recreation visitation as a result of changes in site characteristics (Mullen & Menz, 1985; Rosenthal, 1987; Wetzstein & Green, 1978). However, many of these models include all of the determinants of site visitation in one equation. As a result, coefficients represent the combined effect of resource management changes on trip generation and trip distribution. Rosenthal's (1987) model explicitly divides the visitation equation into a trip-generation component and a trip-distribution component. In that regard, we follow Rosenthal's work, although we separated trip generation and distribution into two equations.

This paper outlines the method used for predicting visitation levels for the ICBEMP under various management directions that would lead to different mixtures of recreational opportunities. The goal was to project future visitation to each recreation management unit in the Basin given projected changes in population and resource management. The largest management decision, and the one highlighted here, pertained to road closures on FS and BLM lands. Our approach was to combine both a site-demand model and a trip-generation model into a two-equation system. The following section describes the modelling framework. Next, we briefly describe the steps used to evaluate the effects of a set of management changes, and present an empirical example. Finally, we discuss limitations and future extensions of this work.

Modelling Framework

As noted above, a two-equation system was used to model the effect of road closures on visitation. The first equation followed the FS-RPA model (Cordell & Bergstrom, 1991; English et al., 1993) and predicted the number of trips originating from each county in seven northwestern states (Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming) as a function of resource and population characteristics. Population characteristics included age, income, and proportion of county population living on farms. Detailed descriptions of the variables, models, and results can be found elsewhere (Cordell & Bergstrom, 1991; English et al., 1993). These models show that a change in recreation opportunities at a particular management unit (such as a National Forest or BLM District) will affect the number of recreation trips made by people living in a number of nearby counties because of the change in the regional supply of available recreation opportunities.

The second equation followed the format of a multiple-site travel-cost model (Mullen & Menz, 1985; Rosenthal, 1987). This equation modelled visitation to a management unit as a function of resource characteristics and the number of trips (estimated in the first equation) generated by all counties within the management unit's market area. As a result, changes in trip generation from any one county could lead to changes in visitation to a number of management units. Conceptually, our model can be specified as:

$$T_i = f\ (RES_1, \ldots, RES_M, POP_i, SUBR_i) \quad (1)$$

$$V_j = g(T_1, \ldots, T_N, RES_j) \quad (2)$$

where T_i is the number of trips generated in each of M population centres (counties, in this case), POP_i are each population centre's demographic characteristics, and $SUBR_i$ are substitute resources. The number of visits to each of N management units are V_j, and RES_j *are the* recreation resources at each unit.

'hip-Generation Data

Our first step was to construct the dependent variable for our first equation using coefficients and data from the 1989 RPA Assessments of Outdoor Recreation and Wilderness (Cordell et al., 1990; English et al., 1993). We focused on activities relevant to public land managers in the Columbia River Basin. We aggregated specific activities into activity types to match the categories of recreation visitation data currently gathered by management units in the Basin (Table 1). Statewide trips estimated for each recreation activity using RPA equations were compared to state-level household-trip production estimates from a 1987 survey of a random sample of 678 households in Washington, Idaho, and Oregon (Hospodarsky, 1987). Correction factors were calculated to equate RPA trip estimates to statewide participation means from the three-state survey and divided into each county's estimated number of trips. Correction factors varied depending on whether the activity occurred in developed land (1.27), dispersed land (1.69), water (0.91), or winter (2.18) settings.

Table 1
Activity Definitions Used in RPA Recreation Models and in Models for the Interior Columbia Basin Ecosystem Management Project

Activities in Basin	Activities modelled for RPA
Trail use	Bicycling, day hiking, horseback riding, backpacking, walking for pleasure
Camping	Developed camping, primitive camping
Non-motor boating	Rafting, kayaking, canoeing, sailing
Viewing wildlife	Photography, nature study, wildlife viewing
Day use	Picnicking, family gathering, visiting historic sites, museum visits, visiting prehistoric sites, lake swimming, collecting forest products
Motor boating	Water skiing, motor boating
Motor viewing	Sightseeing, pleasure driving
Off-road driving	Off-road driving
Winter sports	Downhill and cross-country skiing
Snowmobiling	Snowmobiling
Fishing	Fishing
Hunting	Hunting

Because RPA recreation equations did not estimate hunting or fishing, we constructed trip-origin estimates for these activities using coefficients published by Walsh et al. (1992). These logit equations use population variables for county aggregates comparable to those used in the RPA equations (e.g., county median age rather than individual's age, or mean household income rather than the percentage of households with more than **$30,000** annual income). We developed a probability value for each county in the seven-state area and interpreted it as the percentage of persons in each county who engaged in hunting or fishing. Our initial estimates of participation rates from the **logit** equations were corrected to conform to more recent statewide participation rates (Claritas Corporation, 1994). Multiplying the number of participants by state-specific mean number of trips per participant from the 1991 National Survey of Fishing and Hunting produced estimates of hunting and fishing trips from each county. Table 2 shows the number of trips generated for each recreation activity for both people living in the Basin and others in the seven-state region.

Table 2
Mean Number of Annual Trips Per Participant for Hunting and Fishing, for CRB States

State	Hunting	Fishing
Idaho	9.923	19.078
Montana	9.983	17.748
Nevada	6.604	33.447
Oregon	7.156	20.608
Utah	5.840	21.009
Washington	9.632	23.145
Wyoming	6.126	16.059

Relating Trip Generation to Basin Supply

Our first equation estimated the relationship between recreation opportunities affected by EM and recreation trips generated by counties in and around the Basin. We needed to estimate this equation because the recreation resource variables affected by EM in the Basin were not the same as those used either in RPA modelling or the fishing and hunting **logit** models. Had they been identical, the data and coefficients from those efforts would have been sufficient. The resource variables were acres of land in three Recreation Opportunity Spectrum (ROS) categories. Primitive/semi-primitive lands (including wilderness areas) were natural appearing, of moderate to large size, and had road densities under 1.7 miles per square mile. Roaded natural areas had moderate evidence of human activity generally in harmony with the natural environment, and road densities between 1.7 and 4.6 miles per square mile. Rural/urban settings were substantially modified from the natural environment, with moderate to high density of visitors and road densities over 4.6 miles per square mile; many of these were ski areas. To integrate recreation activity with ecosystem characteristics, we included variables indicating the acres of several ecological types in the origin county. These variables accounted for the county's proximity to ecological units with different capacities to produce opportunities for particular recreation activities. The model used was:

$$\ln(T_i) = a + \beta RES \tag{3}$$

where

T_i = recreation trips generated from origin i;

a = constant equal to coefficients (fixed) and population characteristics used in constructing T_i;

β = coefficients estimated in the regression for resource variables;

RES = a set of variables describing the amount of recreation resources available to county i, including all of the following:

- FSPSP = distance weighted measure of FS acres in PSP-ROS class available to county i;
- FSRN = distance weighted measure of FS acres in RN-ROS class available to county i;
- FSRU = distance weighted measure of FS acres in RU-ROS class available to county i;
- BLMPSP = distance weighted availability of BLM acres in PSP-ROS class for county i;
- BLMRN = distance weighted availability of BLM acres in RN-ROS class for county i;
- FWSAC = distance weighted availability of FWS acres in all ROS classes for county i;
- NPSAC = distance weighted availability of NPS acres in all ROS classes for county i;
- M242, M331, M332, B331, B342 = acres of these ecoregions in county i, as defined by Bailey, Avers, Rind, & McNab (1994).

Resource acreage measures represented the sum of acres in each management unit, weighted by a declining function of the distance to that unit from the origin county. The distance function was determined from visitor travel patterns to several sites in the Basin, combined with expert judgment about the minimum distance visitors usually travel for recreation in different settings. The distance function was:

for PSP:	1	if d_{ij} S.8;
	$1.117 * \exp(-1.17 * (d_{ij} - .8))$	if $.8 < d_{ij} < 7$;
	0	if $d_{ij} \geq 7$
for RN:	1	if $d_{ij} \leq .5$;
	$1.117 * \exp(-1.17 * (d_{ij} - .5))$	if $.5 < d_{ij} < 7$;
	0	if d_{ij} 27
for RU:	$0.9777\ 1 * \exp(-0.9777\ 1 * d_{ij})$;	if $d_{ij} < 7$;
	0	if $d_{ij} \geq 7$;

where d_{ij} is the straight line distance between locations i and j measured in hundreds of miles, plus a 20% **circuity** factor. Combining the distance function with acreage amounts allowed computation of a resource measure for any county. For example, for FS-PSP lands the measure was:

$$FSPSP_i = \sum_j AC_j * DECAY_{ij} \tag{4}$$

where

AC' **=** acres of FS-PSP land, for management unit j; and
$DECAY_{ij}$ = distance function as outlined above.

A double-log model was used to estimate parameters. Results of the regression for the first equation in our system are shown in Table 3. For most activities, the coefficients for FS and BLM lands show that **roaded** natural lands are more positively associated with recreation-trip production than either completely undeveloped or completely developed lands.

Modelling-Site Visitation

Recreation visitation by activity type and ROS class was requested from each management unit in the Basin. Seventy-five percent of the 88 units provided usable data. Some units did not report visitation in certain ROS classes (notably BLM in the rural-urban category), and a few did not report certain activities. Missing values were not used, but

Table 3
Results of Trip Origin Modelling, for Counties in CRB States (N = 245)

Variable (t-value)	Trail use	Camping	Winter use	Non-motor boating	Viewing wildlife	Day use	Motor viewing	Motor boating	ORV use	Snow-mobiling	Hunting	Fishing
	Activity											
Intercept	-27.6484	-25.1517	-11.8022	6.5797	-18.8536	-13.2340	5.4521	7.9419	-1.6964	-42.5251	5.73099	6.536189
	(-4.817)	(-4.799)	(-3.297)	(1.487)	(-2.985)	(-4.200)	(5.100)	(1.772)	(-1.256)	(-5.866)	(2.449)	(2.680)
FWAC	-1.7878	-3.7973	-2.1086	1.4334	-1.6862	-3.0247	-0.6522	2.1706	-1.1099	-5.5486	-0.59022	-0.209634
	(-4.454)	(-4.641)	(-3.118)	(2.076)	(-1.482)	(-5.081)	(-3.388)	(2.564)	(-4.434)	(4.087)	(-1.347)	(-0.551)
NPSAC	-0.9384	-2.1797	-0.8886	0.1314	-1.2599	-1.0077	-0.2607	-0.4929	-0.4770	-0.7493	a.43998	-0.524260
	(-1.617)	(-4.636)	(-2.430)	(0.331)	(-1.995)	(-3.130)	(-2.439)	(-1.077)	(-3.349)	(-1.023)	(-1.860)	(-2.397)
BLMPSP	12.3334	5.3993	5.9140	-5.1752	4.0149	6.6858	-0.8607	-5.2683	0.5049	15.9436	-1.09792	1.582705
	(3.949)	(2.133)	(3.057)	(-2422)	(1.229)	(3.926)	(-1.557)	(-2.176)	(0.673)	(4.041)	(-0.862)	(-1.344)
BLMRN	-16.3894	-1.4608	-6.0268	6.6977	0.2355	-3.6778	1.1338	11.4243	0.1081	-21.3890	3.4991	3.275967
	(-3.915)	(4.5%)	(-2.218)	(3.238)	(0.072)	(-1.538)	(2.047)	(3.359)	(0.103)	(-4.045)	(2.050)	(2.874)
M242SUP	0.2094	—	0.0210	—	0.3360	0.3504	0.0500	-0.5272	0.1071	1.1099	0.04479	-0.545778
	(0.305)		(0.050)		(0.500)	(0.938)	(0.440)	(-0.992)	(0.641)	(1.280)	(0.160)	(-2.615)
M261SUP	—	-0.4977	-0.9650	-1.4449	-1.5728	-0.3892	0.1482	-0.4677	0.0034	—	—	—
		(-1.110)	(-2.981)	(-3.817)	(-2.902)	(-1.366)	(1.617)	(-1.154)	(0.027)			
M331SUP	0.9167	0.8295	0.7580	0.1010	0.8251	0.4982	0.0315	0.2807	0.1812	1 .2298	0.09245	0.171539
	(3.519)	(3.552)	(4.505)	(0.513)	(2.895)	(3.363)	(0.655)	(1.333)	(2.773)	(3.738)	(0.870)	(1.579)
M332SUP	-4.9743	-6.5136	-4.6701	-2.5602	-6.4240	-3.5328	-0.4934	-3.6873	-1.2049	-3.7869	-236972	-2.816056
	(-3.245)	(-5.2%)	(-4.627)	(-2.466)	(-3.791)	(-3.976)	(-1.721)	(-2.919)	(-3.183)	(-1.956)	(-3.791)	(-4.921)
M333SUP	—	0.1419	—	0.3070	0.1961	—	0.0616	—	0.0482	—	—	—
		(0.546)		(1.400)	(0.618)		(1.147)		(0.945)			

B331SUP	-0.4679 (-1.169)	-0.7739 (-1.561)	-0.1893 (-0.765)	0.2526 (0.604)	-0.3191 (-0.532)	-0.2146 (-0.986)	0.0764 (0.754)	0.2079 (0.671)	—	-1.2317 (-3.436)	0.23318 (1.429)	0.047066 (0.389)
B342SUP	6.7620 (2.238)	—	3.1030 (1.643)	—	—	-0.2608 (–0.157)	—	-4.8019 (-2.03 1)	0.0731 (0.099)	7.6025 (1.992)	(-0.958)-1.17998	0.181865 (0.788)
FSPSP	–0.1431 (-0.085)	2.5936 (2.239)	0.2503 (0.241)	-1.4362 (-1.469)	1.4073 (0.911)	0.65 12 (0.711)	0.3293 (1.259)	2.0029 (1.538)	0.3069 (0.755)	-1.2270 (4.579)	1.61076 (2356)	1.110902 (2.061)
FSRN	10.3164 (6.137)	7.4220 (5.979)	6.0468 (5.730)	1.5702 (1.499)	5.9655 (3.990)	5.4608 (5.879)	0.4481 (1.771)	-1.2764 (-0.966)	1.7923 (4.348)	11.7559 (5.537)	0.340080 (0.4%)	0.856940 (1.484)
FSRU	-1.7375 (-1.882)	-0.2748 (-0.481)	-0.5222 (-0.907)	-0.2239 (-0.465)	-0.7259 (-0.751)	-1.0585 (-2.089)	-0.1901 (-1.163)	0.9829 (1.364)	-0.3288 (-1.551)	-2.0146 (-1.728)	-0.01738 (-0.046)	0.099133 (0.373)

Variable definitions are:

FWSAC	distance weighted availability of Fish and Wildlife Service acres in all ROS classes for county i;
NPSAC	distance weighted availability of National Park Service acres in all ROS classes for county i;
BLMPSP	distance weighted availability of Bureau of Land Management (BLM) acres in PSP-ROS class for county i;
BLMRN	distance weighted availability of BLM acres in RN-ROS class for county i;
M242SUP	acres in Pacific mixed forest ecoregion, in mountains, in county i;
M261SUP	availability of Coastal Chaparral Forest, in mountains;
M333SUP	availability of Northern Rocky Mountain Forest, in mountains;
M33 1 SUP	acres of Great Plains-Palouse ecoregion, in mountains, in county i;
M332SUP	acres of Great Plains-Steppe ecoregion, in mountains, in county i;
B331SUP	acres of Great Plains-Palouse ecoregion, in county i;
B342SUP	acres of Intermountain semi-desert ecoregion in county i;
FSPSP	distance weighted measure of Forest Service (FS) acres in Primitive-semiprimitive ROS class available to county i;
FSRN	distance weighted measure of FS acres in Roaded Natural (RN) ROS class available to county i;
FSRU	distance weighted measure of FS acres in Rural-Urban ROS class available to county i.

Table 4
Results of Site Visitation Modelling, for Federal Management Units in the CRB

	Activity											
Variable (t-value)	Trail use	Camping	Winter use	Non-motor boating	Viewing wildlife	Day use	Motor viewing	Motor boating	ORV use	Snow-mobiling	Hunting	Fishing
constant	-19.5480	-16.5410	-11.920	-3.5119	-13.5830	-11.187	-27.664	-2.7685	-4.9234	4.4520	-10.389	-18.782
	(-2.615)	(-3.095)	(-1.340)	(-2.620)	(-1.654)	(-1.282)	(-2.455)	(-1.785)	(-4.020)	(-3.826)	(-1.416)	(-2.358
NPS	—	1.0830	—	-1.0183	-3.7771	3.2333	-1.7349	-0.2655	-0.9133	-0.3956	-1.8311	-0.95917
		(1.209)		(-1.069)	(-3.785)	(2.619)	(-1.692)	(-0.241)	(-0.945)	(-0.431)	(-1.874)	(-0.874)
FS	2.8605	1.9857	5.0218	2.0271	—	2.6204	2.4828	-0.9788	3.0371	4.5965	2.4485	2.5331
	(3.015)	(2.752)	(4.787)	(2.645)		(1.842)	(3.018)	(-1.103)	(2.724)	(4.339)	(2.183)	(2.007)
BLM	0.8550	—	2.3941	—	-3.4908	0.1255	-5.7552	—	2.8030	1.5244	2.3477	1.6986
	(0.772)		(1.958)		(-3.735)	(0.079)	(-3.5 17)		(2.263)	(1.2%)	(1.824)	(1.173)
PRIM	-3.2884	-6.0355	-4.1017	-3.8232	-1.2810	-4.0792	-0.5870	-6.1578	-2.1129	-2.1263	3.5563	1.7429
	(-2.275)	(-4.387)	(-2.538)	(-2.643)	(-0.911)	(-2.236)	(-0.413)	(-3.678)	(-1.494)	(-1.582)	(1.563)	(0.684)
ROADNAT	-2.6084	-5.0100	-2.30%	-0.4267	0.9827	-0.8240	0.9567	-2.9448	-0.4662	-0.0399	0.73560	-1.1787
	(-1.961)	(-4.133)	(-1.569)	(-0.334)	(0.776)	(-0.492)	(5.015)	(-1.994)	(-0.358)	(-0.032)	(0.549)	(-0.789)
LNAC	1.0711	1.4610	0.7347	0.7230	0.5191	0.8443	-0.5591	0.9238	0.7545	0.6484	0.67978	0.91313
	(5.090)	(8.756)	(3.167)	(4.092)	(2.928)	(3.161)	(-0.351)	(4.517)	(3.603)	(3.259)	(3.200)	(3.830)
M242	2.5321	1.4365	0.1182	0.3898	-0.4253	-0.4235	3.6741	0.9113	-1.7295	0.2082	-5.1233	-4.7208
	(1.886)	(1.032)	(0.80)	(0.274)	(-0.272)	(-0.251)	(3.049)	(0.553)	(-1.370)	(0.174)	(-2.380)	(-1.942)
M331	—	—	—	—	—	—	—	—	—	—	-5.6670	-5.9957
											(-2.619)	(-2.460)
M332	2.5885	1.7484	1.6220	0.8252	1.6436	2.2428	0.3818	0.0298	3.0435	2.2406	-1.4278	-2.1549
	(2.548)	(1.654)	(1.440)	(0.735)	(1.346)	(1.766)	(0.292)	(0.023)	(3.056)	(2.368)	(-0.812)	(-1.090)

M333	1.3294	0.7155	−0.6126	1.6234	1.8139	2.1522	1.8587	1.3250	−0.8856	−0.1402	−2.0518	−2.0704
	(1.202)	(0.621)	(−0.504)	(1.336)	(1.386)	(1.555)	(2.165)	(0.942)	(−0.821)	(−0.137)	(−1.259)	(−1.131)
B342	—	—	—	—	—	—	—	—	—	—	−4.1997	−4.5167
											(−2.062)	(−1.970)
TRIPS	0.9127	0.6953	0.5924	—	0.8838	0.6344	—	—	—	—	0.55147	1.0085
	(1.910)	(1.935)	(0.956)		(1.705)	(1.099)					(1.018)	(1.879)

Variable definitions are:

NPS Dichotomous variable indicating National Park Service Ownership;
FS Dichotomous variable indicating USDA-Forest Service ownership;
BLM Dichotomous variable indicating Bureau of Land Management ownership;
PRIM Indicator variable for primitive ROS class;
RN Indicator variable for roaded natural ROS class;
LNAC Natural log of acreage;
M242 Indicator variable for location in Pacific mixed-forest ecoregion, in mountains;
M331 Indicator variable for location in Great Plains-Palouse ecoregion;
M332 Indicator variable for location im Great Plains-Steppe ecoregion, in mountains;
M333 Indicator variable for location in North Rocky Mountain Forest;
B342 Indicator variable for location in Intermountain semi-desert ecoregion;
TRIPS Distance weighted summation of trips originating from counties in market area.

legitimate zero values were included and recoded to one. Because recreation visitation data are highly variable (in part due to unevenness in data collection and in part due to real variability in recreation), we averaged annual data for 199 1, 1992, and 1993, and used this average as the starting point for our projections. An observation was the reported annual number of visits to each ROS class within each management unit for a given activity. For each observation, the log of reported visitation was modelled as a linear function of the log of acreage in the unit (ACRES), the log of a measure of the activity trips generated by counties near the unit (e.g., TRAILDIS), and a set of indicator variables for ownership (FS, BLM, NPS), ROS class (PRIM, RN), and ecoregion (M242, M261, M331, M332, M333, and B342). Trip-generation measures were calculated consistently with the supply measures in equation (2). For example, the trip-generation measure for trail use was:

$$TRAILDIS_j = \sum_{i=1}^{245} TRAILTRIP_i * (\lambda e^{-\lambda d_{ij}}) \quad (5)$$

where $TRAILTRIP_i$ are the trail-use trips estimated to originate from county i, and all other variables are as previously defined. Results from these regression models are presented in Table 4.

For five activities, there was a non-significant negative coefficient for the TRIPS variable (non-motor boating, motor boating, motor viewing, ORV use, snowmobiling). This means that our model would predict that visitation at CRB management units for these activities would decline as the population grew and the number of trips generated increased. We avoided such a counter-intuitive result by deleting the trips variable from the affected equations and re-estimating. For these activities the absence of a trips variable has two consequences. First, site visitation is not affected by population-related changes. Second, site visitation will only change as a result of changes in ROS acres at that site. With the exception of motor viewing these activities are minor in importance relative to ones such as camping, day use, trail use, hunting, and fishing.

Predicting Visitation Change

Based on the results of the regressions presented in Tables 3 and 4, we were able to estimate the effect of a resource allocation at one management unit, or the joint effects of a set of changes at a number of units. Resource changes at any unit will directly affect its visitation levels, as indicated by resource coefficients in Table 4. In addition, resource changes may have an indirect effect on visitation. First, resource changes will impact trip-generation behaviour of nearby origins (see Table 3). Subsequently, changes in trip generation will affect visitation to other management units via the TRIPS variable (see Table 4). Naturally, for the five activities without a TRIPS variable in the estimated visitation equation, there is no indirect effect.

The effect of a set of resource management changes in any year could be determined via the following sequence of steps:

1. Calculate trip origin amounts for individual recreation activities based on population assumptions for the target year and starting resource conditions;
2. Calculate the effect of management changes on trip origin behaviour based on the relationships described in Table 3; and
3. Use resulting trip-origin estimates and new resource conditions to determine new visitation levels, as per Table 4.

Empirical Example

The results from our two-equation system are presented for the Deschutes and Malheur National Forest (NF). Both these forests are in Oregon east of the Cascade Mountains. The Deschutes NF lies on the east slope of the Cascades near the town of Bend and attracts recreation visitors from a broad region. One fifth of its recreation visits are to the most highly developed recreation settings (Table 5). Day uses and winter sports are particularly popular activities in this forest.

The Malheur NF is further east in the more-arid and lower-elevation Blue Mountains. Because it is more remote, this forest has less than 10% of the recreation activity on the Deschutes. Both day uses and winter sports are a smaller percentage of total recreation activity and motor viewing and hunting are a higher percentage of recreation activity than on the Deschutes.

Table 5 shows the distribution of acres on each forest between the three ROS classes. It also compares the average number of recreation visits provided by each forest with the number the model estimated given the same resources and population. The model slightly overestimated visits for boating and off-road vehicle use and underestimated hunting and fishing.

We ran the model under three different scenarios of recreation resources (Table 6). In all three scenarios we assumed demographic' pro-

Table 5
Visits Per Year Made to Deschutes and Malheur National Forests by Recreation Opportunity Spectrum Classification, Average for Years 1991-1993, and Model Estimates

Activity	Primitive/ Semi-primitive	Roaded natural	Rural and urban	Total	Model estimates 1992
Deschutes National Forest					
Trail use	55,554	63,622	113	119,289	119,289
Camping	18,336	282,861	61,360	362,557	362,557
Non-motor boating	5,958	83,870	0	89,828	90,437
Viewing wildlife	8,474	66,693	115,582	190,749	190,749
Day use	120,684	919,171	293,964	1,333,819	1,333,8 19
Motor boating	8,256	10,464	0	18,720	24,073
Motor viewing	228,196	1,085,530	35,433	1,349,159	1,349,159
Off-road vehicles	0	0	0	0	1,345
Winter sports	55,651	42,845	361,128	459,624	459,624
Snowmobiling	24,00 1	30,551	9,946	64,498	64,498
Hunting	2,571	14,735	0	17,306	14,746
Fishing	26,939	101,741	0	128,680	94,702
Total	554,620	2,702,083	877,526	4,134,229	
Malheur National Forest					
Trail use	13,546	10,669	0	24,215	24.216
Camping	9,331	3 1,706	0	41,037	41,037.
Non-motor boating	38	4,545	0	4,583	4,590
Viewing wildlife	1,081	2,534	0	3,615	3,636
Day use	11,385	26,250	0	37,635	37,768
Motor boating	0	227	0	227	835
Motor viewing	13,486	131,560	0	145,046	145,193
Off-road vehicles	4,081	15,662	0	19,743	19,752
Winter sports	1,325	6,566	0	7,891	7,912
Snowmobiling	168	7,598	0	7,766	7,791
Hunting	14,289	16,745	0	3 1,034	26,4 13
Fishing	3,884	9,267	0	13,151	9,666
Total	72,614	263,329	0	335,943	

jections for the year 2005 obtained from the U.S. Census Bureau (Campbell, 1994; Day, 1993) and McCool and Haynes (1996). In the first scenario we assumed no change in the number of acres in each of the three ROS classes. The second scenario assumed roads were closed, moving acres from the roaded natural class into the primitive/semi-primitive class. The third scenario assumed roads were built, moving acres from the primitive/semi-primitive class into the roaded natural class. These assumptions were applied uniformly across all NF and BLM units within each ecological region. The number of acres moved in each forest depended on its share of NF and BLM acres in its ecological region: 102,000 for the Deschutes and 43,000 for the Malheur.

Table 6
Acres in Recreational Opportunity Spectrum Classes, Under Three Scenarios, for Deschutes and Malheur National Forests

	Setting		
	No change in settings	Less roaded natural	More roaded natural
Deschutes National Forest			
Primitive/Semi-primitive	318,235	479,970	276,501
Roaded natural	1,204,731	1,102,997	1,306,465
Rural and urban	1,533	1,533	1,533
Total	1,584,500	1,584,500	1,584,500
Malheur National Forest			
Primitive/Semi-primitive	294,7 19	337,994	25 1,443
Roaded natural	1,164,781	1,121,506	1,208,057
Rural	0	0	0
Total	1,459,500	1,459,500	1.459.500

With no change in recreation resources, projecting demographic characteristics for the year 2005 resulted in substantial increases in day use and motor viewing, already important activities in both forests (Table 7). Changes in the road network have different effects on different forms of recreation. Road closures benefit people who participate in trail use, camping, day use, and snowmobiling. Road building bene-

Table 7
Visits Made Per Year for 12 Recreation Activities to Deschutes and Malheur National Forests, Actual Data and Model Projections for the Year 2005 with U.S. Census Demographic Projections and Modifications in Recreation Settings

		Demographic projections for the year 2005 showing the percentage change from the 1992 projections		
	Average data 199 1 to 1993 (visits/year)	No change in settings	Less roaded natural	More roaded natural
Deschutes National Forest				
Trail use	119,289	28.43	73.95	-9.83
Camping	362,557	19.33	32.23	I.22
Non-motor boating	89,828	5.24	-26.05	23.82
Viewing wildlife	190,749	21.49	20.45	22.35
Day use	1,333,819	20.69	33.02	5.88
Motor boating	18,720	6.21	4.56	5.74
Motor viewing	1,349,159	35.75	29.26	42.24
Off-road vehicles	0	8.85	3.35	14.13
Winter sports	459,624	17.11	22.24	11.88
Snowmobiling	64,498	5.25	15.37	-5.87
Hunting	17,306	8.44	12.53	3.28
Fishing	128,680	20.5 l	15.96	24.91
Malheur National Forest				
Trail use	24,215	30.24	105.97	-23.38
Camping	41,037	19.89	38.18	1.33
Non-motor boating	4,583	4.55	-24.77	21.07
Viewing wildlife	3,615	22.83	23.24	22.19
Day use	37,635	19.75	42.96	-4.46
Motor boating	227	6.35	2.99	4.43
Motor viewing	145,046	34.20	22.94	45.47
Off-road vehicles	19,743	9.20	8.55	9.72
Winter sports	7,891	21.42	30.46	12.35
Snowmobiling	7,766	6.89	16.79	-3.58
Hunting	3 I.034	10.97	13.46	8.15
Fishing	13,151	24.78	I l.62	37.43

fits people who participate in motor viewing and fishing. The relationship between fishing and road density is simply one of access; the model lacks negative feedback loops that might exist between road-building activity and fish populations. Some activities (trail use and day use) appear to be more sensitive to changes in the road network than others (viewing wildlife and motor boating). Trail use is more sensitive to changes in the road network on the Malheur NF than on the Deschutes; far greater percentage changes occur as a result of switching less than half the number of acres. This result is partly due to the lower baseline visitation for the Malheur and partly due to the greater qualitative effect of road building on the more remote character of the Malheur.

Information such as presented in these results can be useful in formulating land management decisions. A significant factor affecting recreation on National Forests outside control of land managers is changing demographic characteristics. Not only is recreation activity going to increase, particular activities (motor viewing and day use) are going to increase more rapidly than others (boating and snowmobiling). Given this overall increase in recreation activities, decisions to change the road network will likely create controversy among the recreating public. If they can understand the source and strength of support and opposition, managers can devise plans that target consensus and common ground rather than feeding conflict and controversy.

Extensions of the Model

This paper has shown how recreation-trip-generation models developed for national assessments can be linked with site-specific recreation-demand models to evaluate alternative management scenarios. Our application was for visits to parks, forests, and other large tracts of public lands within a large watershed and evaluated the effect of a general measure of road access to those public lands. There are several ways future research could extend our effort to model the effects of resource changes on visitation. One improvement would be to include other components of recreation resources besides road density, such as fish and game population characteristics, scenic condition, and biological diversity. Overlaying recreation resources with ecological descriptions in a GIS application may be one way to obtain needed data. Access could be modelled with greater complexity as well. Some types of roads support greater recreation traffic than others, notably forest roads passable by non-specialized autos. Removing these roads would have a greater impact on recreation activity than remote roads passable only by high-clearance or 4WD vehicles. This effect may also vary by activity: closing poorly maintained or rougher roads would probably have less impact on motor viewing than on hunting.

As additional measures of resource quality are incorporated, it would be beneficial to incorporate additional equations to account for linkages between management actions and those resources. For example, road-building activity and higher road densities are often positively related to stream siltation and subsequent reduction in fish populations. Fish population levels would seem to be important predictors in models of fishing recreation.

Our visitation and resource data were at rather coarse geographic scales, entire National Forests, or BLM districts. For this application, the scale was appropriate. However, many land-management planning decisions are made for subsets of these areas. Greater geographic specificity in resource and visitation data could benefit forest-level planning or planning for smaller ecosystems. Although for such alterations in scale different data would be necessary, the modelling framework we used could be employed directly.

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