Journal of Leisure Research
2012, Vol. 44, No. 2, pp. 234-256

Development, Psychometric Qualities, and Cross-Validation of the Leave No Trace Attitudinal Inventory and Measure (LNT AIM)

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Abstract

This article discusses the process undertaken to develop and validate the Leave No Trace (LNT) Attitudinal Inventory and Measure (LNT AIM), an instrument designed to measure attitudes regarding specific practices addressed by the LNT Principles for Responsible Recreation. We envision this tool being useful for determining the necessity for LNT educational programming or for evaluating existing LNT education efforts. A mailed questionnaire was used to collect data from overnight backcountry visitors who had recently visited one of two U.S. National Park Service Units during the summer, 2007. The final measurement model exhibited satisfactory psychometric fit properties across both samples and is largely consistent with the conceptual framework used to develop the measure.

KEYWORDS: Scale development, Leave No Trace, Leave No Trace Attitudinal Inventory and Measure, confirmatory factor analysis

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Acknowledgments: The first author thanks Clemson University faculty members Fran Mainella, DeWayne Moore, Bill Norman, Bob Powell, and Brett Wright for their guidance on the doctoral research from which this article is based.

Author Note: Facts and views expressed in this paper are the responsibility of the authors and do not necessarily reflect the opinions or policies of the National Park Service. The Wilderness Stewardship Division of the National Park Service funded this research.

Introduction and Purpose

Education is widely regarded as an effective visitor management strategy in wilderness and other protected area settings and is preferred over more direct methods such as sanctions or regulations for both philosophical and practical grounds (Hendee & Dawson, 2002; Passineau, Roggenbuck, & Stubbs, 1994). The most pervasive minimum-impact visitor education programs is Leave No Trace (LNT), a program designed to educate visitors regarding proper outdoor practices with the end goal sustaining or improving resource conditions. The LNT message currently consists of seven principles intended to encourage an environmental ethic and lessen human-caused impacts to the environment or the experience of other visitors. The program has been formally adopted by the four primary U.S. federal land management agencies (Bureau of Land Management, Fish and Wildlife Service, U.S. Forest Service, and National Park Service), the National Association of State Park Directors representing some 5,482 parks (Marion & Reid, 2001; www.lnt.org), the Boy Scouts of America, as well as several foreign countries including Ireland, New Zealand, Canada, Australia, Montenegro, Hong Kong, South Korea, Greece, Scotland, Argentina, Mexico, and Taiwan (www.lnt.org).

Despite widespread promotion of this important visitor education program, little research has focused on evaluating its effectiveness (Cole, 1998; Marion & Reid, 2001, 2007; Miller, Borrie, & Harding, 2001; Wright, 2000) and at present, a scale does not exist to assess attitudes towards widely promoted LNT practices. We envision such a tool as useful for determining the need for LNT educational programming or for refining existing LNT education efforts. Additionally, understanding salient attitudes regarding common outdoor practices can assist with developing more specific, refined, and targeted educational programming. To this end, this article examines the development, validation process, psychometric qualities, and cross-validation of the LNT Attitudinal Inventory and Measure (LNT AIM), a scale designed to measure attitudes regarding common outdoor practices addressed by the LNT Principles for Responsible Recreation.

Literature Review

Foundation and Evolution of Leave No Trace

The origins of the LNT message can be traced to initiatives undertaken by U.S. Forest Service (USFS) wilderness managers in the 1970s to better manage increasing visitation and associated resource impacts. These early efforts included "pack it in, pack it out" messages at primary wilderness access points (Marion & Reid, 2001). These messages became precursors to what are now considered early minimum-impact camping messages (Daniels & Marion, 2005). In 1990, the USFS teamed with the National Outdoor Leadership School (NOLS) to consolidate the various minimum-impact messages that had developed over the years into one consistent message, provide structure to emerging best practices, and develop a complementary training program (Marion & Reid, 2001). These advancements in LNT messaging were primarily based on science provided by the field of recreation ecology, "the field of study that examines, assesses and monitors visitor impacts, typically to protected natural areas, and their relationships to influential factors" (Leung & Marion, 2000, p. 23). Recreation ecology studies have examined damage to trees, campfire impacts, loss of ground cover, trampling effects, and soil compaction amongst other biophysical impacts (Cole, 1992; Cole & Spildie, 1998; Leung & Marion, 2000). While it is beyond both the scope and intent of this scale development paper to chronicle the refinement of the LNT Principles and their links to recreation ecology, the reader is encouraged to see Leung & Marion (2000), Hammitt & Cole (1998), or visit www.lnt.org for reviews of this body of research.

Leave No Trace (now the Leave No Trace Center for Outdoor Ethics or 'The Center') was incorporated as a 501(c)(3) nonprofit organization in 1994. According to its mission statement, The Center is "dedicated to the responsible enjoyment and active stewardship of the outdoors by all people, worldwide" (www.lnt.org). Also in 1994, a Memorandum of Understanding (MOU) was signed with the USFS, Bureau of Land Management, Fish & Wildlife Service, and National Park Service (NPS) to promote the LNT message on federal lands. The signing of the MOU signified the formal adoption of the LNT program as the primary visitor education tool for recreationists on federal lands and helped position LNT as the most widely promoted minimum-impact visitor education program in existence. For a full review of the history and evolution of LNT, see Marion & Reid (2001).

Leave No Trace Principles

Seven principles currently comprise the LNT message. Principle One is *Plan ahead and prepare*. This involves knowing the regulations for the area one intends to visit, taking appropriate equipment, and repackaging food to minimize waste. Principle Two is *Travel and camp on durable surfaces*. Key practices related to this principle include hiking single-file on trails, not cutting trail switchbacks, and camping where impacts already exist on surfaces durable enough to sustain impacts. The third principle is *Dispose of waste properly*. This principle addresses outdoor practices including disposal of human waste, handling of dishes and dishwater, and litter. Principle Four, *Minimize campfire impacts,* is dedicated to reducing different types of campfire impacts. LNT Principles five and six refer to respect towards other visitors (*Be considerate of other visitors*) and respect for other natural objects (titled *Leave what you find*). LNT Principle seven, *Respect wildlife*, addresses appropriate human–wildlife interactions (for further information regarding the LNT Principles, visit www.lnt.org or see Hampton & Cole, 2003).

Research into the Efficacy of Leave No Trace

Past research efforts exploring minimum-impact camping, including LNT, have focused primarily on visitors' knowledge of best practices. Fazio (1979) examined Rocky Mountain National Park visitors' knowledge of minimum-impact practices utilizing multiple-choice tests, concluding that overall knowledge levels among respondents was low. In another early study, Dowell and McCool (1986) assessed Boy Scouts' knowledge of wilderness ecology and minimum-impact practices post-participation in an education program. Results indicated that the treatment group's knowledge increased both immediately after and one month post-treatment (see also Daniels & Marion, 2005). Stubbs (1991) investigated visitors to

Shining Rock Wilderness knowledge of minimum-impact camping practices and the effectiveness of printed media (posters) on outdoor practices. He concluded that posters addressing practices such as campsite selection, tent placement, and use of stoves, increased knowledge and improved behavior (observed). Christensen and Cole (1999) examined preferences of visitors in eight different U.S. wildernesses regarding campsite locations (proximity to lakes) and the use of cook stoves. Still others have investigated human waste disposal (Cilimburg, Monz, & Kehoe, 2000), campfire impacts (Reid & Marion, 2005), travel and camping practices (Vagias & Powell, 2010), leaving what is found (Widner & Roggenbuck, 2000), and consideration of other visitors (Manning & Valliere, 2001).

Using the Theory of Reasoned Action (Fishbein & Ajzen, 1975), Reuhrwein (1998) assessed knowledge, attitudes, and self-reported behavior of backcountry recreationists in southern Utah and found nonsignificant correlations between primary study constructs. More recent contributions have included work by Newman, Manning, Bacon, Graefe, and Kyle (2003) who evaluated Appalachian Trail hikers' knowledge of minimum-impact (LNT) skills. Manning (2003), after reviewing studies by Manfredo, Yuan, and McGuire (1992) and Bright et al., (1993) and others, concluded education can effectively modify visitor attitudes and reduce depreciative behavior.

Theoretical Orientation

The predominance of previous LNT research has focused on measuring knowledge of best practices as a predictor or proxy for behaviors, however research indicates that understanding and predicting human behavior is "much more complex than knowledge alone" (Chawla & Cushing, 2007, p. 437). Hungerford and Volk (1990) and others challenge the assumption that a direct relationship exists between knowledge-based education and increases in environmentally responsible behavior. Instead, a large number of psychological and social psychological theories suggest that human behavior is driven in large part by attitudes and underlying belief structures (Ajzen, 1991; Ajzen & Fishbein, 1973; Eagly & Chaiken, 1993; Fishbein & Ajzen, 1975, Fiske, Gilbert, & Lindzey, 1998), particularly in environmental contexts (Cottrell, 2003; Kaiser, et al., 1999; Pooley & O'Connor, 2000; Roberts & Bacon, 1997; Tarrant & Green, 1999; Hungerford & Volk, 1990). A positive relationship between environmental attitudes and environmentally responsible behavior has been demonstrated empirically by Tarrant and Greene (1999), Cottrell (2003), Kaiser, Wolfing, and Fuhrer (1999), Newhouse (1990), and Roberts and Bacon (1997) amongst others. Other research substantiates the need to move away from knowledge-based assessment tools to attitudinal or belief-based measures when investigating behaviors and behavioral intentions (Ham, in press). Regarding the present investigation, consider Stubbs's (1991) conclusion that even though recreationists might know the "correct" answer regarding outdoor practices, their behavior may not consistently reflect that knowledge. Similarly, Daniels and Marion (2005) found no correlation between knowledge and behavior variables, suggesting that information may not be the most important tool in promoting appropriate behavior and suggested that ethical appeals may be more influential in modifying behavior.

There were several backcountry oriented attitudinal measures examined as part of this research, one of which was introduced by Hendee, Catton, Marlow, and Brockman (1968). The scale consisted of 30 statements designed to differentiate users based on such constructs as features, activities, and perceived benefits of a wilderness experience. The Wilderness Purism Scale was devised "to meet the need for a unit of analysis that would recognize the wide range of individual involvement, concern, and knowledge about wilderness among the respondents" (Stankey, 1973, p. 10). However, these measures lacked the specificity needed to assess attitudes regarding recommended LNT practices.

Methods

The LNT Principles were utilized throughout all aspects of the scale development process as our guiding conceptual framework. We followed scale development procedures outlined by DeVellis (2003) with additional direction from both Noar (2003) and Gould et al. (2008). The process was initiated with a comprehensive review of previous empirical investigations into LNT. Previous LNT-oriented instrumentation was collected from Belcher (2004); Cole, Hammond, and McCool (1997); Confer, Absher, Graefe, and Hille (1999); Daniels and Marion (2005); Newman et al. (2003); Reuhrwein (1998); and Stubbs (1999). Several books dedicated to minimum-impact camping practices (Hampton & Cole, 2003; Harmon, 1997) as well as LNT-specific publications, including a variety of LNT skills and ethics booklets, were reviewed. All previously developed questions and item statements were compiled and sorted by LNT Principle, resulting in an 80-item pool. We decided early on not to include LNT Principle One, Plan ahead and prepare, in the development of the LNT AIM. Our reason was that this principle addresses behaviors that occur prior to an individual engaging with the backcountry resource and we wanted to keep the focus on attitudes toward behaviors that occur in the backcountry environment. The items were refined utilizing the six "on-trail" LNT Principles, with each item written to align with a specific LNT Principle. Our end goal was to develop a set of indicators reflective of the six LNT Principles of interest (Jarvis, MacKenzie, & Podsakoff, 2003).

Several anchor-wording options were assessed, including levels of appropriateness, acceptability, agreement, and importance. The anchors *very inappropriate* to *very appropriate* were chosen after a thorough literature review because we felt *appropriateness* best reflected the primary purpose of the scale: to measure attitudes regarding the appropriateness of specific LNT recommended outdoor practices. For example, one item is *having a campfire*. Having a campfire in the backcountry has been, and will likely continue to be, common practice amongst many backcountry campers (Hampton & Cole, 2003). However, the LNT message recommends forgoing a fire to lessen environmental impact and instead cook on a stove and use a candle lantern for light. In fact, all of the items (see Table 1 for a complete list) are considered inappropriate backcountry behaviors under strict interpretation of the LNT Principles. And while the items presented in Table 1 are strongly worded, we felt it essential to do so in order to fully capture the wide variability in attitudes regarding the appropriateness of the behaviors being investigated. A 7-point scale was chosen to solicit maximum variation in scores.

A panel of eight backpacking instructors at a large southeastern university subsequently reviewed the item pool. The experience level of these instructors ranged from 4 to 15+ years in outdoor/adventure education capacities for organizations such as NOLS, Outward Bound, and university outing clubs. These instructors were selected as each integrated LNT as a core component of their courses. Reviewers were asked to independently evaluate the items against the LNT Principles for scope, clarity, and coverage and were asked to provide other additional items or wording changes they felt appropriate. Finally, the Leave No Trace Center for Outdoor Ethics Education Director reviewed items prior to pilot testing.

Pilot Testing

The items were randomized to lessen the potential for measurement bias, formatted into a questionnaire, and administered, as a pilot test, to undergraduate students at a large southeastern university (N=225). Univariate statistics were examined for measures of central tendency, including means, standard deviations, and unreasonable skew and kurtosis issues using SPSS v.15. The developing measure was hypothesized a priori to be multidimensional, thus correlations were examined amongst items within each of the six LNT Principles. In multi-item scale development, items that are highly correlated indicate a underlying latent variable (DeVellis, 2003).

The data were next analyzed using confirmatory factor analysis (CFA), a form of structural equation modeling. A CFA strategy was chosen over exploratory factor analysis (EFA) because CFA permits testing of an a priori hypothesized measurement model, accounts for sources of common measurement error, and provided empirical justification for model and scale development decisions (Byrne, 2006; Kline, 2005). Because each item was developed to correspond directly to a LNT Principle (a factor in the measurement model), a CFA procedure was warranted. Conversely, exploratory factor analysis is used when “a researcher has relatively little theoretical or empirical basis for making strong assumptions about how many common factors exist” (Fabrigar, Wegener, MacCallum, & Strahan, 1999, p. 272). A CFA approach also provides multiple statistics that can be used to evaluate the appropriateness (goodness-of-fit) of a specified model to the sample data and its associated parameter estimates (factor loadings) (Byrne, 2006; Hurley, et al., 1997). However, it is explicitly recognized that once respecification commences, the analysis is no longer completely confirmatory because the model may be changed based on model fit criteria (Gerbing & Hamilton, 1996). All analyses were conducted using the EQS v6.1 software package (Bentler, 2005).

During the analysis of the pilot data, we eliminated many potentially problematic items based on descriptive statistics and results from the iterative CFA process. Latent factors for LNT Principle Five (Be considerate of other visitors) and Six (Leave what you find) were highly correlated, indicating that they were likely measuring the same underlying concept. Consequently, we collapsed the two latent constructs into a more holistic “Respect” category. Our rationale for this decision, in addition to the statistical evidence, included that in the vast majority of backcountry environments, negative environmental impacts are caused primarily through improper travel and camping practices, inappropriate handling of waste, and from campfires. By collapsing these two latent variables into one we were able to reduce the number of observed variables necessary to measure the construct and keep the focus of the developing scale centered on LNT Principles Two (Travel and camp on durable surfaces), Three (Dispose of waste properly), Four (Minimize campfire impacts), Five (Be considerate of other visitors), Six (Leave what you find), and Seven (Respect wildlife). This reasoning is similar to Stubbs (1991), who likewise reduced the scope of his research to concentrate on only a select number of the LNT Principles. We retained a parsimonious list of 29 items at the end of the pilot testing phase.

Cognitive Interviews

A series of cognitive interviews were undertaken to refine the item pool using the process outlined by Willis (1999). Cognitive interviewing is a process through which a scale can be refined by identifying potential instances that might cause confusion or misinterpretation (Willis, 1999). Interviews were conducted at the Apgar Backcountry Ranger Station in Glacier National Park, MT in summer 2007. Participants in the interviews included overnight backpacking groups (18 individuals). Interviews continued until data saturation (redundancy in responses) was achieved. The process indicated that respondents were able to complete the items without difficulty and without the assistance of the researcher. The findings also suggested that respondents understood the items and were able to match their responses with the anchor statements provided. However, the process also highlighted that some items were repetitive and that minor wording changes were warranted on several items within the pool. At the conclusion of the cognitive interviewing process, 22 items were retained for this study (Table 1). Of the items eliminated, most were removed on the basis of wordiness or concern expressed by interviewees about the items' repetitiveness or potential for soliciting confusion.

Study Locations, Sampling, and Data-Collection Procedures

Glacier National Park (GNP), Montana and Olympic National Park (ONP), Washington were selected as the two study sites. Selection was based upon the following criteria: large contiguous wilderness or de-facto wilderness areas, recognition in popular media as a backpacking destination, large numbers of overnight backcountry visitors, willingness to cooperate with the research team, and mandated check-ins with ranger staff prior to the trip at a limited number of permit issuing sites. For example, overnight backcountry visitors to GNP can only obtain permits at one of five stations and over 60% of users utilize the Apgar Backcountry Visitor Center located at the park's primary western entrance.

Names and mailing addresses were obtained by systematically intercepting individuals and groups at backcountry offices in the two NPS units during the summer, 2007. All group members, aged 18 or older, were asked to provide a mailing address, allowing us to sample all adult party members not just the registered trip leader. Over 95% of those solicited completed a contact card. Questionnaires were subsequently mailed following a modified Dillman approach (2007). A final response rate of 68.4% at GNP (N=279) and 73.4% at ONP (N=314) was achieved. Telephone interviews with a sample of nonrespondents (N=30/unit) was conducted with no significant differences between groups on selected variables.

Data Screening and Imputation

Eight cases, four from each sample, were missing more than 50% of data and were dropped prior to screening. Data were screened independently using SPSS V.15 for both univariate and multivariate outliers. Particular attention was paid to cases exhibiting undue leverage or discrepancy (Tabachnick & Fidell, 2001). Two cases, one from each sample, were deemed to exceed recommended cut-off values and were eliminated from further analyses (Fox, 1991). Twenty-five cases from the GNP sample and 33 cases from the ONP sample were missing one or more data points across the 22 items, less than 1.5% of total data in each sample. A missing data analysis was conducted using EQS v6.1 to examine if significant patterns of missing data existed. Test results indicated the pattern of missing data could be considered missing completely at random (MCAR) for both the GNP data (χ^2=1201.5, df=1386, p=.999) and the ONP data (χ^2=1622.2, df=1596, p=.318) (Allison, 2003). Missing data were imputed using an expectation maximization procedure rather than following more conventional methods such as listwise deletion, which suffers from lower power for hypothesis testing and wider confidence intervals, or pairwise deletion, which results in unspecified sample size (Allison, 2003). There were no multivariate outliers after imputation.

Model Assessment and Modification Criteria

Confirmatory Factor Analysis was used to construct all models with model construction proceeding sequentially using maximum likelihood (ML) estimation. One of the primary advantages of a CFA approach to scale development, in addition to the reasons provided earlier, are the large number of goodness-of-fit (GOF) statistics that offer insight into the appropriateness of the specified model. However, because a single "global" measure of GOF is nonexistent, researchers are encouraged to report multiple measures for assessing model quality (Kline, 2005). Therefore, we report the Satorra-Bentler Scaled Chi-Square (S-Bχ^2), Comparative Fit Index (CFI), Standardized Root Mean Square Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA) and its associated 90% confidence interval. Mardia's coefficient indicated the presence of non-normality within both datasets (Byrne, 2006), a fact not uncommon in social research (Micceri, 1989). Transformations were not considered to allow meaningful interpretation of scores on items and because skew values were minimal on most observed variables (Table 1). The S-Bχ^2 was chosen over standard chi-square as it is more suitable for data exhibiting signs of non-normality by correcting for this issue (Satorra, 1992; Satorra & Bentler, 1994). The S-Bχ^2 provides a measure of "misfit" in that a p-value of less than .05 indicates the covariance structure of the researchers' hypothesized model differs significantly from the observed covariance matrix. However, with large samples, it is likely that a significant model chi-square will be obtained even if the model fits the observed data well (Byrne, 2006). The CFI and RMSEA fit statistics are based on robust estimates. The CFI is an incremental fit measure that is less susceptible to sample size than other similar measures such as Normed Fit index (Kline, 2005). The CFI is based on scale of 0 to 1; values greater than .9 indicate an acceptable fit and values greater than .95 indicate an excellent fit to the data (Hu & Bentler, 1998). The RMSEA is based on the analysis of residuals in the model with values from .05 to .08 deemed acceptable and values <.05 considered excellent (Browne, 1982; Steiger, 1988). The SRMR statistic provides an indication of differences between observed and predicted covariances with a value of less than .1 considered acceptable (Kline, 2005).

The Lagrange Multiplier (LM) Test was used during configural measurement model construction to explore areas of "misfit" (i.e., parameters which if removed would significantly improve overall model fit). Care must be exercised however in considering the theoretical soundness of each modification indicated by the LM Test (Byrne, 2006), as the LM test is completely empirical and statistical improvements must not supersede theoretical criteria (Tabachnick & Fidell, 2001).

Results

Participant Characteristics

Olympic National Park respondents averaged 41.4 years of age and were approximately 60% male. Greater than 63% of the GNP sample was male with a mean age of 36.2 years. Over 97% of ONP respondents and 99% of GNP respondents identified themselves as White (not of Hispanic descent). Greater than 90% of all respondents reported having a bachelor's degree or higher. Slightly over half of those sampled were registered as the trip leader. Nine out of ten respondents indicated they were traveling with friends or family members. Approximately two out of three ONP respondents reported prior camping experience in the backcountry of ONP while only approximately one out of every four GNP respondents had prior camping experience in the backcountry of GNP.

Descriptive Statistics

Table 1 displays the means, standard deviations, and skew of the 22 items used to develop the LNT AIM. Mean scores are based upon the 7-point scale described previously: lower scores reflect attitudes more congruent with recommended LNT practices. Review of descriptive statistics indicated significant measurement issues with the two items designed to assess the latent factor "Respect Wildlife" (LNT Principle 7). Descriptive statistics showed minimal variability for each item across both samples (mean<1.2, SD<.75, skew > 5.25) and frequency statistics showed that greater than 96% of respondents in each sample indicated a 1 or 2 for these items. Because including them in additional analyses would essentially make them constants in the model, they were removed from further analysis.

Configural Model Development

The configural models were developed and refined using the ONP Data (N=309). This allowed the authors to later confirm the structure and cross validate the final model using a separate, independent sample (the GNP data) (see Byrne, 2006). Goodness-of-fit statistics for the configural model are presented in Table 2. Items within constructs were hypothesized to be unidimensional. With all first-order models tested, the variance of the factor was fixed to one to provide meaningful factor loadings for each observed variable, latent variables were expected to be correlated, and error terms, unless otherwise specified, were not allowed to correlate.

Table 1

Means, Standard Deviations, and Skew for the LNT AIM Items (Shaded items not included in the final model)

		ONP			GNP		
Item ID	Items[a]	M	SD	Skew	M	SD	Skew
LNT Principle #2 - Travel and Camp on Durable Surfaces							
TC-1	Walking around muddy spots on the trail	4.01	1.55	-0.09	4.33	1.67	-0.17
TC-2	Hiking side by side with my friends on existing backcountry trails	2.94	1.59	0.58	2.89	1.67	0.73
TC-3	Camping along the edge of a stream or lake	3.77	1.91	0.08	4.22	1.92	-0.11
TC-4	Moving rocks from where I plan to place my tent	4.73	1.67	-0.53	4.33	1.63	-0.37
TC-5	Moving rocks and/or logs to make a campsite more comfortable	4.24	1.66	-0.28	3.60	1.72	0.16
TC-6	When camping in heavily used areas, placing the tent in an undisturbed spot	2.07	1.36	1.53	2.14	1.57	1.57
TC-7	In popular backcountry areas, camping where no one has camped before	1.75	1.20	1.84	1.77	1.22	1.93
TC-8	Camping two nights in a pristine camp	4.68	1.78	-0.41	4.87	1.73	-0.48
LNT Principle #3 - Dispose of Waste Properly							
DW-1	Burying used toilet paper	4.46	2.13	-0.30	4.19	2.21	-0.10
DW-2	Urinating on vegetation	3.46	1.68	0.22	3.16	1.65	0.32
DW-3	Using soap in streams as long as there are currents to help dilute the suds	1.96	1.31	1.54	1.90	1.26	1.52
DW-4	Depositing human waste on top of the ground so it will decompose rapidly	1.56	1.05	2.21	1.56	1.14	2.45
DW-5	Burning paper trash in the campfire	3.83	2.07	-0.08	3.17	1.86	0.32
DW-6	Disposing of dishwater in streams or lakes	1.53	1.05	2.51	1.53	0.94	1.93
LNT Principle #4 - Minimize Campfire Impacts							
CF-1	Having a campfire	4.10	1.82	-0.26	4.13	1.66	-0.13
CF-2	Cooking over a fire in the backcountry	3.74	1.90	0.01	3.85	1.87	0.03
CF-3	Building a fire ring if one is not present	2.81	2.04	0.73	2.41	1.93	1.21
CF-4	Leaving charred wood contained in the fire ring	4.13	1.90	-0.21	3.86	1.85	-0.03
LNT Principles #5 & #6 - Be Considerate of Other Visitors / Leave What You Find							
CL-1	Keeping a single small item like a rock or feather as a souvenir	3.51	1.73	0.10	2.90	1.73	0.64
CL-2	Camping with large groups (8 or more people) in the backcountry	2.98	1.61	0.56	3.10	1.67	0.47
LNT Principle #7 - Respect Wildlife							
RW-1	Dropping food on the ground to provide wildlife a food source	1.19	0.65	5.70	1.19	0.70	5.57
RW-2	Feeding wildlife	1.19	0.71	5.29	1.15	0.59	5.70

[a] measured via 7-point scale; 1=very inappropriate, 4=neutral, 7=very appropriate

Table 2

Configural Model Evolution of the LNT AIM (ONP Sample)

	Model Description		Goodness-Of-Fit				
Model	Factor Structure	Number of Items	S-BX^2	df	CFI	SRMR	RMSEA (90% CI)
Null	One factor	20	571.1	170	.703	.078	.088 (.080-.096)
1	Four factors	20	463.2	164	.779	.074	.078 (.069-.086)
2	Four factors	17	206.4	114	.906	.056	.052 (.040-.063)
3	Three factors	17	207.8	116	.906	.056	.051 (.039-.062)
4a	Three factors	15	153.8	87	.920	.054	.050 (.037-.063)
4b[a]	Three factors	15	140.3	86	.935	.052	.045 (.031-.058)
5[a]	2nd order	15	146.4	87	.929	.054	.047 (.033-.060)

[a] Cross-load specified from 1st Order Factor 1 to Item 'Having a campfire' (see Figure 1)

We started by evaluating a single factor or "null" model. This model included all of the items in Table 1 specified to load on a single factor with the exception of the two items representing Respect Wildlife, which were dropped for reasons noted earlier. The null model exhibited poor fit (CFI=.703, RMSEA=.088).

Model One, the first multi-dimensional model tested, contained the 20 remaining items with the factor structure specified to align with the conceptual framework. Goodness-of-fit improved from the null, but it was not within admissible bounds (Table 2). According to Bentler and Chou (1987), respecification of a measurement model to generate a parsimonious solution should focus on the deletion of items with insignificant paths or items with large residuals or correlated error terms and whose elimination will not sacrifice theoretical meaningfulness. Review of LM Test results indicated significant error covariance between three sets of similarly worded items within two constructs, Principle 2 and the combined Principles 5 and 6. Specifically, highly correlated error terms were evident between items "moving rocks from where I plan to place my tent" and "moving rocks and/or logs to make a campsite more comfortable"; items "using soap in streams as long as there are currents to help dilute the suds" and "disposing of dishwater in streams or lakes"; and items "when camping in heavily used areas, placing the tent in an undisturbed spot" and "in popular backcountry areas, camping where no one has camped before." These highly inflated error terms are likely an artifact of similarities in wording, and given the high inter-item correlations (>.50), each appears to be measuring analogous concepts. Additionally, a near perfect correlation (r=.99) was identified between these two latent factors. Given the similarities in wording amongst these items, it was surmised that the problematic items were analogous and one from each set could be omitted without harming theoretical meaningfulness. The identical factor structure was modeled using the GNP data to cross-validate this finding. The results were nearly indistinguishable regarding both the item and latent variable correlation discussed above. Therefore, one item from each pair was dropped, improving model fit without harming theoretical meaningfulness or explanatory power.

Model Two eliminated the three items identified as problematic within Model One. Goodness-of-fit significantly improved (CFI=.906, RMSEA=.056), however the near-perfect correlation between latent factors "Travel and Camp on Durable Surfaces" and "Respect" was still present. To cross-validate this finding, the model was again replicated using the GNP Data, which likewise indicated a near-perfect correlation between the same latent factors. Although the items from a "face" validity standpoint appear to measure different constructs, results indicate that respondents held similar attitudes toward (or responded similarly to) these two LNT Principles. Based on this rationale, the two factors were combined on the grounds of parsimony.

Model Three maintained the 17 items evaluated in Model Two but was constructed using only three factors by combining the two latent factors described previously. This new factor was renamed General Backcountry Attitude to more accurately reflect the indicators that comprise this latent variable. Goodness-of-fit statistics were virtually unchanged. However, the discriminate validity, as represented by latent variable correlations between constructs, improved.

The fourth configural model (4a) was the final first-order configural model. It eliminated the items "hiking side-by-side with my friends on existing backcountry trail" and "burning paper trash in the campfire" due to significant and multiple error covariances and low factor loadings. This model also freely estimated a cross-loading from factor "General Backcountry Attitude" to the item "Having a campfire." This cross-loading appears to indicate that ONP respondents feel that having a campfire *is an integral part* of the backcountry camping experience. Goodness-of-fit improved significantly with a CFI value of .935 and an RMSEA value of .045 (Table 2, Model 4b). Note the only difference between Models 4a and 4b is the estimation of the error covariance.

We next structured the model to include a second-order latent construct, visually depicted in Figure 1. This allowed testing of the hypothesis that a single, second-order factor could account for the covariation between the three first-order latent factors (General Backcountry Attitude, Dispose of Waste Properly, and Minimize Campfire Impacts) and is appropriate given the LNT Principles. In order to estimate the path coefficients, the disturbance terms for Factors 1 (General Backcountry Attitude) and Factors 2 (Disposal of Waste Attitude) needed to be constrained equal, resulting in an increase of one degree of freedom in the second-order portion of the model, which resulted in a lower overall GOF (for additional information on this process, see Byrne, 2006). Goodness-of-fit statistics for this model indicated that the data can be represented by a single higher order construct (S-Bχ^2=146.4, df=87, CFI=.929, RMSEA=.047) on the grounds of consistency with the LNT conceptual framework, parsimony, and statistical criteria. The higher order factor was termed LNT Attitude.

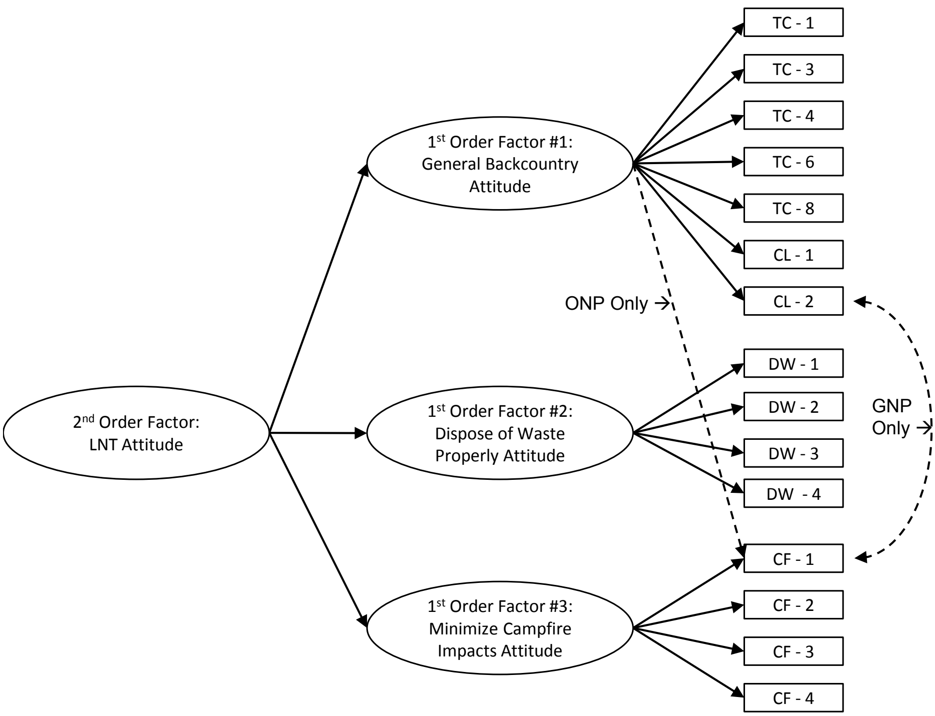

Figure 1. Final Measure Model

Cross Validation of the Model

To cross validate the final measurement model, we statistically examined measurement invariance (MI) and construct validity of the LNT AIM across both samples. Demonstrating MI provides evidence of the stability of both the factor structure and the individual items that comprise the scale (Byrne 2006; Byrne, Shavelson, & Muthen, 1989). Examining MI necessitates two hierarchical steps: determining if a statistically identical factor structure exists across samples (configural invariance or "weak factorial invariance") and examining if factor loadings are equivalent across samples (metric invariance or "strong factorial invariance") (Byrne, 2006; Kline, 2005; Vandenberg & Lance, 2000). Configural invariance was examined by fitting the GNP data to Model 4a with results presented in Table 3 alongside ONP results to facilitate comparison.

Fit was admissible but the LM Test results indicated a significant error covariance between items "Camping with large groups (eight or more people) in the backcountry" and "Having a campfire." This finding suggests that GNP respondents viewed having a campfire as appropriate if they were camping with a large group of individuals. Given the plausibility of this finding and its similarity to the cross-loading involving the identical item with the ONP data, the model was respecified to include this error covariance (ΔCFI=.030, ΔRMSEA=.008).

To statistically assess configural invariance, a multi-group model was specified and both datasets run simultaneously (Byrne, 2006; Widaman & Reise, 1997).

Table 3

Configural Invariance of the LNT AIM

			Goodness-of-Fit				
Model	NPS Unit	Number of Items	S-Bχ^2	df	CFI	SRMR	RMSEA (90% CI)
4a	ONP	15	153.8	87	.920	.054	.050 (.037-.063)
4a	GNP	15	135.8	87	.907	.055	.045 (.030-.059)
4b[a]	ONP	15	140.2	86	.935	.052	.045 (.031-.058)
4b[b]	GNP	15	119.0	86	.937	.053	.037 (.019-.053)
5[a]	ONP	15	146.4	87	.929	.054	.047 (.033-.060)
5[b]	GNP	15	129.9	87	.918	.056	.042 (.026-.057)

[a] Cross-load specified from First Order Factor 1 to Item 'Having a campfire' (CF-1)

[b] Error covariance modeled between items 'Camping with large groups (8 or more people) in the backcountry' (CL-2) and 'Having a campfire' (CF-1)

Table 4

Factor Intercorrelations (Model #4a) and Second Order Loadings (Model #5)

	Model #4a Latent Variable Correlations				Model #5 2nd Order Factor: LNT Attitude	
	1		2			
Parameter/Variable	ONP	GNP	ONP	GNP	ONP	GNP
1. General Backcountry Attitude	--	--			.96	.96
2. Disposal of Waste Properly Attitude	.84	.87	--	--	.90	.92
3. Minimize Campfire Impacts Attitude	.75	.83	.57	.50	.82	.81

Note: All parameter estimates statistically significant (p<.01)

Model 4a was chosen as it lacked any sample-unique error-covariances or cross-loadings. Goodness-of-fit was acceptable (S-Bχ^2=289.3, df=174, p<.001, CFI=.910, RMSEA=.048). The same test was then run on Model 5. Note this model was run without the cross-loading (ONP) and error-covariance (GNP) as these were unique to each sample. Goodness-of-fit was also acceptable (S-Bχ^2=294.8, df=174, p<.001, CFI=.910, RMSEA=.049).

Metric invariance, the second step necessary to demonstrate overall measurement invariance, is defined as statistical equality of factor loadings across groups (Vandenberg & Lance, 2000). Metric invariance is assessed through adequacy of GOF statistics with limited model degradation when factor loadings are constrained equal between groups (Byrne, 2006; Widaman & Reise, 1997). Metric invariance was examined for two models: Model 4a, as it lacked any unique parameter estimations, and Model 5, the second-order model. Model 4a was specified with equality constraints imposed on all 15 factor loadings (15 constraints) and both datasets run simultaneously. Alpha was set at .01 to lessen instances of a type one error (Gould, et al., 2008). Goodness-of-fit for the loading constrained model was acceptable (S-Bχ^2=304.8, p<.001, CFI=.914, RMSEA=.046) with a non-significant level of deterioration in GOF (ΔS-Bχ^2=14.9, df=15, p=.455). Review of the 15 factor loadings indicated that none were significantly different at p<.01. Model 5 was then examined with constraints imposed on all second order paths (N=3) as well as all first order paths (N=12), less those fixed to 1.0 for identification purposes. None of the constrained parameters were significantly different (p>.01), GOF was within acceptable bounds (S-Bχ^2=305.0, p<.001, CFI=.914, RMSEA=.046), and a S-Bχ^2=difference test indicated no significant deterioration in model fit (ΔS-Bχ^2=9.5, df=15, p=.850).

Construct validity is defined as encompassing the three primary types of validity: content, convergent, and criterion (Anastasi & Urbina, 1998). *Content validity* addresses whether each item is related to the construct of interest and if the items selected are an accurate representation from the universe of potential items (Anastasi & Urbina, 1998; DeVellis, 2003). Content validity was addressed in this study by grounding our study in relevant social psychological theory, the use of the LNT principles as an overarching guiding conceptual framework, review of relevant literature, integration of past LNT assessment tools, cognitive interviewing, and the use of content experts to assist with item generation (Anastasi & Urbina, 1998; DeVellis, 2003). *Convergent validity* is demonstrated through high correlations amongst scores (e.g., Byrne, 2006). While a specific statistical test is nonexistent, the use of CFA procedures does show that both samples exhibit high levels of convergent validity as demonstrated through second order factor loadings (Table 4) (Kline, 2005). *Criterion (predictive) validity* addresses how well a test predicts a later outcome and is regarded as the "gold standard" because of the assessment difficulties (DeVellis, 2003). In the present case, we would expect both first-order and second-order factors to be positively correlated to actual behaviors in backcountry environments. However, determination of the criterion validity of the LNT AIM must be assessed in the future by investigating the relationship between this measure and LNT behaviors or behavioral intentions.

Discussion

Outdoor recreational activities within protected natural areas will continue to be popular within the U.S. and abroad. Consequently, managers, who prefer to use education to manage these forms of recreation, will likely use some form of LNT education, to help protect valuable resources. Yet despite the current widespread use of LNT, our review of literature highlighted the absence of a scale to assess salient LNT attitudes. We therefore undertook a systematic effort to develop and empirically evaluate a measure to accurately assess attitudes toward common backcountry behaviors. The resultant scale, termed the LNT AIM (Leave No Trace Attitudinal Inventory and Measure) appears to be a psychometrically sound tool for determining attitudes regarding specific practices addressed by the LNT Principles for Responsible Recreation among the two populations sampled.

Table 5

Standardized Factor Loadings, Alpha, and Composite Reliabilities (Model 4a)

		ONP			GNP		
Latent Construct	Item	λ	α	CR	λ	α	CR
Factor 1: General	TC-1	.41			.47		
Backcountry	TC-3	.58			.59		
Attitude	TC-4	.48			.48		
	TC-6	.40			.36		
	TC-8	.36			.39		
	CL-1	.42			.43		
	CL-2	.38			.39		
			.60	.62		.63	.63
Factor 2: Dispose	DW-1	.39			.34		
of Waste Properly	DW-2	.48			.43		
Attitude	DW-3	.53			.51		
	DW-4	.36			.39		
			.42	.49		.41	.46
Factor 3:	CF-1	.84			.78		
Minimize	CF-2	.85			.79		
Campfire Impacts	CF-3	.54			.36		
Attitude	CF-4	.55			.36		
			.77	.80		.63	.68

λ = standardized factor loading; α = alpha; CR = composite reliability

Note: all factor loadings significant ($p<.01$)

Several strengths of this research deserve note. The development of the scale conformed closely with widely accepted development procedures (see DeVellis, 2003; or Noar, 2003). The use of the LNT Principles as a conceptual framework provided a basis for item development and later for hypothesis testing and is a recommended step in all scale development procedures (DeVellis, 2003). The employment of an expert panel during the item generation phase sparked a spirited dialog and resulted in the addition of numerous items to the developing item pool. The cognitive interviewing process, conducted on-site at GNP with individuals from the population of interest, provided additional assurance regarding item quality and identified potential problems not discovered in pilot testing. The use of a CFA data analysis strategy provided sound statistical criteria for model assessment and item selection. The use of a separate independent sample provided additional assurances regarding the ability of the LNT AIM to transcend geographic boundaries and speaks to the overall validity of the measure. Our exploration of measurement invariance analyses (cross-validation procedures) highlighted that the items and factor structure were stable across different samples. These high and nearly equal loadings (across samples) provide empirical support and justification for the use of a higher-order (second order) factor to account for correlations amongst first-order factors. The consistency of this finding across groups, coupled with the nearly equivalent fit statistics, provides strong evidence of the configural equivalence of the LNT AIM. The results of the series of invariance tests indicate that the scale appears to be both structurally and metrically consistent across the two independent samples.

Our analyses indicated that the data, structured as a second order factor (Model 5), is empirically justifiable and preferable according to the parsimony principle. This has important implications for both theory and practice. Conceptually, this finding indicates that respondents view LNT as an interconnected program; each principle of the framework is not viewed as drastically different or inconsistent with other principles. In other words, individuals appear to internalize the LNT message as one global attitude and do not necessarily differentiate strongly between the individual principles. Practically, this suggests that while dissemination of the message may be aided by organizing the LNT message around the existing seven LNT Principles, attitudes regarding recommended LNT practices seem to coalesce under a single LNT attitude or ethic.

Goodness-of-fit statistics for the single-factor model (Model #4b) and the 2nd order model (Model #5) were admissible in both samples. Similar to the decision criteria discussed by Noar (2003), substantive theoretical considerations, parsimony, and empirical findings were considered in arriving at the final measurement model. The final model taps three distinct dimensions of what we have termed a "LNT Attitude."

Several limitations need to be recognized so that they may be addressed in future research. We decided early on to not include LNT Principle 1, "Plan Ahead and Prepare," in the scale development effort and instead focus our efforts on the six "on-trail" practices. Future efforts to advance this scale should look to include items related to this principle to fully address the breadth of current LNT Principles. Our findings suggest that respondents hold similar attitudes regarding the "Travel and Camp on Durable Surfaces" and "Respect for Other Visitors"/"Respect for What is Found." Future efforts to assess the congruency between backcountry attitudes and the structure of LNT principles should consider developing and testing additional items to further examine the psychometric relationship between these principles. The two items exploring "Respect for Wildlife" (LNT Principle 7) solicited minimal variation from respondents. The potential reasons for this include that all respondents strongly agree that "feeding wildlife" and "dropping food on the ground to provide wildlife a food source" are truly inappropriate backcountry behaviors. However, it is also plausible that these items were influenced by social desirability bias. Future efforts to extend the LNT AIM are advised to develop alternative items to address the concept of "respecting wildlife" so that it is better captured within the scale

Similarly, first-order factor loadings for four items are on the low side of what is commonly accepted, even in exploratory analyses (Hatcher, 1994). This could be attributed to any number of reasons including poorly written items, socially desirable answering by survey respondents, or a well-diffused and accepted message.

However, lower factor loadings could also be indicative of a broad operational definition for the LNT principles of interest. In this situation, what would typically be regarded as "bad" indicators because of low factor loadings, are actually "good" indicators because they capture more of the construct of interest than would a set of highly correlated items (see Little, Lindenberger, & Nesselroade, 1999). Future research could also look to link salient backcountry attitudes (as measured via the LNT AIM or a subsequent version) to actual on ground behavior, thus addressing the criterion validity of the instrument. Do attitudes drive behaviors in backcountry contexts, and if so, to what extent? If positive LNT attitudes are found to be linked with positive LNT behavioral intentions and LNT behaviors, then the LNTAIM could be used to evaluate educational efforts and their influence on attitudes and the potential reduction of impacts in the backcountry. Finally, the LNT AIM could be used to examine the effectiveness of various education strategies and determine which are the most effective in modifying existing attitudes and subsequent behaviors.

Directions for Use

To utilize the LNT AIM, administer the scale to a sample drawn from the population of interest following recommended sample selection criteria. We recommend a seven-point scale using the "appropriateness" anchors. Scores on each of the three subsections can be averaged to assess attitudes regarding specific LNT principles. Additionally, the three subsections can be summed to create an overall composite score. More advanced analyses could weight individual items prior to calculation of composite scores. For these two levels of analyses, we recommend a sample size of approximately 200 to 250 individuals. For those interested in testing the psychometric qualities of the LNT AIM with CFA, we recommend 300 to 400 individual respondents. For further information on how to use scales and implement survey research see Babbie, 2001.

Conclusion

Managing recreation in backcountry environments will continue to be a difficult task for managers. Additional understanding of attitudes regarding common backcountry practices can assist with developing more specific, refined, and targeted educational programming and messaging to address problematic behaviors and help maintain or improve resource conditions. The LNT AIM appears to be a valid and psychometrically sound scale that can be used to measure backcountry visitors' attitudes regarding promoted LNT practices. Park and protected area managers and others interested in designing, developing, and promoting LNT educational efforts could use the LNT AIM to evaluate the influence of their programs on visitors' attitudes. In addition, information obtained via the LNT AIM can be used to track long-term trends regarding overnight backcountry visitors' salient attitudes.

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