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Monitoring of livestock grazing effects on Bureau of Land Management land

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1 **Monitoring of livestock grazing effects on Bureau of Land Management land**

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23

24 **ABSTRACT**

25 Public land management agencies, such as the Bureau of Land Management (BLM), are
26 charged with managing rangelands throughout the Western United States for multiple uses such
27 as livestock grazing and conservation of sensitive species and their habitats. Monitoring of
28 condition and trends of these rangelands, particularly with respect to effects of livestock grazing,
29 provide critical information for effective management of these multi-use landscapes. We
30 therefore investigated the availability of livestock grazing-related quantitative monitoring data
31 and qualitative region-specific Land Health Standards (LHS) data across BLM grazing
32 allotments in the Western United States. We then queried university and federal rangeland
33 science experts about how best to prioritize rangeland monitoring activities. We found that the
34 most commonly available monitoring data were permittee-reported livestock numbers and
35 season-of-use data (71% of allotments) followed by repeat photo points (58%), estimates of
36 forage utilization (52%), and finally, quantitative vegetation measurements (37%). Of the 57% of
37 allotments in which LHS had been evaluated as of 2007, BLM indicated 15% had failed to meet
38 LHS due to livestock grazing. A full complement of all types of monitoring data, however,
39 existed for only 27% of those 15%. Our data inspections, as well as conversations with
40 rangeland experts, indicated a need for greater emphasis on collection of grazing-related
41 monitoring data, particularly ground cover. Prioritization of where monitoring activities should
42 be focused, along with creation of regional monitoring teams may help improve monitoring.
43 Overall, increased emphasis on monitoring of BLM rangelands will require commitment at
44 multiple institutional levels.

45 **KEY WORDS**

46 land health status, land use impacts, public lands, rangeland health, sagebrush steppe

INTRODUCTION

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Effective rangeland management requires regular monitoring and assessment of natural resource status and management effects. (Williams et al. 2007). Monitoring provides documentation of changes in resource status, and the resultant information should be used to make management adjustments and improve progress towards meeting management objectives. Numerous handbooks, technical references, and websites provide guidance on rangeland monitoring and assessment (e.g., Elzinga et al. 2001a; Herrick et al. 2005, 2009; Karl et al. 2012; Pellant et al. 2005) and there exists a long history of laws and initiatives intended to improve monitoring and status of rangelands in the western U.S. (e.g., recent BLM initiatives such as Rapid Ecoregional Assessments (REA) and Assessment, Inventory and Monitoring (AIM) Strategy; see West 2003 for history of rangeland monitoring). Yet despite its importance, regular monitoring often is lacking and remains a systemic problem, due to other priorities or to lack of resources such as time, money and personnel. This is true not only for rangelands (West 2003), but for natural resource management in general (e.g., Bernhardt et al. 2007; Kettenring and Reinhardt Adams 2011; Kiesecker et al. 2007).

Rangeland monitoring is an especially important issue for the Bureau of Land Management (BLM) which manages almost 1,000,000 km² of public land, of which 635,000 km² are managed for livestock grazing (BLM 2012). Private livestock operators are issued either grazing permits or leases which specify when and how intensely they may graze their allotments of BLM land. Grazing and monitoring of BLM lands, however, has long been steeped in conflict. Monitoring data, including its quality and interpretation, lies at the heart of much of this conflict. Organizations of interested people focused on ameliorating perceived negative effects of livestock grazing on public lands have regularly engaged the BLM in litigation (Pool 2010). At

70 question is the status or health of rangelands. Monitoring data, collected by or provided to the
71 BLM, should be able to provide answers, but in many cases may be difficult to interpret and/or
72 may be incomplete. Similarly, livestock operators also litigate against the BLM over disputes
73 about enforcement or interpretation of federal regulations on their grazing allotments (Pool
74 2010). Again, high quality monitoring data could be used to provide a clear indication of
75 rangeland status and clarify whether livestock grazing management is resulting in achievement
76 of resource management objectives.

77 Rangeland monitoring and management on BLM land also has long been a subject of
78 legislative actions. According to the Federal Land Policy and Management Act of 1976 the BLM
79 must “manage the public lands under principles of multiple use and sustained yield.” (Public
80 Law 94-579, Sec. 302). The Public Rangelands Improvement Act of 1978 further commits
81 federal land management agencies to providing regular updates on the condition and trend of
82 rangelands. For the BLM, these legislative actions typically translate into management of
83 livestock use in a way that sustains other land uses (e.g., wildlife conservation), and the
84 monitoring of livestock grazing effects. Current grazing regulations require that monitoring data
85 and/or field observations be used to support decisions about stocking rates on BLM allotments
86 (43 CFR 4110.3). Thus, quantitative condition and trend data (commonly reported as ground
87 cover and seral status) can directly influence management, and collection of these data
88 constitutes a major priority for grazing management on BLM land.

89 In addition to collecting and reporting quantitative condition and trend data, the BLM
90 also qualitatively evaluates land health across its allotments. Rangeland health indicators have
91 long been used to determine rangeland status (West 2003) and, in combination with available
92 quantitative data, are used to evaluate specific rangeland attributes or land health standards. In

93 1995, the BLM identified nation-wide fundamentals of rangeland health that must address
94 minimum standards for: (1) watershed function, (2) nutrient cycling and energy flow, (3) water
95 quality, (4) habitat for endangered, threatened, proposed, candidate, and other special status
96 species, and (5) habitat quality for native plant and animal populations and communities (43
97 CFR 4180.2). The BLM also required individual regions to use these national standards to
98 develop, in consultation with local Resource Advisory Councils, region-specific land health
99 standards (LHS) and indicators. To evaluate land health, BLM field office personnel are required
100 to perform individual, on-the-ground evaluations of these standards in all grazing allotments.
101 Evaluations are based on a suite of indicators associated with region-specific standards (see
102 Table S1).

103 Since 1997, livestock grazing practices on BLM land have been linked to the status of
104 land health standards (LHS); if an allotment fails LHS due to current livestock grazing
105 management, appropriate corrective action must be taken and the terms and conditions of the
106 grazing permit may be adjusted (43 CFR 4180.2). If current grazing practices are identified as
107 significant causal factors resulting in failure to meet LHS, management actions must be proposed
108 to help achieve compliance (Fig. 1; 43 CFR 4180.2). In cases when allotments fail LHS,
109 monitoring data can play a critical role in identification of causal factors (see Fig. 1). Yet BLM
110 monitoring efforts have been criticized over the last several decades as being hampered by
111 funding/personnel issues and confusion and inconsistencies associated with monitoring methods
112 (West 2003). It is not clear at regional or range-wide scales which types of vegetation, soil, and
113 livestock grazing-related monitoring data are being collected on BLM land, which methods are
114 being used, or how consistently data are being collected, analyzed, and interpreted. Similarly, it

115 is unclear whether these datasets are complete and sufficiently consistent across time and space
116 to make region-wide assessments of livestock grazing effects on rangeland status.

117 The first major objective of our study was to address the availability and status of
118 existing livestock grazing-related BLM monitoring and rangeland health data. Specifically, we
119 (a) examined types, availability, and consistency of rangeland monitoring data from a sample of
120 BLM offices, and (b) evaluated the degree to which these data could be used to infer livestock
121 grazing effects. Our second major objective was to use expert opinion to identify potential
122 strategies for improving monitoring of rangeland status and livestock grazing impacts on BLM
123 land. Our study focused on livestock grazing because it has been identified as a potential threat
124 to Sage-Grouse habitat, yet there is no consistent means of evaluating its impact (Connelly
125 2011).

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METHODS

128 **Field Office Sampling**

129 We visited BLM field offices to evaluate availability of rangeland monitoring
130 information. We first inspected individual grazing allotment files for presence of grazing plans
131 and/or allotment management plans (AMPs). Though not required, these plans outline specific
132 resource management objectives relating to livestock grazing (for example, forage allocations for
133 wildlife or range improvements) and in the case of AMPs, wildlife. We next inspected allotment
134 files for availability of four types of monitoring data: (1) *Actual Use* – livestock numbers and
135 grazing dates (self-reported by grazing allotment permittees or lessees), (2) *Utilization* – percent
136 of current year's vegetation production consumed by animals, (3) *Vegetation Trend* –
137 quantitative measures of plant community changes over time and (4) *Photo Points* – repeated

138 photos at fixed locations within the allotment. We did not inspect supporting riparian, wildlife or
139 wild horse data.

140 We inspected these data for a total of 310 randomly selected allotment files in 13 BLM
141 offices (covering 15 BLM resource areas and 6 States) that fell within sagebrush (*Artemisia*
142 *tridentata*) steppe and potential Greater Sage-Grouse (*Centrocercus urophasianus*) range. Seven
143 of the thirteen field offices we selected were among those already participating in a
144 complementary BLM study exploring spatially explicit approaches to land health evaluations.
145 The remaining six offices were selected semi-randomly with preference given to offices with a
146 history of cooperation or collaboration on previous or related projects. Thus, our BLM office
147 selection is biased towards those with a greater willingness to participate and share monitoring
148 data.

149 For each allotment, we recorded presence or absence of each data type (grazing/allotment
150 management plans, Actual Use, Utilization, Vegetation Trend, Photo Points) for every year
151 between 1997 and 2007. We did not include earlier dates because data prior to 1997 were
152 typically archived off-location. We were unable to account for incomplete spatial coverage of
153 data within a given allotment because sample locations changed over time and were
154 inconsistently named (i.e., data were counted as present even if they existed for only a subset of
155 pastures or key areas within that allotment). We then identified which of these 310 allotments
156 were deemed by BLM to have not met LHS (see below). By examining data presence in the
157 resulting subset of data, we were able to assess which monitoring information was available to
158 support determinations of livestock-caused LHS failures.

159 The 310 allotments were stratified to be one-third “Maintain” (n=109) and two-thirds
160 “Improve” (n=201). Since 1982, BLM has been classifying allotments as “Maintain” or

161 “Improve,” with the intention of concentrating monitoring efforts on “Improve” allotments
162 (BLM WO IM 82-292). Allotments classified as “Maintain” are characterized by resource
163 conditions that do not require management changes, while resource conditions in “Improve”
164 allotments suggest a need for management changes. We excluded allotments classified as
165 “Custodial” because management changes are considered unfeasible in those allotments.
166 “Custodial” allotments are typically small, isolated pieces of federal land located within non-
167 federal land areas. “Uncategorized” allotments were also excluded.

168 **Land Health Standards (LHS) Data**

169 To determine LHS status across all BLM land, we used a dataset compiled by the
170 national BLM office in 2008. Individual states/regions were responsible for translating the five
171 nation-wide fundamentals of rangeland health into their own state/region-specific standards. As a
172 result, the specific content, wording and number of standards varies across states/regions (Table
173 S1). Our examination of broad-scale patterns required us to standardize data by placing state or
174 region-specific LHS into three universal categories relevant to livestock grazing: Upland,
175 Riparian, and Biodiversity (Table S1). We omitted standards that fell outside the scope of this
176 study (e.g., air quality or water quality). For allotments where LHS evaluations were completed
177 between 1997 and 2007, we determined if standards in our universal Upland, Riparian, and
178 Biodiversity categories were “met” or “not met”. If a standard was not met, we identified
179 whether BLM attributed failure to meet the standard to livestock.

180

181 **Expert Opinions**

182 We assembled, through informal conversations, opinions of 20 federal rangeland
183 scientists (representing USDA-Agricultural Research Service in six states, USDA-Natural
184 Resources Conservation Service in four states, and USDA- Forest Service in one state) and 22
185 university rangeland scientists (representing 13 universities) on how best to monitor rangeland
186 condition and livestock grazing effects. We selected rangeland experts based on their
187 membership in the Society for Range Management, professional reputation, and record of peer-
188 reviewed publications in rangeland science literature. In addition, we selected individuals that
189 would not have a potential vested interest in the current monitoring system or any potential
190 financial benefit or loss associated with current monitoring information. Conversations took
191 place at the 2009 Society for Range Management annual meeting in Albuquerque, New Mexico,
192 or over the telephone. We presented scientists with the following hypothetical monitoring
193 scenario asking them to prioritize activities for monitoring of livestock grazing effects on
194 rangeland resources: “Assuming a new piece of land has been acquired by the BLM or some
195 other land management agency, how would you set up a monitoring program to (1) monitor
196 rangeland condition, and (2) determine livestock impacts (that is, make explicit connection
197 between livestock grazing and land condition)? First, what would be the single most important
198 field measurement, and how would you interpret that data with respect to (1) and (2)? Second, if
199 you could instate a full monitoring program for that piece of land, what would you do? Assume
200 that one person can spend ½ day per year collecting this monitoring information. Also, assume
201 that the number of livestock, dates of livestock grazing, and climate/rainfall information will be
202 collected (outside of your ½ day monitoring program) and made available to you.”

203 **Statistical Analyses**

204 For field office data, we used Pearson’s chi-square contingency tests to compare presence
205 of all four data types (Actual Use, Utilization, Trend, Photo Points) between all Maintain and
206 Improve allotments sampled (n=310). Then, for each data type (Actual Use, Utilization, Trend,
207 and Photo Point) we used contingency tests to compare data presence between the full dataset
208 and the subset of data that had failed LHS due to livestock. Specifically, we tested data presence
209 for Maintain vs. Improve allotments for those two datasets. Next, we used ANOVA to test for
210 differences in percent data presence among those four data types. Our model included a main
211 effect of data type (n=4), a block effect of field office (n=13), and their interaction. The response
212 variable was the arcsin-transformed percent presence of each data type.

213 For LHS data, we used a split-block ANOVA design to test for differences between
214 allotment categories (Maintain/Improve) and among data types (Upland, Riparian, Biodiversity).
215 The model included BLM state offices as block, allotment category (Maintain/Improve) as sub-
216 block, data type as main treatment (Upland, Riparian, Biodiversity), and all 2-way interactions.
217 The model was run twice, first with arcsin square-root transformed “% of allotments meeting
218 LHS” as the response variable, and second with arcsin square-root transformed “% of allotments
219 with unmet LHS attributed to livestock” as the response variable. In all cases, we used Tukey
220 post-hoc tests to compare among data types.

221
222

RESULTS

223 **Field Office Sampling**

224 Overall, more data were present for the 201 “Improve” than the 109 “Maintain”
225 allotments we sampled, although differences were not significant (Table 1; $\chi^2 = 2.0$, $p = 0.57$). We
226 found that, between 1997 and 2007, allotment files contained significantly more Actual Use data

227 (Maintain/Improve = 59% / 77 %) and repeat Photo Point data (Maintain/Improve = 53% / 61%)
228 than quantitative Vegetation Trend data (Maintain/Improve = 34% / 38 %), with forage
229 utilization present an intermediate amount (Maintain/Improve = 51% / 52%) (Table 1, $F_{3,36}=7.56$,
230 $p=0.005$; Tukey $p<0.05$). We also found significant variation among field offices with respect to
231 data availability ($F_{12,36}=3.69$, $p=0.001$).

232 Actual Use was reported in an average of 6.3 (of Maintain) and 6.8 (of Improve) of the
233 11 years sampled (Table 1). Actual Use data were present for at least one of the eleven years in
234 59% of the 109 Maintain and 77 % of the 201 Improve allotments (Table 1). When Actual Use
235 data were present for an allotment in a given year, data were not necessarily complete. This was
236 especially the case on, large multi-permittee (e.g., 8-10 different livestock operators) allotments
237 where only a subset (e.g., 1-2) of permittees may have reported numbers.

238 Although all field offices surveyed had some photo monitoring data, only 58% of all
239 allotments were monitored with photo points. Those allotments were monitored an average of
240 1.3 (Maintain) and 1.7 (Improve) times between 1997 and 2007 (Tables 1, 2). Additionally, we
241 observed that even those allotments with little or no photo point data acquired during study years
242 typically had earlier photo points from the 1960s through 1980s. Utilization data had been
243 collected at least once in the last eleven years in 52% of allotments. All but one office used the
244 Key Species method (BLM 1996) of making ocular utilization estimates (Table 2). Quantitative
245 vegetation trend data had been collected at least once in eleven years in 34% of Maintain and
246 38% of Improve allotments and by 10 of 13 offices. Approaches to vegetation data collection,
247 however, varied among offices (Tables 1 and 2). In particular, cover data were collected by 10 of
248 13 offices, with five different methods, and frequency data were collected by six offices, using
249 three different methods (Table 2).

250 We found that 17% of Maintain and 26% of Improve allotments contained grazing or
251 allotment management plans that had been updated since 1997. An additional 35% and 29%,
252 respectively, contained plans that had last been updated prior to 1997 (Table 1).

253 **Land Health Standards (LHS) Data**

254 Across all BLM allotments in the United States the percentage of allotments with LHS
255 evaluations completed between 1997 and 2007 ranged from 22 to 95% across surveyed states,
256 with an overall average of 57% (Table 3). Of the 5991 allotments with completed LHS
257 evaluations the BLM found 67% to be meeting all LHS (77% of Maintain, 59% of Improve;
258 Table 3) and 15% to have failed at least one standard due to livestock. Failures of Riparian
259 standards were attributed to current livestock grazing management significantly more (63% of
260 cases) than were Upland or Biodiversity standard failures (52% and 46%, respectively; Table S2,
261 Tukey $p < 0.05$). This effect appears to have been driven largely by the failure of Riparian
262 Improve allotments (significant standards * allotment status interaction, Table S2). We found
263 that three offices did not use systematic indicator ratings for assessing uplands (e.g., Pellant et al.
264 2005), while nine did, and one was unknown.

265 **Land Health Standards and Monitoring Data**

266 We examined which types of data were being collected to support determinations that
267 current livestock grazing management contributed to failures in meeting LHS. In our sample of
268 310 allotment files, we found that when current livestock grazing management was identified as
269 the reason for not meeting LHS ($n=62$), Actual Use data were present for 47% of Maintain and
270 84% of Improve allotments (Table 1), and forage utilization measurements had been made in
271 52% of these allotments (Table 1). Quantitative vegetation data were present for 35% of

272 allotments failing due to current livestock grazing management, though additional vegetation
273 data could potentially be gleaned from permanent photo points, which were present for 69% of
274 allotments (Table 1). A full complement of monitoring data (four data types) was present for
275 27% of allotments, while 15% lacked data entirely (Table 1). Overall, the amount of data
276 associated with the 62 Maintain and Improve allotments failing standards due to current
277 livestock grazing management did not differ significantly from the full data of 310 allotments
278 (Actual Use $\chi^2=2.3$, $p=0.13$, Utilization $\chi^2=0.53$, $p=0.47$, Trend $\chi^2=0.28$, $p=0.60$, Photo Points
279 $\chi^2=0.68$, $p=0.41$).

280 **Expert Opinions**

281 Overall, federal and university rangeland scientists expressed relatively similar opinions
282 on our discussion topics (Table 4). For data presentation, we separate our results for these two
283 groups, but given our small sample sizes we did not attempt to analyze group differences
284 statistically.

285 Ground cover (including vegetation, litter, rocks, biotic crusts and bare soil) was the
286 quantitative variable most consistently identified by federal and university rangeland scientists
287 (55 and 70%, respectively) as a top priority field measure for monitoring rangeland condition
288 and livestock effects (Table 4). Although measures of bare ground are implicit in some
289 approaches to cover measurement, 45% of federal and 21% of university scientists who
290 mentioned cover also specifically mentioned bare ground measurements, as did one other federal
291 scientist (who had not specifically mentioned cover). Additionally, 5% of federal and university
292 scientists mentioned gap measurements (which quantify the proportion of ground occupied by
293 inter-plant gaps and provide information about potential for erosion). In addition to bare ground,

294 25% of federal and 10% of university scientists specifically mentioned soil measurements such
295 as aggregate stability and compaction.

296 Utilization measures were suggested by 35% of federal and 25% of university scientists
297 as a highest monitoring priority (with an additional 15% of university scientists mentioning it as
298 a secondary measure). Methodological approaches varied among individuals and included
299 utilization cages (3 federal/2 university scientists), stubble height or residual biomass (4 federal/5
300 university), use pattern mapping (2 university), and height/weight calculations (1 university).

301 Thirty percent of federal and 40% of university scientists stressed the importance of
302 having a reference for comparison when monitoring (Table 4). These bases for comparison
303 included ungrazed reference areas (4 federal/3 university), moderately grazed reference areas (3
304 university), and NRCS ecological site descriptions (3 federal/4 university).

305 Thirty percent of federal and 15% of university scientists recommended using repeat
306 photo points as a primary approach to vegetation and soil monitoring (with an additional 15% of
307 university mentioning it secondarily) (Table 4). Approaches included traditional methods of
308 returning regularly to fixed locations to take landscape and ground plot photos, as well as more
309 intensive photo sampling along transects.

310 The use of remote sensing was suggested by 30% of federal and 35% of university
311 scientists (Table 4). Approaches included high resolution aerial photography (from airplane or
312 lower-flying remotely controlled devices) and satellite imagery. In many of these cases, remote
313 sensing was suggested as a tool for identifying risk and/or prioritizing monitoring activities.
314 Overall, 25% of federal and 20% of university scientists mentioned the importance of using
315 some type of tool or indicator (e.g., remote sensing or other ground-based assessment) to

316 prioritize monitoring. One expert suggested that monitoring programs could be improved by
317 forming specialized regional monitoring teams.

318

319 **DISCUSSION**

320 Increased emphasis on collection of monitoring information, especially if data were
321 collected with more consistent methodology, could facilitate reporting of condition and trend of
322 BLM rangelands and enhance data-supported justification for management decisions. Such a
323 shift in emphasis would likely not rely solely on action taken at the level of individual BLM field
324 offices but rather would require increased commitment of resources at the institutional level.
325 Standardization of techniques is a balancing act that requires cost-benefit analyses of various
326 science-based approaches with input from the institution, science community and interested
327 stakeholders. The current BLM Assessment, Inventory and Monitoring Strategy has attempted to
328 move the agency in this direction (Herrick et al. 2010b; Toevs et al. 2011).

329 We found that when current livestock grazing management was identified as the reason
330 an allotment failed to meet Land Health Standards (LHS) 27% of allotments possessed a full
331 complement of data to support that determination, while 15% lacked data entirely. Monitoring
332 data are needed for these determinations for two major reasons. First, although use of key
333 indicators provides information on whether or not LHS are being met at the time of assessment,
334 the process does not provide information about causality (e.g., Pellant et al. 2005). Instead,
335 causality can be gleaned from regularly-collected monitoring data (e.g., livestock numbers,
336 utilization, vegetation trend) (Fig. 1). Second, BLM grazing regulations require that if an
337 allotment fails LHS due to current livestock grazing management, appropriate corrective action
338 must be taken and the terms and conditions of the grazing permit may be adjusted (43 CFR

339 4180.2). Although expert opinion of BLM personnel may provide accurate assessments of
340 livestock grazing effects, grazing management and permit adjustment decisions are difficult to
341 defend in the absence of long-term monitoring data and may lead to legal challenges of such
342 decisions.

343

344 **Vegetation cover and frequency**

345 Rangeland experts identified ground cover as one of the most important field measures
346 for monitoring rangeland condition and livestock impacts (when combined with livestock actual
347 use, season of use and climate data). Methods for measuring cover are included in BLM
348 technical manuals, and most BLM offices we surveyed conducted cover measurements. Cover
349 measurements made by species, life-form, or functional group can provide key information about
350 health and functioning of plant communities and ecosystem properties (Herrick et al. 2005).
351 Furthermore, cover measurements often include measurements of bare ground, with higher-than-
352 normal bare ground typically reflecting increased potential for soil degradation (Pellant et al.
353 2005). Cover measurements are best made at phenologically consistent times within and across
354 management units (to account for changes over a growing season such as presence/absence of
355 short-lived annual plants or leafing out of perennial plants) and, where possible, before major
356 precipitation events occur that may contribute to soil erosion. Other potential approaches include
357 focusing on perennial vegetation cover, which is the least sensitive to time of year, and
358 acquisition of remotely-sensed cover data that can be timed to control for time of year. Measures
359 of inter-plant distances (i.e., basal gap or canopy intercept) also are less sensitive to timing and
360 also serve as useful supplemental indicators of longer-term change and potential for erosion
361 (Herrick et al. 2005).

362 A supplementary approach to on-the-ground cover measurements is use of photo points.
363 Overhead views of small (e.g., 1 ×1 m) permanent plots and landscape views can be repeated
364 over time to track bare ground and cover by species or functional groups and detect significant
365 landscape-scale changes in vegetation (Elzinga et al. 2001b; Herrick et al. 2005; Webb et al.
366 2010). Intensive sampling of multiple points along transects and use of high resolution
367 panoramic images are potentially useful modifications to standard photo point methodology
368 (e.g., Nichols et al. 2009). Photo sampling is quick and inexpensive and requires little training.
369 Moreover, qualitative or quantitative assessments of photos can be performed in the office,
370 freeing up field time for other monitoring activities. In the case of BLM, despite representing the
371 most complete historic vegetation information, photo points were not used extensively or
372 consistently over time; only 58% of allotments in our sample had been surveyed with photo
373 points, on average less than twice in eleven years. Increased emphasis on photo point data may
374 provide opportunities for improvements in both quantitative and qualitative assessments, and
375 photographic evidence also may provide the most compelling evidence when grazing decisions
376 are contested and people are unfamiliar with data interpretation.

377 Alternative vegetation measures such as frequency (i.e., presence/absence data) may be
378 easier and faster to collect and allow greater flexibility in timing of data collection. However,
379 frequency may serve as a poor early-warning indicator because it only detects declines with plant
380 mortality and is not likely to detect more subtle (but potentially important) reductions in plant
381 vigor within plant communities. For example, decreasing plant cover or vigor, assuming weather
382 was not the cause, may indicate a need for intervention, but would not be detected by frequency
383 measures. Conversely, for specific plant species or functional groups (e.g., rare plants, invasive

384 species, woody species), methods such as frequency or density may be well suited to assessing
385 increases in their status and making predictions about future distributions (Elzinga et al. 2001b).

386

387 **Grazing and climate information**

388 Interpreting and relating vegetation and ground cover data to livestock grazing requires
389 information on grazing intensity and timing. Grazing intensity, including stocking rate, duration
390 and frequency, as well as timing of grazing relative to plant phenology, have consistently been
391 identified as factors affecting ecosystem and rangeland health (Briske et al. 2008; Vallentine
392 1990). We found that grazing information (Actual Use) was commonly available for BLM
393 allotments (Table 1). Utilization information was less available. Although measuring utilization
394 can be problematic (Jasmer and Holechek 1984), utilization information can be helpful for
395 making causative links between grazing and vegetation changes. For example, heavy use by
396 free-roaming ungulates such as wild horses can reduce plant cover or increase erosion. In such
397 cases, Actual Use data indicating only moderate livestock numbers, coupled with Utilization and
398 Vegetation Trend data indicating heavy use, could highlight the need to examine effects of free-
399 roaming ungulates. In other cases, if livestock are the only known large herbivore grazers, and
400 both Actual Use and Utilization indicate only moderate livestock use, poor rangeland health may
401 point to other causes such as historic grazing intensity or energy development activities.

402 Climate and weather data, particularly inter- and intra-annual variation in precipitation,
403 provide necessary context for interpreting vegetation and livestock grazing information. Grazing
404 information, coupled with climatic data, can be used to retrospectively examine appropriateness
405 of stocking rates. For instance, yearly rainfall amounts have direct bearing on impacts of a given
406 grazing intensity (Thurow and Taylor 1999), and timing of grazing relative to rainfall (and

407 phenology) also determines how grazing affects plants (Briske and Richards 1995). Likewise,
408 any long-term trends in vegetation cover would be strongly affected by lengthy drought periods,
409 both with and without grazing. Improved and continued efforts to collect and ensure accuracy of
410 grazing information, along with climate data collected by BLM offices or regularly retrieved
411 from other sources (e.g., NOAA), would aid interpretation of monitoring data. Similarly,
412 assessments of long-term relationships between grazing and climatic patterns could provide
413 insights into how rangelands might respond to future climate scenarios and suggest whether
414 permitted grazing amounts may need to be adjusted to cope with altered climate patterns. This
415 type of approach remains an active area of research due to the challenge of quantifying climatic
416 factors across complex landscapes, with sometimes limited historical climate data.

417

418 **Identification of at-risk areas**

419 Almost one quarter of experts specifically mentioned identification of areas at high-risk
420 of degradation to help prioritize monitoring. Although BLM already classifies allotments as
421 “Maintain” or “Improve” with the intention of prioritizing monitoring of the latter, more “at risk”
422 sites, we did not find significant differences in data availability between the two allotment
423 classifications. Moreover, a potential pitfall of this approach is that it may not include areas in
424 good condition, and the resulting data may erroneously represent overall conditions as being
425 worse than they really are. Alternative approaches, such as the “key area” approach, which
426 entails monitoring representative areas that contain dominant livestock forage, also may not
427 provide an accurate representation of the condition of a larger area. Potential remedies include a)
428 prioritizing and dedicating more resources to monitoring, and b) creating more efficient
429 monitoring plans which are applied over a greater percentage of total land area. Recent efforts

430 out of the BLM National Operations Center (NOC) include development of an ecological site-
431 based stratification and sampling approach to more effectively evaluate Land Health Standards
432 (LHS) status of a given allotment (Taylor et al. 2012). This approach attempts to reconcile that
433 an allotment may be characterized by high variability in factors such as land form, species
434 composition, land use history, and ultimately LHS status.

435 The identification and subsequent monitoring of at-risk areas can, however, play a
436 positive role in a monitoring program providing it does not replace efforts to create a more
437 complete picture of overall rangeland status. On one hand, areas in good or excellent condition
438 may yield the best pay-off of management and conservation efforts. On the other hand, areas that
439 appear to be at or near thresholds of change (in a state-and-transition model framework) may be
440 the ideal sites to more intensively manage, thereby maintaining and/or improving range
441 conditions (Bestelmeyer 2006). Potential tools include on-the-ground indicators (e.g., bare
442 ground, vegetation gaps, and biotic crusts which are sensitive to grazing), Geographic
443 Information Systems (GIS) analyses (e.g., use stocking rate and ecological site information to
444 identify areas more vulnerable or less resilient to grazing) and remote sensing. Remotely-sensed
445 data in particular can be used to assess ecosystem properties at multiple scales (Booth and Cox
446 2009; Bradley and O'Sullivan 2011; Homer et al. 2012; Rango et al. 2009), identify thresholds of
447 change (Homer et al. 2012; Xian et al. 2012), and monitor changes in rangeland health
448 conditions (see Xian et al. 2012).

449

450 **Monitoring teams and participatory monitoring**

451 Yearly monitoring may be difficult to accomplish because it typically requires significant
452 time investment for travel to remote areas and conducting field sampling methods. One potential

453 remedy is regular, but less frequent monitoring by state- or regional-level field monitoring teams
454 that emphasize centralized training and use of consistent methodologies across the state/region
455 One model for this approach is the Utah Division of Wildlife Resources Range Trend Studies
456 program, which uses a centralized state-level field team to collect trend data at designated key
457 areas throughout the State (<http://wildlife.utah.gov/range/>). Monitoring of vegetation variables
458 occurs on a five-year cycle for each land unit, such that only a subset of land units must be
459 monitored in a given year. If adopted by the BLM, this type of approach could facilitate regular
460 monitoring by ensuring appropriate expertise and consistency in execution of field methods. This
461 approach could free time for rangeland management specialists to make more frequent
462 qualitative observations and measure complementary short-term variables (e.g., yearly
463 utilization) over greater land areas. More time also could be dedicated to nurturing relationships
464 with permittees and glean information from their experience and knowledge of the land. To
465 be effective, this type of data-intensive approach would require that a data storage and analysis
466 plan be in place (sensu James et al. 2003). Use of monitoring teams may not constitute a
467 dramatic shift in monitoring approach for BLM; in some cases allotment permittees already
468 contract with private organizations to monitor BLM allotments (C. Addy, pers. comm).

469 Another model for increasing monitoring capacity is participatory monitoring by
470 livestock operators. Permittees typically are already engaged in the management of their
471 allotments, working closely with BLM personnel to determine pasture rotations, annual grazing
472 adjustments, and other management actions that are too specific to be covered under the more
473 general grazing permit (which specifies maximum AUMs and grazing dates at the scale of the
474 whole allotment). The BLM could further engage permittees by formally involving them in the
475 monitoring process. Accordingly, the BLM has a Memorandum of Understanding (MOU WO

476 220-2004-1) with the Public Lands Council of the National Cattlemen’s Beef association to
477 foster and provide guidance for participatory monitoring of BLM land by permittees/lessees.
478 Participatory monitoring has been shown to be effective for rangelands (Curtin 2002; Herrick et
479 al. 2010a) in part because ranchers can provide site-specific information that aids the monitoring
480 process (Knapp and Fernandez-Gimenez 2009). Monitoring that is done collaboratively (e.g.,
481 participation by both BLM and permittees) also increases transparency of the monitoring
482 process, which facilitates trust-building among participants (Cundill and Fabricius 2009;
483 Fernandez-Gimenez et al. 2008). The Pinedale, WY BLM field office initiated a participatory
484 monitoring program in 2004
485 (http://www.blm.gov/wy/st/en/field_offices/Pinedale/range/4Cs.html). The program ran
486 successfully for four years until grazing was suspended due to energy development. There are
487 current plans to resume the program because of strong interest by permittees (R.C. Lopez,
488 personal communication). Several handbooks on participatory monitoring are available (e.g.,
489 Flintan and Cullis 2010; Peterson 2006).

490

491 **IMPLICATIONS**

492 Effective monitoring programs require long-term data to be collected regularly and with
493 consistent methodology over time. Although BLM monitoring could be improved on both
494 accounts, encouragingly, the primary methods being used by BLM offices are largely consistent
495 with methods recommended by rangeland experts. Thus, in cases where sound, historic data
496 exist, methodologies should arguably be retained for future sampling efforts to facilitate long-
497 term data analysis (Sergeant et al. 2012). Consistency of monitoring approaches across
498 allotments or regions, along with collection of local-level data that are amenable to broader-scale

499 analyses, would aid landscape-scale management, such as conservation and maintenance of
500 ecosystem services, which transcend field office and political boundaries. Thus, protocols may
501 require supplementation with additional, more standardized methods. Cases where little historic
502 data exist represent excellent opportunities to revise protocols for standardization across sites and
503 regions.

504 Many handbooks, guides and research programs are available to guide BLM monitoring
505 efforts (e.g., BLM 1999; Elzinga et al. 2001a; Elzinga et al. 2001b; Herrick et al. 2005, 2009;
506 USDA-NRCS 2009). Both deciding among the many methods/approaches and implementing
507 landscape-scale coordinated monitoring efforts will require decision-making at, and guidance
508 from levels higher than individual BLM field offices. Coordinated efforts could include unified
509 prioritization strategies and monitoring teams (discussed above). Collaborations between
510 research and management could also help reconcile the benefits of using consistent methodology
511 across broad scales vs. the need to use a diversity of methods to effectively sample ecologically
512 variable sites across broad scales.

513

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524

525

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678

679 **FIGURE CAPTIONS**

680

681 **Figure 1.** Schematic of (1) the BLM allotment evaluation process which is based on monitoring
682 data and (2) the Land Health Evaluation process which is based on a combination of quantitative
683 and qualitative rangeland health indicators. Dotted arrows indicate feedbacks between the two
684 processes.

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TABLES

Table 1. Top table summarizes office file results from 310 allotments selected at random across 13 Bureau of Land Management (BLM) field offices. Bottom table summarizes results from 62 of 310 allotments that cited livestock grazing as reason for not meeting at least one Land Health Standard. In both tables, allotments are divided into those being managed to “Maintain” vs. “Improve” rangeland condition. For each data type, “Freq.” indicates the percentage of allotments across the region with at least 1 year of data between 1997 and 2007 (although completeness of data within a given allotment is variable, e.g., some allotments may have data for only a subset of key areas or pastures). The “mean # years” column indicates the average number of years for which data exist \pm 1 SE (excluding allotments that had no data). AMP = Allotment Management Plan.

ALL SAMPLED ALLOTMENTS				
Data type	Maintain (n=109)		Improve (n=201)	
	Freq.	mean # yrs	Freq.	mean # yrs
1) Actual Use	59%	6.3 \pm 0.46	77%	6.8 \pm 0.29
2) Utilization	51%	4.4 \pm 0.47	52%	4.7 \pm 0.33
3) Vegetation Trend	34%	1.0 \pm 0	38%	1.04 \pm 0.03
4) Photo Points	53%	1.3 \pm 0.06	61%	1.7 \pm 0.09
AMP or Grazing Plan	17%	-.	26%	-.

698

ALLOTMENTS CITING LIVESTOCK ISSUES				
Data type	Maintain (n=17)		Improve (n=45)	
	Freq.	mean # yrs	Freq.	mean # yrs
1) Actual Use	47%	5 \pm 1.22	84%	3.66 \pm 0.59
2) Utilization	53%	2.56 \pm 1.07	51%	4.43 \pm 0.69
3) Vegetation Trend	35%	1.0 \pm 0	36%	1.01 \pm 0.03
4) Photo Points	65%	1.6 \pm 0.19	71%	2.02 \pm 0.22
All 4 data types	35%	-.	24%	-.
Data types 1,2,3	35%	-.	27%	-.
Data types 1, 2	42%	-.	49%	-.
No data	29%	-.	9%	-.

699

700 **Table 2.** Shading indicates types of data (collected between 1997 and 2007) contained in a sample of 310 allotment files from 13
 701 Bureau of Land Management (BLM) offices across 6 six states (labeled A-F). All frequency, cover, and production techniques are
 702 described in the 1996 Interagency Technical Reference 1734-4, except Line-point, which is a variation of the point-intercept method.
 703 All Utilization techniques are described in the 1996 Interagency Technical Reference 1734-3(BLM 1996), except the Utilization
 704 Gauge method which is a US Forest Service stubble height method. Both “State D” offices also collected Observed Apparent Trend
 705 data, a subjective numerical rating that considers vigor, seedlings, surface litter, pedestals and gullies. Offices A-1, C-1, D-1 and D-2
 706 also used 3ft × 3 ft or 5ft × 5 ft Range Trend Plots for visual estimates of key species attributes such as cover, frequency, density, and
 707 vigor. Specific methodology varied across BLM offices.

Office	frequency			cover				production		utilization					
	Quadrat	Nested	Pace	Daubennire	Line intercept	Line-point	Step-point	Method not specified	Dry-weight- rank	Com-parative yield	Grazed-class	Height-weight	Utilization gauge	Key species	Photo points
A-1															
B-1															
B-2															
C-1															
C-2															
D-1															
D-2															
E-1															
E-2															
F-1															
F-2															
F-3															
F-4															

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709 **Table 3.** Results of Land Health Standards (LHS) evaluations conducted by Bureau of Land Management (BLM) allotments between
710 1997 and 2007. Allotments are divided into those managed to “Maintain” vs. “Improve” rangeland condition. For allotments that had
711 “Not met” a standard, the “Livestock-caused” column indicates the percentage of “Not met” due to livestock. Table summarizes
712 whether allotments met all of their state Upland, Riparian and Biodiversity Land Health Standards (three to five, depending on state;
713 see Table S1). ANOVA indicates significant differences in meeting of “all standards” between Maintain and Improve allotments
714 ($F_{1,18}=7.74$, $p=0.02$) and across states ($F_{9,18}=31.27$, $p<0.0001$). Standards that were “Not met” due to livestock differed significantly
715 across states ($F_{9,18}=3.14$, $p=0.02$). Raw LHS data supplied by BLM.
716

ALL STANDARDS										
State	"MAINTAIN" ALLOTMENTS				"IMPROVE" ALLOTMENTS				NO DATA	
	All stds met	≥ 1 std Not met	Livestock- caused		All stds met	≥ 1 std Not met	Livestock- caused			
A	n=67	73%	27%	11%	n=83	66%	34%	14%	n=189	56%
B	n=182	71%	29%	42%	n=461	64%	36%	47%	n=292	31%
C	n=62	35%	65%	55%	n=57	25%	75%	72%	n=409	77%
D	n=204	61%	39%	56%	n=262	52%	48%	46%	n=353	43%
E	n=140	79%	21%	52%	n=246	82%	18%	43%	n=565	59%
F	n=385	70%	30%	23%	n=352	47%	53%	30%	n=862	54%
G	n=100	63%	37%	14%	n=107	34%	66%	34%	n=71	26%
H	n=371	63%	37%	45%	n=469	39%	61%	60%	n=583	41%
I	n=1463	87%	13%	47%	n=670	68%	32%	56%	n=124	5%
J	n=130	89%	11%	14%	n=180	85%	15%	41%	n=1093	78%
TOTAL	n=3104	77%	23%	41%	n=2887	59%	41%	48%	n=4541	43%

717

Table 4. Results of informal conversations with federal and university rangeland science experts on how best to prioritize monitoring of rangeland condition and livestock impacts. Experts were presented with a hypothetical monitoring scenario. Of the 22 university scientists, three participated in a group conversation and expressed consensus opinions; they are therefore counted as a single expert.

Monitoring priority	Federal (n=20)	University (n=20)
cover	55%	70%
bare ground	25%	15%
gap	5%	5%
production	10%	10%
frequency	5%	0%
density	10%	10%
utilization	35%	25%
cattle and/or wildlife condition	5%	10%
soils	25%	10%
reference areas or ecological sites	30%	40%
photos	30%	15%
remote sensing	30%	35%
identification of at-risk areas	25%	15%

Table S1. Bureau of Land Management regional Land Health Standards (LHS), number of allotments (according to a LHS dataset compiled by the national BLM office in 2008) in each region, and sources outlining LHS. Parentheses indicate which state- or region-specific LHS standards were placed into Upland (U), Riparian (R), or Biodiversity (B) categories. We did not include water quality, air quality, seedings, exotic plant communities, ecosystem components, wild horse/burro, or cultural resources in our categorization or analyses.

BLM LHS Regions	LHS Standards	Number of Allotments	Source
Arizona	Uplands (U) Riparian (R) Biodiversity – native species, special status species, desired species (B)	795	http://rangelandswest.arid.arizona.edu/rangelandswest/jsp/hottopics/legal/policy/azstandards/azstandardsstandards.jsp
Northwestern California and Central California Regions	Soils (U) Species (B) Riparian (R) Water Quality	331	http://www.blm.gov/ca/st/en/prog/grazing.html
Northeastern California and Northwestern Nevada Regions	Upland Soils (U) Streams (R) Water Quality Riparian and Wetland Sites (R) Biodiversity (B)	116	http://www.blm.gov/ca/st/en/prog/grazing.html
California Desert Region	Upland Soils (U) Riparian and Wetland (R) Stream Channel Morphology (R) Native Species (B)	51	Fundamentals of Rangeland Health and Standards and Guidelines for Grazing Administration (43 CFR 4180), Section 4180.2 (f)
Colorado	Upland Soils (U) Riparian Systems (R) Native Plant and Animal Communities (B) Threatened and Endangered Species (B) Water Quality	2088	http://www.blm.gov/co/st/en/BLM_Programs/grazing/rm_stds_guidelines.html
Idaho	Watersheds (U) Riparian and Wetlands (R) Stream Channel/Floodplain (R) Native Plant Communities (B) Seedings Exotic Plant Communities Water Quality Threatened and Endangered Plant and Animal Species (B)	1945	http://www.blm.gov/pgdata/etc/medialib/blm/id/publications.Par.91993.File.dat/SGFinal.pdf
Montana (including North Dakota and South Dakota)	Uplands (U) Riparian and Wetlands (R) Water Quality Air Quality	5000	http://www.blm.gov/mt/st/en/prog/grazing.1.html

	Native Plant and Animal Habitat or Biodiversity (B)		
New Mexico	Upland Sites (U) Biotic Communities including Threatened and Endangered Species (B) Riparian Sites (R)	2152	http://www.blm.gov/pgdata/etc/medialib/blm/nm/field_offices/nmso/nmso_planning/nmso_misc_planning.Par.47309.File.dat/memo-RMPA.pdf
Nevada – Mojave and Southern Great Basin	Soils (U) Ecosystem Components Habitat/Biota (B) Wild Horse/Burros	80	http://www.blm.gov/nv/st/en/prog/grazing/grazing_s_gs.html
Nevada – Sierra Front and Northwestern Nevada	Soils (U) Riparian/Wetlands (R) Water Quality Plant /Animal Habitat (B) Special Status/Threatened and Endangered Species (B)	184	http://www.blm.gov/nv/st/en/prog/grazing/grazing_s_gs.html
Nevada – Northeastern Great Basin	Uplands (U) Riparian/Wetlands (R) Habitat (B) Cultural Resources Healthy Wild Horse/Burros	482	http://www.blm.gov/nv/st/en/prog/grazing/grazing_s_gs.html
Oregon and Washington	Uplands (U) Riparian (R) Ecological Processes (B) Water Quality Habitat for Threatened and Endangered Species (B)	1810	http://www.blm.gov/or/resources/recreation/csnm/files/rangeland_standards.pdf
Utah	Upland Soils (U) Riparian/Wetlands (R) Desired Species (natives, threatened and endangered, special status) (B) Water Quality	1380	http://www.blm.gov/ut/st/en/fo/vernal/grazing/_rangeland_health_standards.html
Wyoming (including Nebraska)	Soils (U) Riparian/Wetlands (R) Upland Vegetation (U) Habitat for Threatened and Endangered Species (B) Water Quality Air Quality	3433	http://www.blm.gov/wy/st/en/programs/grazing/standards_and_guidelines/standards.html

Table S2. Results of Land Health Standards (LHS) evaluations conducted by Bureau of Land Management (BLM) allotments between 1997 and 2007. Allotments are divided into those managed to “Maintain” vs. “Improve” rangeland condition. For allotments that had “Not met” a standard, the “Livestock-caused” column indicates the percentage of “Not met” due to livestock. Standards that were “Not met” due to livestock differed significantly among Upland, Riparian and Biodiversity standards ($F_{2,18}=5.18$, $p=0.02$), and there was a significant interaction between standards (Upland, Riparian, Biodiversity) and allotment status (Maintain, Improve) ($F_{2,18}=21.09$, $p<.0001$). Raw LHS data supplied by BLM.

UPLAND SOIL STANDARD										
State	"MAINTAIN" ALLOTMENTS				"IMPROVE" ALLOTMENTS				NO DATA	
	Met	Not met	Livestock-caused		Met	Not met	Livestock-caused			
A	n=54	96%	4%	0%	n=67	96%	4%	0%	n=218	64%
B	n=182	87%	13%	39%	n=457	79%	21%	48%	n=296	32%
C	n=57	81%	19%	73%	n=55	60%	40%	68%	n=416	79%
D	n=204	87%	13%	50%	n=260	85%	15%	35%	n=355	43%
E	n=140	95%	5%	71%	n=246	91%	9%	43%	n=565	59%
F	n=375	91%	9%	34%	n=336	85%	15%	31%	n=888	56%
G	n=96	98%	2%	50%	n=88	93%	7%	50%	n=94	34%
H	n=371	95%	5%	71%	n=464	79%	21%	67%	n=588	41%
I	n=1455	95%	5%	57%	n=656	93%	7%	73%	n=146	6%
J	n=127	93%	7%	0%	n=178	87%	13%	48%	n=1098	78%
TOTAL	n=3061	93%	7%	50%	n=2807	86%	14%	53%	n=4664	44%

RIPARIAN STANDARD										
State	"MAINTAIN" ALLOTMENTS				"IMPROVE" ALLOTMENTS				NO DATA	
	Met	Not met	Livestock-caused		Met	Not met	Livestock-caused			
A	n=54	94%	6%	33%	n=67	96%	4%	67%	n=218	64%
B	n=182	94%	6%	73%	n=457	88%	12%	72%	n=296	32%
C	n=56	70%	30%	65%	n=47	36%	64%	83%	n=362	78%
D	n=200	75%	25%	66%	n=260	66%	34%	49%	n=359	44%
E	n=139	91%	9%	77%	n=246	93%	7%	82%	n=566	60%
F	n=371	86%	14%	40%	n=324	75%	25%	49%	n=904	57%
G	n=96	89%	11%	9%	n=87	70%	30%	77%	n=95	34%
H	n=358	85%	15%	68%	n=436	66%	34%	72%	n=629	44%
I	n=1459	93%	7%	61%	n=656	77%	23%	68%	n=142	6%
J	n=130	100%	0%	0%	n=180	98%	2%	100%	n=1093	78%
TOTAL	n=3045	90%	10%	59%	n=2760	78%	22%	66%	n=4664	45%

BIODIVERSITY STANDARD										
State	"MAINTAIN" ALLOTMENTS			"IMPROVE" ALLOTMENTS			NO DATA			
	Met	Not met	Livestock-caused	Met	Not met	Livestock-caused				
A	n=68	84%	16%	36%	n=55	93%	7%	25%	n=216	64%
B	n=459	74%	26%	50%	n=182	75%	25%	40%	n=294	31%
C	n=55	40%	60%	67%	n=59	51%	49%	52%	n=414	78%
D	n=260	65%	35%	40%	n=204	74%	26%	50%	n=355	43%
E	n=245	87%	13%	31%	n=140	86%	14%	45%	n=566	60%
F	n=341	77%	23%	33%	n=375	88%	12%	30%	n=883	55%
G	n=88	72%	28%	36%	n=96	79%	21%	20%	n=94	34%
H	n=466	54%	46%	61%	n=367	74%	26%	43%	n=590	41%
I	n=665	88%	12%	58%	n=1460	94%	6%	32%	n=132	6%
J	n=178	87%	13%	43%	n=128	91%	9%	18%	n=1097	78%
TOTAL	n=2825	75%	25%	50%	n=3066	87%	13%	39%	n=4641	44%