

1 **Adapting Natural Resource Management to Climate Change:**
2 **Useful Concepts and Tactical Approaches**

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6**Abstract**

7 Concrete ways to adapt to climate change are needed to help natural resource managers
8take the first steps to incorporate climate change into management and take advantage of
9opportunities to balance the negative effects of climate change. Because the development of
10adaptation tools and strategies is at an early stage, it is important that ideas and strategies are
11disseminated quickly to advance thinking and practice. Here we offer an example of a successful
12workshop that allowed quick dissemination of ideas and strategies for climate change adaptation
13in resource management through an interaction between scientists and managers. We share both
14the process used in the workshop and the outcome of facilitated dialogue at the workshop. By
15presenting concrete adaptation methods and demonstrating the value of a focused scientist-
16manager dialogue, we hope to motivate National Forests and other natural resource agencies to
17emulate our approach and begin the process of adapting to climate change.

18**Keywords:** climate change, adaptation, forest management

19**Introduction**

20 Climate change presents a major challenge to natural resource managers both because of
21the magnitude of potential effects of climate change on ecosystem structure, process, and
22function, and because of the uncertainty associated with those potential ecological effects.
23Furthermore, managers lack operational strategies to aid in adaptation to climate change. In the

24nascent literature on climate change adaptation, much of the focus has been on conceptual issues
25(Hansen et al. 2003), potential actions by governments and municipalities (IPCC 2007, Snover et
26al. 2007), individual resources (Slaughter and Wiener 2007, Sadowski 2008), and biological
27diversity (Heller and Zavaleta 2009). Recent information on climate change adaptation for
28natural resources provides general adaptation strategies (Millar et al. 2007, Joyce et al. 2008,
29Innes et al. 2009). Only a few sources contain information on adaptation to climate change that
30is relevant and usable for natural resource managers from a tactical or operational perspective
31(Ogden and Innes 2007a, 2007b, 2008). Now that most land managers have accepted that
32climate change is real and of great concern, more concrete ways to adapt to climate change are
33needed to help managers take the first steps to incorporate climate change into management and
34reduce the negative effects of climate change on natural resources.

35 The United States Forest Service administers over 78 million ha of land in 155 National
36Forests and 20 National Grasslands across the United States. The Forest Service also advises
37and partners with private and state forest land managers and the international community. The
38National Forest System encompasses a wide range of different ecosystems and much of the
39country's terrestrial biodiversity. In addition to biodiversity, other ecosystem services provided
40by the National Forest System include timber, grazing, municipal and agricultural water supplies,
41recreation, and aesthetics. Climate change will impact all of these ecosystem services provided
42by National Forests, perhaps most importantly, water supplies. The U.S. Forest Service is
43responsible for restoring, sustaining, and enhancing forests and grasslands while providing and
44sustaining benefits to the American people. Because of these responsibilities, federal scientists
45and land managers are tasked with reducing the negative effects of climate change on ecosystem
46function and services, while promoting and enabling beneficial aspects. Timely implementation

47of strategic and tactical adaptation options, with an emphasis on practical approaches that can be
48applied within the broader context of sustainable resource management, will be critical to meet
49both goals (Innes et al. 2009).

50 Resource managers are expected to incorporate science and climate change adaptation
51practices into planning, and they have the skill and local knowledge to do so. Scientists have
52technical knowledge but often a poor understanding of management and regulatory, policy, and
53collaborative social processes for resource planning and decision-making. A clear need exists for
54these two groups of specialists to work together to develop and implement applied adaptation
55projects. However, lack of formal relationships, differences in work culture, time frames, and
56communication styles, etc. have limited this dialog at all scales. In addition, with climate
57change, there is an overwhelming amount of information that managers are trying to absorb, a
58very steep learning curve with climate change science, and little time for learning given
59managers' many responsibilities. Here we offer an example of a successful workshop that
60allowed quick dissemination of ideas and strategies for climate change adaptation in resource
61management through an interaction between scientists and managers. This interaction serves as
62an example of what might be done to promote collaboration between scientists and managers in
63climate change adaptation.

64 We convened a workshop with a novel format to develop Web-based educational
65materials on climate change, and management options for adapting to climate change in the U.S.
66Forest Service and natural resource management in general. We chose a workshop format
67because other studies have reported that managers do not have sufficient time to read referred
68journal articles (one form of scientific outreach), and workshops provide opportunities to transfer
69information and facilitate interaction between managers and scientists (Barbour 2007,

70Youngblood et al. 2007). The workshop not only served to transfer climate change science and
71adaptation information, but also gave managers the opportunity to ask the 'so what' question
72when presented with climate change science information and heightened the managers'
73participation in vetting current adaptation strategies. This event was significant because of the
74process used, group of people assembled, and depth and utility of ideas produced. Because the
75development of adaptation tools and strategies is at an early stage, it is important that ideas and
76strategies are disseminated quickly in order to advance thinking and practice. With this purpose
77in mind, we share here both the process used in the workshop and the outcome of the facilitated
78dialogue of the workshop. In addition to describing the outcomes of interactions between
79scientists and land managers, the ideas put forth in this paper build on existing principles of
80adaptation to climate change, such as the U.S. Climate Change Science Program Synthesis and
81Assessment Product 4.4 (Joyce et al. 2008), Millar et al. (2007), and Bosworth et al. (2008) by
82providing more concrete and tactical ways for resource managers to adapt to climate change.

83 The workshop was conducted over a three-day period and was focused on two specific
84goals: 1) to develop and videotape a coordinated lecture series and related discussions on
85climate change, ecosystem response, and resource management in order to develop a multi-
86media, Web-based educational module; and 2) to promote focused dialogue on climate change
87and management within a select group of resource managers and scientists, and to capture the
88lessons learned from these interchanges. Key Forest Service and other scientists with expertise
89on the topics and contextual experience were invited to develop talks for videotaping. Themes
90were selected for the lecture series to ensure that a range of relevant topics for resource
91management were covered. Many of the talks were based on previous presentations, so
92coordination, review, and vetting were well advanced. A group of resource managers with

93expressed interest in climate change issues was invited as reviewers and discussants. After talks
94were given by the scientists, both scientists and managers discussed the talks and provided
95critical review. Respondents (scientists and managers) were also asked to develop questions and
96commentary that were used during formal videotaping. Scientists then revised their talks to
97accommodate the reviews and delivered the revised talk the following day for formal taping.
98Videotapes from the workshop have been developed into educational modules for a Web-based
99short course (Figure 1; Furniss et al. 2009).

100 In addition to producing lectures, we held a facilitated discussion session during the
101workshop to take advantage of the diverse group assembled and thereby advance thinking on
102issues related to incorporating climate into resource management. These discussions were
103focused on two main questions: (1) How can climate science be directly incorporated in
104resource management?; and (2) How can the uncertainty of future climate change and effects be
105evaluated and managed? The concepts and tactical approaches produced during this workshop
106provide some concrete ways to incorporate climate change science into resource management.

107 **Tangible ways to incorporate climate change science in resource management**

108 Many ideas from the facilitated dialogue focused on how climate change science can be
109institutionalized in government agencies involved with the management of natural resources,
110such as the U.S. Forest Service and the U.S. National Park Service (Table 1). Forest Service
111resource managers and scientists have dealt with a number of major challenges over the last few
112decades, including a major transition from emphasis on production of timber and commodities to
113ecological restoration and management for biodiversity. These past challenges leave the agency
114well-prepared for the shift in thinking required to meet the challenge of climate change.
115Institutionalization will involve incorporating climate change into many aspects of agency

116planning and process (Ogden and Innes 2007a, Innes et al. 2009). If climate change is
117institutionalized, it will be more fully considered in the National Forest planning process, at all
118stages of project development, and in work prioritization, funding prioritization, hiring decisions,
119and staff performance reviews. Ideally, barriers to dealing with the issue of climate change, such
120as policies and regulations that delay implementation of climate change adaptation practices, will
121be removed or altered without changing the benefits of aspects such as public participation in the
122environmental review process (Joyce et al. 2008). In addition, incentives can be created to
123promote advances in addressing climate change and reducing vulnerability to climate change.

124 Education is critical to increasing awareness of and promoting problem-solving related to
125climate change (Spittlehouse and Stewart 2003, Moser and Luers 2008, Littell et al. *in review*).
126Exposing resource managers to climate change science, promoting dialogue, and creating
127opportunities for education will help managers to be aware of the best available science,
128understand concepts associated with climate change science, acknowledge and accept
129uncertainties associated with future climate projections, and incorporate climate change into
130routine management activities (Table 2). Educating the public on climate change will have
131multiple benefits for natural resource agencies. For example, engaging landowners adjacent to
132fire-prone public lands will assist efforts to reduce wildfire hazard and severity (Baron et al.
1332008). Educating the public on climate change will also promote understanding of the steps that
134state and federal land management agencies can take to address climate change, thus promoting
135support for these actions and helping to avoid costly litigation.

136 Scientists will play a key role in helping managers deal with climate change by providing
137the best available information on climate change science and the ecological effects of climate
138change to inform management decision-making. In addition, scientists can encourage managers

139to think more scientifically: to base their decisions on high-quality literature, to understand and
140disclose assumptions and limitations, to subject their work to critical review, and to take an
141experimental approach and monitor results. Managers, in turn, can help scientists be more
142practical, tune their scientific inquiries to the most relevant problems, and focus on solutions and
143the applicability of findings. Thus, iterative interactions and dialogue between scientists and
144managers, and forums for doing so, will be critical to incorporating climate change in natural
145resource management (Moser and Luers 2008, Blate et al. 2009, Innes et al. 2009). There are
146multiple ways to promote scientist/manager interactions, including iterative small meetings and
147informal discussions within communities of practice (e.g., water resources, vegetation
148management) (Table 3). Manager information needs can be determined with the use of surveys
149(e.g., Ogden and Innes 2007b). Science delivery can be enhanced by commissioning technical
150communication teams for natural resource agencies. Scientists and managers can also share
151information with others on successes and failures in climate change adaptation via the Internet or
152other means.

153 In addition to collaboration between scientists and managers, collaboration among
154agencies, organizations and stakeholder groups will facilitate adaptation to climate change
155(Baron et al. 2008, Littell et al. *in review*). Developing common plans and shared visions of
156resource management can result in saved time and financial resources, and more innovative, and
157ultimately more effective, strategies in the face of climate change (Table 4). For example,
158management for species such as ungulates and carnivores with home ranges larger than any
159single agency's ownership can be improved through collaboration among stakeholders (Baron et
160al. 2008, Heller and Zavaleta 2009). Collaboration can also be expanded to a united climate
161change outreach program, such as the proposed U.S. National Climate Service, that provides

162credible information on climatology, predictions of climate change effects, planning tools, and
163tutorials.

164 Many plant species will be subjected to increasing stress in a changing climate, and some
165species and genotypes may be unable to adapt to rapid warming. Genetic stock that is better
166adapted to climatic conditions of the future will be more resilient and also increase overall
167ecosystem resilience. For these reasons, it will be imperative that natural resource agencies
168reassess genetic resources (e.g., seed availability, nursery stock) with climate change in mind
169(Parker et al. 2000, Spittlehouse and Stewart 2003, Millar et al. 2007) (Table 5). Agencies may
170want to put more resources into state and federal nursery programs, expand germplasm
171collections (seed, pollen), restore germplasm archives (many seed storage units have been
172closed), and include broader representation of diverse provenances. Experimentation to
173determine the best provenance and species mixes to plant after disturbance in different locations
174can help to increase plant community resilience to both climate change and the disturbance
175regimes of the future.

176 Increased disturbance will almost certainly be associated with a warmer climate in many
177locations. For example, area burned by wildfire (McKenzie et al. 2004) and subjected to bark
178beetle outbreaks (Hicke et al. 2006) is expected to increase significantly across the western
179United States. Incorporating disturbance into natural resource planning, rather than treating it as
180an anomaly, will facilitate timely and effective management actions when disturbance events
181occur (Millar et al. 2007, Littell et al. *in review*) (Table 6). Using past extreme events and
182response to those extreme events as a context may help to structure thinking and improve
183response to future events. In addition, management activities that reduce the severity of

184disturbance, such as reduction of hazardous fuels in fire-prone forests, may help to reduce
185ecosystem vulnerability to a warmer climate (Dale et al. 2001, Joyce et al. 2008).

186 **Tools and methods to evaluate and manage uncertainty**

187 Dealing with uncertainties associated with the magnitude of changing temperature and
188precipitation, and the magnitude and nature of ecological effects of climate change, is one of the
189biggest challenges for land managers facing a changing climate. The many types of uncertainties
190can be overwhelming and delay adaptive responses. The second part of the facilitated dialogue,
191summarized below, was focused on tools and methods to evaluate and manage uncertainties
192associated with climate change in natural resource management.

193 Dealing with uncertainty requires that risks associated with uncertainty are both
194identified and evaluated (Table 7). Risks to ecosystems and risks associated with taking the
195wrong management path can be identified by asking ‘what if...?’ during planning and project
196development. Once risks are identified, they can be evaluated to determine which are most
197important to consider (i.e., set priorities). Uncertainties are important only when they are
198associated with high risks to ecosystems at local or larger scales. Confidences of risk (level of
199likeliness) can be quantified or approximated instead of quantifying uncertainty (e.g., Brekke et
200al. 2009).

201 To incorporate risk and uncertainty into management, scenarios can be developed to
202bracket a credible range of potential future climates and ecosystem conditions, and managers can
203work to develop associated strategies for dealing with those future conditions (Baron et al. 2008)
204(Table 8). In addition, employees/functions that assess risks associated with climate change can
205help managers incorporate risks into management. For example, development of tools that

206 assess post-disturbance risks, such as debris flows following fire and heavy rain, can help
207 managers consider and incorporate those risks into post-disturbance planning.

208 Conducting watershed vulnerability assessments could also help to incorporate risk into
209 management (Table 9). An effective assessment of watershed vulnerability will require 1) the
210 ability to identify the watersheds of highest priority for protecting watershed amenity values
211 (such as domestic and industrial water supplies, endangered species, and recreational uses); 2)
212 the ability to identify the watersheds in which climate-related risk to those amenity values is
213 greatest, as well as “climate-change refugia” that are expected to see the least effects; 3) the
214 ability to detect evidence of the nature and likely magnitudes of change as early as possible; and
215 4) the ability to select mitigations appropriate for the effects likely in particular watersheds.
216 Development of a procedure for watershed vulnerability assessments would be most useful if it
217 were capable of providing information over large areas for relatively small outlays of time and
218 effort. This tool would be applicable both in the context of a Forest Service watershed condition
219 assessment and as a stand-alone assessment procedure for use by anyone concerned about
220 watershed change.

221 Increasing the resilience of ecosystems is one way to prepare for an uncertain future
222 (Dale et al. 2001, Spittlehouse and Stewart 2003, Millar et al. 2007), and increasing the diversity
223 of vegetation structures across large landscapes can help to increase ecosystem resilience to
224 climate change (Table 10). Using a portfolio of management approaches and practices, much
225 like a stock portfolio, can help managers to “hedge their bets,” increase the diversity of outcomes
226 on the ground, and thus increase ecosystem resilience (Millar et al. 2007, Joyce et al. 2009).
227 Diversifying seed banks and plantings will similarly increase resilience by reducing the
228 likelihood of forest stand failure (Heller and Zavaleta 2009).

229 Reducing the effects of already existing non-climatic stressors on ecosystems, such as
230 landscape fragmentation and invasive species, will also increase ecosystem resilience to climatic
231 changes (Baron et al. 2008, Joyce et al. 2008). Climate change is not the only issue that natural
232 resource managers must deal with, and because of financial and time constraints, climate change
233 may be a low priority for some natural resource managers (Moser and Luers 2008). However,
234 embracing integrated ecosystem-based management and sustainable resource management in
235 general (Ogden and Innes 2007a, Innes 2009), in which climate change is one of many stresses
236 considered, could help alleviate current constraints on allocation of time and effort for managing
237 climate change effects.

238 Keeping an open mind is also going to be important for managers in dealing with
239 uncertainties of climate change (Table 11). Periodic failures will be an inevitable part of dealing
240 with uncertainties related to climate change. However, periodic failures will be an important
241 component of active learning as climate change effects are realized.

242 **Discussion**

243 Ideas generated from the workshop are consistent with the more general strategies for
244 adaptation of natural resources to climate change outlined in recent reports. For example, the
245 concept of promoting ecosystem resilience as an adaptation to climate change is common across
246 existing guides to adaptation (e.g., Dale et al. 2001, Spittlehouse and Stewart 2003, Millar et al.
247 2007). Promoting resilience is a concept that was also highlighted in the workshop as a way to
248 deal with uncertainties associated with climate change, and multiple ways to increase forest
249 resilience by increasing landscape diversity and watershed health were discussed. Resilient
250 forests and watersheds can better accommodate changing conditions, such as gradually changing
251 temperature and precipitation, and maintain ecosystem function after a disturbance such as fire.

252 Even if managers are uncertain about exactly what the future holds, resilient forests will be more
253 likely to accommodate future conditions (Innes et al. 2009) and reduce the number of situations
254 in which land managers must respond in “crisis mode.”

255 Most guides to adaptation suggest using a variety of tools and management practices to
256 deal with an uncertain future (e.g., Smith and Lenhart 1996, Millar et al. 2007, Joyce et al. 2009),
257 similar to the suggestion of using a ‘portfolio of management approaches’ suggested here.
258 Related and often cited adaptation strategies include flexibility and active learning, or the idea of
259 adaptive management (e.g., Dale et al. 2001, Millar et al. 2007, Baron et al. 2008). With
260 flexibility and active learning, tools and strategies that are most effective under a changing
261 climate can be discovered and more widely implemented.

262 Reassessing genetic resources is another climate change adaptation strategy that is often
263 suggested in guides to adaptation (e.g., Smith and Lenhart 1996, Parker et al. 2000, Noss 2001),
264 as it was in the workshop. Appropriate species and genotypes can be planted in anticipation of a
265 warmer climate, thus allowing resource managers to diversify the phenotypic and genotypic
266 template on which climate and competition interact, and to avoid widespread mortality at the
267 regeneration stage.

268 Several guides to adaptation recommend that education and awareness about climate
269 change be promoted to facilitate adaptation (e.g., Smith and Lenhart 1996, Spittlehouse and
270 Stewart 2003, Moser and Luers 2008). Similarly, in the workshop, there was much discussion
271 about ways to promote education and awareness on climate change, both in government agencies
272 and with the public. Education and awareness will increase capacity to analyze climate change
273 information and use it in decision-making (Moser and Luers 2008). Scientists will play a key role
274 in providing the best available information to managers, and effective communication between

275scientists and managers will be critical for successful adaptation to climate change in natural
276resources management (Baron et al. 2008, Joyce et al. 2008, Moser and Luers 2008).

277Collaboration among agencies, stakeholders, and other groups will also help develop support for
278and consistency in adaptation options (Baron et al. 2008, Littell et al. *in review*).

279 Though many of the ideas put forth during the discussion were consistent with current
280literature, new and different ideas for adaptation to climate change were also discussed. Many of
281these ideas, listed in Tables 1-11, would affect resource management more directly than the more
282general ideas that dominate current adaptation literature (e.g., increase ecosystem resilience).
283These more concrete ways to adapt natural resource management to climate change were
284developed as a result of the workshop setting that allowed for direct engagement between
285scientists and managers. The workshop was not only an efficient method for science delivery to
286managers, but it also allowed managers to critique existing ideas and suggest new methods for
287adaptation to climate change. The workshop also resulted in efficient development of online
288education materials for use by natural resource managers. This workshop can serve as a model
289others can follow for future development of adaptation options for natural resource management.

290 Adaptation to climate change presents organizational and cultural challenges in addition
291to ecological ones. Many ideas that emerged in the workshop with natural resource managers
292and scientists focus on institutional changes that need to occur for successful adaptation. Even if
293good scientific information and financial resources are available, regulations (e.g., U.S.
294Endangered Species Act), policy (e.g., forest harvest restrictions), and litigation (e.g., lawsuits
295from advocacy groups) can prevent or reduce the effectiveness of proposed adaptation activities.
296This will be a significant challenge for the implementation of adaptation on public lands.

297 Finally, with the possible exception of the Waxman-Markey climate bill that will be
298 considered by the U.S. Senate, the Forest Service and other federal agencies that manage natural
299 resources in the United States currently do not have a mandate for developing adaptation plans or
300a framework through which adaptation can be accomplished. It is challenging to motivate a
301 geographically dispersed workforce, already stretched by heavy workloads, to expand their
302 management and planning responsibilities to include climate change. In the meantime,
303 leadership is being provided by individual national forests in which managers have volunteered
304 to develop adaptation plans (e.g., Joyce et al. 2008, Littell et al. *in review*) and by *ad hoc* efforts
305 such as the workshop described here. By demonstrating the value of a focused scientist-manager
306 dialogue to develop educational information and adaptation options, we hope to motivate
307 National Forests and other natural resource agencies to emulate our approach and start the
308 process of adapting to climate change.

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393 **Table 1.**

Institutionalize climate change

- 394
395 • Incorporate climate change in the planning
396 process and project development
397 • Incorporate climate change into work
398 prioritization
399
400 • Conduct watershed vulnerability assessments
401 to determine which areas are most sensitive to
402 climate effects and which kinds of adaptations
403 are appropriate
404
405 • Give higher priority and more funding to
406 projects that meet climate change goals
407
408 • Hire staff dedicated to disseminating
409 information and increasing
410 awareness/understanding of climate change
411 effects
412 • Require one specific climate change
413 adaptation or mitigation activity per year in
414 employee performance reviews
415
416 • Remove barriers to dealing with climate
417 change, such as prohibitive policies and lack
418 of funding
419
• Create incentives for solving climate change
problems
-

420

421 **Table 2.**

422 _____

423 **Educate about climate change**

424 _____

424 • Expose managers at all levels to current
425 climate change science and find opportunities
426 for dialogue
427

428 • Create ability for resource managers to learn
429 about climate change through tools, trainings
430 and workshops

431
432 • Educate the public about climate change
433 through information kiosks and shared
434 learning workshops with resource managers

435 • Provide and mandate reading of summaries
436 on climate change science for all agency staff
437

438 • Develop climate change curriculum material
439 for use in existing professional training events

440 _____

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443

444 **Table 3.**

445

446 **Improve information exchange and**
447 **communication**

448

449 • Refine information exchange between
450 scientists and managers by holding small
451 meetings between scientists and managers. In
452 these meetings, managers would communicate
453 information needs and scientists would provide
454 information. Make this an iterative process.

455

456 • Improve technology transfer and science
457 delivery by permanently funding a climate
458 change science delivery team

459 • Initiate informal discussions on climate
460 change at multiple levels: internally, within
461 communities of practice, and with the public
462

463 • Increase collaboration among researchers and
464 managers in identifying key questions for
465 monitoring program design

466

467 • Determine resource managers' information
468 needs with a survey and develop a strategy to
469 meet those needs

470 • Hold 'pulses' in which scientists and
471 managers engage in intensive two- to three-
472 week meetings to discuss climate change
473 adaptation options for a specific geographic
474 location

475

476 • Encourage leadership, formally or informally,
477 to share information

478

479 • Share resources (via the Internet or other
480 means) on successes and near-successes in
481 climate change adaptation

482

483

484 **Table 4.**

485	Increase collaboration among agencies, organizations and groups
486	
487	
488	• Increase interagency strategic coordination in
489	response to climate change and work towards a
490	shared vision of resource management
491	
492	• Design joint, multi-party monitoring and
493	assessment efforts
494	
495	• Develop common plans for addressing fire
496	and fuels, invasive species, corridors,
497	minimizing pollution, and land use
498	• Develop an interagency climate service that
499	provides information, scenarios, toolboxes, tutorials, and credible information

500

501

502 **Table 5.**

503	Reassess genetic resources
504	• Evaluate old genetic transplant/ provenance
505	plantations for viability under current and
506	future conditions
507	
508	• Conduct controlled experiments of different
509	provenance and species mixes after fire, and
510	monitor at 1, 3, 5 and 10 years post-fire
511	
512	• Fund state and federal nursery programs
513	
514	
515	
516	
517	
518	

519 **Table 6.**

520 **Manage for disturbance and extreme events**

521 • Incorporate disturbance into planning

522 • Use past extreme events and response to
523 those events to think about and improve
524 response to future extreme events
525

526 • Consider the effects of extreme events and
527 disturbances on natural resources and how
528 management can alter the vulnerability of
529 ecosystems to these events

530
531 • Sharply increase the area of fuel treatments
532 in fire-prone forests, and consider climate
533 change scenarios in determining the location,
534 type, placement and timing of fuel treatments

535

536

537

538

539 **Table 7.**

540 _____
541 **Identify and evaluate uncertainties and**
542 **risks** _____
543
544 • Ask ‘what if?’ in project development
545 • Match the level of analyses with risk;
546 uncertainty is important only when it is
547 associated with high risk
548
549 • Promote the concept of negotiated risk -
550 identify what is scarce or scary
551 • Consider confidences of risk (level of
552 likelihood) instead of quantifying uncertainty
553
554 • Pare down uncertainties to issues that can be
555 dealt with most easily
556
557 • Identify watersheds and landscapes that are
558 most and least susceptible to loss of ecosystem
559 services due to climatic changes
560 _____
561 Table 8.

562 **Table 8.**

563	Incorporate uncertainty and risk into
564	management
	<hr/>
564	• Manage for the unexpected
565	• Conduct targeted scenario planning that
566	incorporates risk, values, and
	recommendations for actions
567	
568	• Incorporate the concept of non-stationarity
569	(e.g., the 50-year flood concept is changing)
570	• Establish an advisory group that assesses risk
571	and uncertainty
572	
573	• Develop tools to assess post-fire effects and
574	debris-flow risk
575	<hr/>
576	

577 **Table 9.**

578 **Maintain and improve watershed resilience**

579 • Protect and restore riparian forests.

580 • Improve or decommission roads

581 • Restore meadows, wetlands, and flood plains

582 • Maintain and restore environmental flows.

583 • Remove migration barriers and reestablish
584 habitat connectivity

585

586

587 **Table 10.**

588

589 **Increase landscape diversity**

590 • Use a portfolio approach, as done with a
stock portfolio, and implement a range of
591 management practices

592 • Manage for ecosystem process and for
landscape diversity (e.g., diversity of forest
593 ages, structures, and species composition)
while maintaining habitat connectivity

594 • Diversify seed banks and plantings

595

596

597

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600

601

602

603 **Table 11.**

604 **Keep an open mind**

605 • Avoid throwing away ideas just because they
have failed in the past

606 • Incorporate an active learning process in
607 decision-making

608

609

610Figure 1. Cover of Web-based short course for land managers developed from the described
611workshop. This short course is available on the Web at: www.fs.fed.us/pnw/pep/hjar.shtml.

612

613Table 1. Methods to institutionalize climate change into natural resource management agencies.

614

615Table 2. Methods to educate natural resources managers and the public about climate change.

616

617Table 3. Methods to improve information exchange and communication about climate change.

618

619Table 4. Methods to increase collaboration among agencies, organizations and groups to
620facilitate climate change adaptation.

621

622Table 5. Methods to reassess genetic resources in the face of climate change.

623Table 6. Methods to manage for increased disturbance and extreme events that will likely occur
624with climate change.

625Table 7. Methods to identify and evaluate uncertainties and risks associated with climate change.

626Table 8. Methods to incorporate uncertainty and risk associated with climate change into
627resource management.

628Table 9. Methods to maintain and improve watershed resilience with climate change.

629Table 10. Methods to increase landscape diversity and increase ecosystem resilience to climate
630change.

631Table 11. Methods to keep an open mind in adapting to climate change.

632