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Development by design: blending landscape-level planning with the mitigation hierarchy

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Development by design: blending landscape-level planning with the mitigation hierarchy

Joseph M Kiesecker[1*], Holly Copeland[2], Amy Pocewicz[2], and Bruce McKenney[3]

Compensatory mitigation, or biodiversity offsets, provide a mechanism for maintaining or enhancing environmental values in situations where development is being planned, despite detrimental environmental impacts. Offsets are generally intended as an option for addressing any remaining environmental impacts of a development plan, after efforts have been made to avoid, minimize, or restore on-site impacts. Although offset programs require that developers adhere to the mitigation hierarchy to avoid, minimize, and restore biodiversity on-site before considering an offset for residual impacts, no quantitative guidelines exist for this decision-making process. What criteria are needed to require that impacts be minimized or avoided altogether? Here, we examine how conservation planning can provide a way to address this issue. By blending landscape-level conservation planning with application of the mitigation hierarchy, we can ensure that the use of biodiversity offsets is consistent with sustainable development practices.

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There is widespread consensus that the world is currently experiencing a mass extinction event (Wilson 1992; Novacek and Cleland 2001). The biodiversity loss associated with this process is the result of several factors, including: land-use change and habitat destruction, invasive species, overexploitation of resources, pollution, and climate change. Of these factors, habitat destruction is by far the most detrimental, with infrastructure development playing a key role (Hardner and Rice 2002). It is estimated that an unprecedented US$22 trillion will be invested, to support increased infrastructure development by 2030, mostly in developing countries (IEA 2006; World Bank 2007). With the mounting pressure on natural resources as human populations grow, there is increasing urgency to find ways to balance these growing needs with those of biodiversity conservation.

Environmental impact assessment (EIA) is a systematic process that examines the environmental consequences of planned developments (Lawrence 2003). Since its inception in the US in 1969, the concept of EIA has spread worldwide.

In a nutshell:

- Balancing growing resource needs with biodiversity conservation requires an approach beyond traditional project-by-project mitigation for impacts resulting from development
- We show how conservation planning, in combination with the mitigation hierarchy, can guide decision making on where impacts to biodiversity can be offset and where they should be avoided or minimized
- This framework not only guides the use of mitigation strategies, but also provides a structure for funding conservation

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The emphasis of EIA is on prediction and prevention of environmental damage (Lawrence 2003). The mitigation of environmental impacts is therefore a key stage of the EIA process, and lies at its heart (Pritchard 1993). EIA practitioners seek to minimize impacts through the application of the "mitigation hierarchy": avoid, minimize, restore, or offset (CEQ 2000). In theory, this process provides a mechanism to balance development and conservation; however, in practice, EIA is applied on a project-by-project basis, which can underestimate the cumulative impacts of multiple current or projected development projects within an area and also limit flexibility in applying the mitigation hierarchy.

Offsets are an increasingly popular mechanism for achieving environmental benefits (Gibbons and Lindenmayer 2007), by providing a mechanism for maintaining or enhancing environmental values in situations where development is being planned, despite the fact that such development is likely to cause detrimental environmental impacts (ten Kate 2004). Biodiversity offsets seek to ensure that the inevitable negative environmental impacts of development are moderated by environmental gains, with the overall aim of achieving a net neutral or positive outcome (ten Kate 2004; McKenney 2005). Offsets are generally intended as an option for addressing any residual environmental damage, after efforts have been undertaken to avoid and minimize the impacts (Figure 1).

Although the potential benefits of biodiversity offsets are numerous – including benefits for industry, government, and conservation groups alike – establishing offsets involves overcoming several conceptual and methodological challenges. A major problem with this approach is that it implies that all habitats can be offset. A key question concerning the use of offsets therefore centers on when and where they can be used as an appropriate tool. If offset use continues to increase, how do we know that impacts to

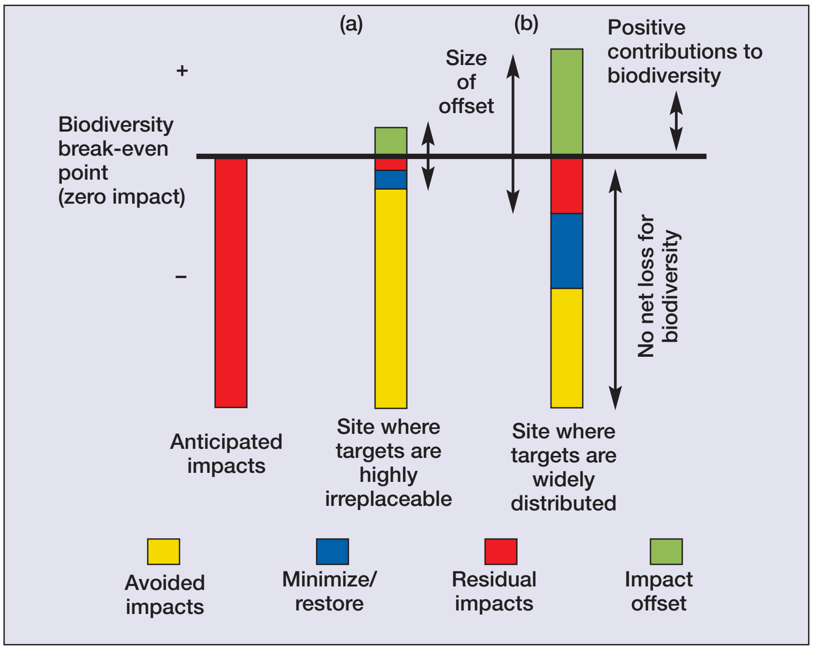

Figure 1. *Site-level mitigation recommendations resulting from a landscape-level plan. Impacts and mitigation to biodiversity are represented here for two examples, each occurring in areas where a landscape-level plan would recommend different mitigation options. (a) Proposed development at a site (ie Flaming Gorge) where targets are irreplaceable, necessitating a greater reliance on the use of avoidance and/or minimization. (b) Proposed development at a site (ie Calamity Ridge) where targets are widely distributed and/or highly conserved.*

biodiversity will continue to be offset? Regulatory agencies often require that developers follow the mitigation hierarchy (CEQ 2000) of seeking to avoid, minimize, and restore biodiversity on the site, before considering an offset for the residual impacts. However, no quantitative guidelines exist to guide this decision-making process.

Conservation planning (eg Groves 2003) provides a framework to ensure that mitigation efforts are consistent with conservation goals; this often includes the maintenance of large, resilient ecosystems to support both healthy wildlife habitats and human communities. Blending the mitigation hierarchy with conservation planning offers three distinct advantages over a traditional project-by-project approach. The mitigation-planning combination (1) takes into account the cumulative impacts of current or projected development projects; (2) provides regional context to better guide which step of the mitigation hierarchy should be applied (ie avoidance versus offsets); and (3) offers increased flexibility in choosing offsets that maximize conservation returns, by providing resources for the most threatened ecosystems or species.

Systematic conservation planning

Landscape-level conservation planning is the process of locating, configuring, and maintaining areas that are managed to maintain viability of biodiversity and other natural features (Pressey and Bottrill 2008). A conservation portfolio (composed of priority sites), the end product of conservation planning, is made up of a selected set of areas that represent the full distribution and diversity of these systems (Noss *et al.* 2002). Plans often optimize (Ball and Possingham 2000) the design of the portfolio to meet the minimum viability needs of each biological target, but in a way that minimizes the area required (Pressey *et al.* 1997; Ball and Possingham 2000). Thus, even though areas outside of the portfolio have not been selected, they may still help to meet biodiversity goals. The key feature of a conservation plan is the clear articulation of a biodiversity vision that incorporates the full range of biological features, how they are currently distributed, and what minimum viability needs each biological target requires to persist in the long term (Lovejoy 1980; Armbruster and Lande 1993; Doncaster *et al.* 1996). The creation of this vision and the implementation of the conservation strategy depend on the active involvement of host governments, experts from many disciplines, development organizations, and local residents. The ultimate goal is a peer-reviewed conservation strategy with specific action plans that are widely embraced and implemented by stakeholders.

Mitigation planning

We envision two ways in which conservation plans could be used to guide the application of the mitigation hierarchy. First, where plans have already been completed, proposed developments can be mapped and assessed relative to the conservation portfolio and the minimum viability needs of the target species. Overlap between the portfolio and the proposed development may result in a "redrawing" of the portfolio to recapture habitat needed to meet biodiversity goals impacted by development. However, if minimum viability needs cannot be met elsewhere within the study area, the development plans would need to minimize impacts to the degree that maintains the viability of the biological targets or development should not proceed (Figures 1 and 2). Second, where future development activities (eg oil and gas development, wind/solar development, residential development, some types of mining) can be estimated, these projections can be either mapped in association with an existing portfolio or used as part of the creation of a new conservation plan (Figure 2). The portfolio should be designed to avoid conflict with potential development. Areas where such projects could hinder conservation goals would again be identified and examined in greater detail and categorized as "avoidance/minimization" areas, as needed. If adopted, this framework would provide an opportunity to avoid conflict between potential development and areas that are critical for biodiversity conservation, and provide a structured framework to guide decisions regarding which step in the mitigation hierarchy should be applied (Figures 1 and 2).

Landscape-level plans can also maximize the benefits to conservation of applying the mitigation hierarchy, in particular where offsets are used. Most biodiversity offset legislation and policies presume "like-for-like" or "in-kind" offsets (ie offsets that conserve biodiversity of a similar kind to that affected by the development). At times, however, better conservation results may be obtained by placing the offset in an ecosystem of higher conservation priority. A regional landscape perspective can provide opportunities for identifying situations where "trading up", or "out-of-kind" offsets may offer valuable alternatives. Consider, for example, development that results in impacts to a widely distributed or highly conserved target. Requiring in-kind offsets could limit the potential benefit that an offset might provide. For example, losses of a particular common habitat type could be offset in a habitat of higher priority in the region, because it is under great threat (ie vulnerable) or because it is the last remaining example of its kind, and is therefore irreplaceable. Out-of-kind offsets may also be preferable where there is an opportunity to take advantage of existing conservation management to locate the offset, or consolidating several offsets in one location. Of course, alternatives to strict in-kind criteria would need to be clearly beneficial to biodiversity conservation or might only be adopted after proper consideration of an in-kind offset, and should not simply be driven by cost reduction.

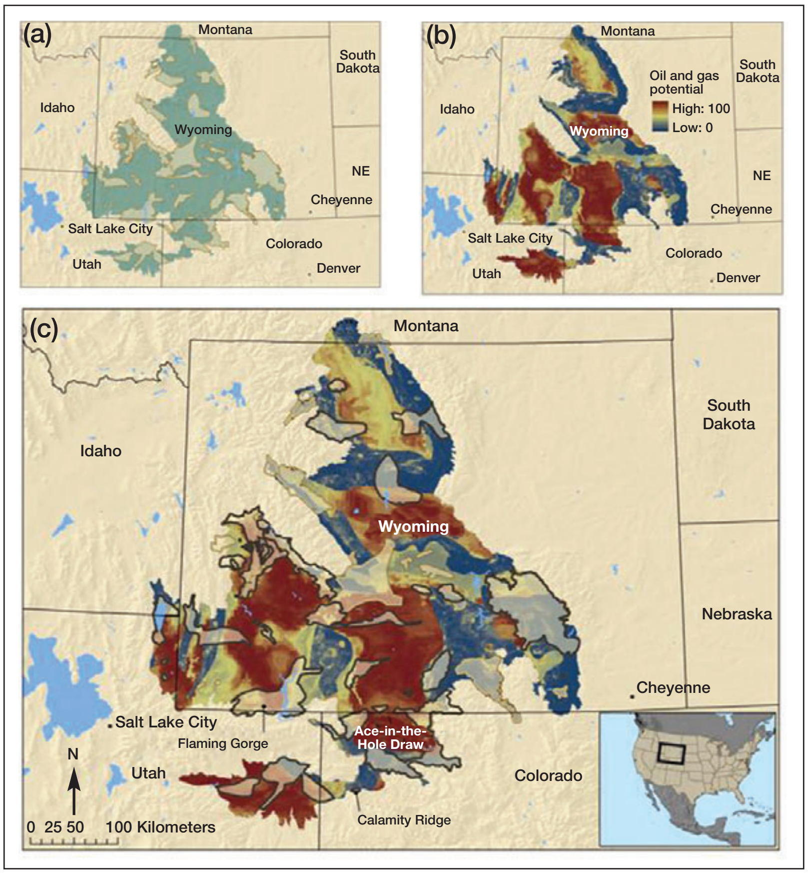

Figure 2. *Landscape-level recommendations for the application of the mitigation hierarchy in the Wyoming Basins ecoregion. (a) Portfolio of conservation sites selected by the Wyoming Basins ecoregional assessment (Freilich* et al. *2001). (b) Oil and gas potential, based on estimates of undiscovered, technically recoverable resources (US DOI 2006; Copeland* et al. *2007; Kiesecker* et al. *2009; Copeland* et al. *in review). (c) Sites that overlap areas with high probability of development outlined in black. Labeled sites – Ace-in-the-Hole Draw, Calamity Ridge, and Flaming Gorge – are discussed in more detail in the text.*

The Wyoming Basins ecoregion: a case study in mitigation planning

The Wyoming Basins ecoregion (WBE) comprises 13.3 million hectares of basin, plain, desert, and "island" mountains in Wyoming, Montana, Idaho, Colorado, and Utah (Bailey 1995; Figure 3). The area is a stronghold for the greater sage-grouse (*Centrocercus urophasianus*), an emblematic native game bird now being considered for listing under the Endangered Species Act (Figure 4). The ecoregion provides critical habitat for migratory big game, songbirds, and raptors within the reaches of the Greater Yellowstone ecosystem. Some of the world's largest herds of mule deer (*Odocoileus hemionus*) and pronghorn antelope (*Antilocarpa americana*) winter here, relying on the snow-free forage to get them through harsh winter weather (Figure 5). In an attempt to identify areas that would maintain long-term persistence of representative biodiversity for the ecoregion, The Nature Conservancy, together with key state and federal land management and wildlife regulatory agencies, universities, and other conservation organizations, set out to conduct an ecoregional plan for the WBE (Freilich *et al.* 2001). The portfolio of sites chosen during the WBE ecoregional assessment totals 3.5 million ha, or 27% of the total area in the ecoregion (Figure 2a). The WBE is also home to some of the richest oil and gas deposits in the western US (US DOI 2006; Figures 2b and 5), including some that intersect areas selected in the ecoregional assessment (Figure 2c). In fact, the number of producing oil and gas wells in the ecoregion has nearly tripled since the 1980s and is expected to increase further over the next 30 years (Copeland *et al.* 2007; Doherty *et al.* in press). Conservation of the biological diversity in this area is in question, in part because the US Federal Government has authorized exploration and development on over 4 million of the 8 million ha (52%) of the federal mineral estate within the ecoregion (Doherty *et al.* in press).

Here, we use the portfolio of sites selected in the plan (Freilich *et al.* 2001; Figure 2a) to demonstrate how we can

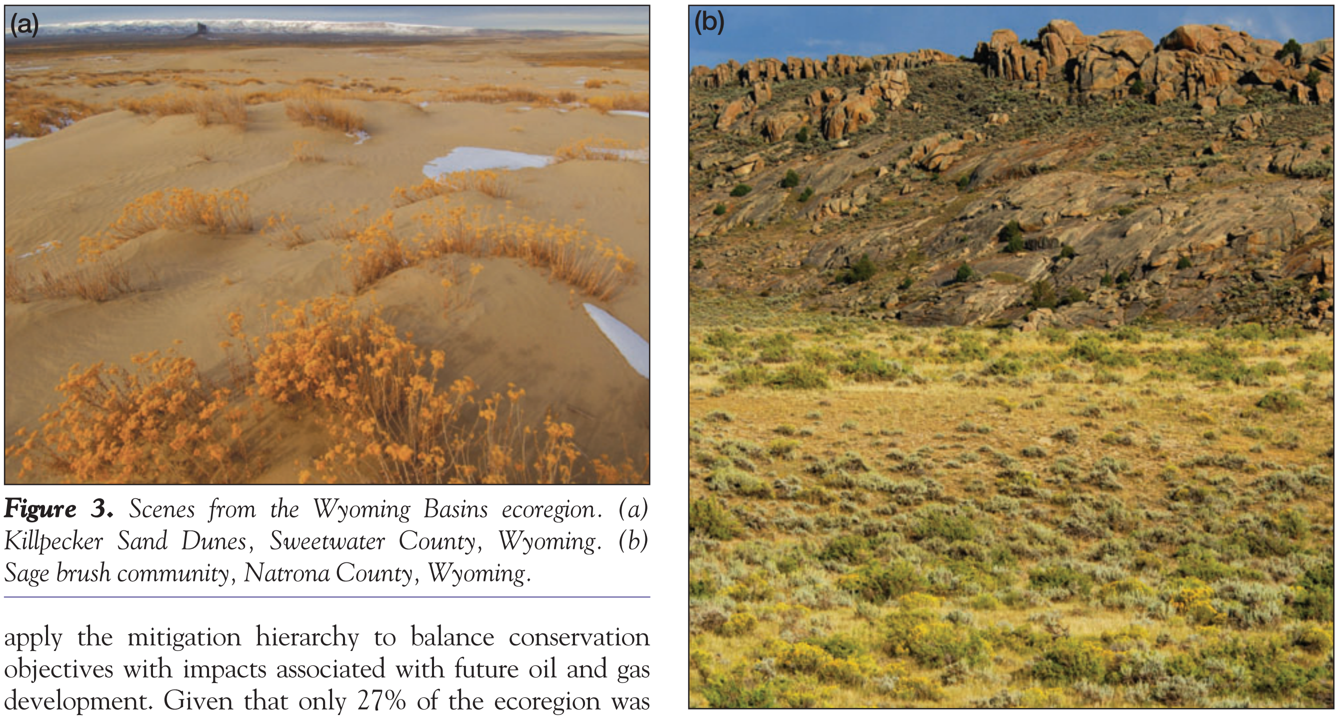

Figure 3. *Scenes from the Wyoming Basins ecoregion. (a) Killpecker Sand Dunes, Sweetwater County, Wyoming. (b) Sage brush community, Natrona County, Wyoming.*

apply the mitigation hierarchy to balance conservation objectives with impacts associated with future oil and gas development. Given that only 27% of the ecoregion was selected as part of the conservation portfolio, conflicts could potentially be resolved by simply redesigning the portfolio to meet the minimum viability needs of the biological targets in areas with lower oil and gas potential (Figure 2c; WebTable 1). We examined the intersection between these conservation areas and the land with the highest 25% of oil and gas potential, based on estimates of undiscovered, technically recoverable resources (US DOI 2006; Copeland *et al.* 2007; Kiesecker *et al.* 2009; Copeland *et al.* in review). A total of 27 conservation areas intersect with areas considered to have high development potential (Figure 2c). Sites would receive different mitigation recommendations, depending on the nature and distribution of conservation targets that the sites attempted to conserve. In our example, 22 of the 27 sites could use offsets to mitigate impacts resulting from development (WebTable 1). Of these 22 sites, nine have target goals that could be met completely elsewhere. For example, the Calamity Ridge site, located in northwestern Colorado, contains four widespread ecological systems (as per Freilich *et al.* 2001) for which goals could be met by substituting areas with low oil and gas potential currently outside of the portfolio. Eight of the 22 sites where offsets could be employed have localized occurrences of rare plants or animals that overlap with high oil and gas development potential. After attempts are made to avoid and/or minimize impacts to these target species, the remaining impacts could be offset. For example, the Ace-in-the-Hole Draw site contains only one rare plant (Nelson's milkvetch, *Astragalus nelsonianus*) that is critical in meeting ecoregional goals. As a first step, direct disturbance to the rocky outcrops and highly saline soils that serve as habitat for Nelson's milkvetch should be avoided and indirect impacts of development (ie spread of invasive plants) minimized. Second, any unavoidable impacts to the three ecological systems also present within the site could be offset. The remaining five sites where offsets could be used also have localized occurrences of rare plants or animals, but these occurrences do not overlap with high oil and gas development potential; therefore, unavoidable impacts to the widespread ecological systems found in these sites can be offset.

At the sites where conflicts can be resolved, development could proceed with a greater degree of flexibility in applying the mitigation hierarchy, so that residual impacts are managed through the use of on-site restoration and offsets (Figure 1). For example, a development proposed within the Calamity Ridge site that would result in residual impacts to its ecological systems could be offset. Applying the "no-net-loss" concept, as prescribed by Kiesecker *et al.* (2009), to impacts associated with development at this site and offsetting any residual impact would be consistent with the ecoregional goals. Moreover, the ecoregional perspective provides the opportunity to maximize offset benefits. Because irreplacability scores can be calculated for each biological target across the ecoregion (Ferrier *et al.* 2000), decisions regarding offsets can maximize benefits when made at this scale. For example, consider impacts to juniper woodlands at the Calamity Ridge site. Offsets could be directed at other juniper woodlands (in-kind offsets) or directed toward targets of greater conservation value (out-of-kind offsets). Juniper woodlands are widespread, highly conserved, and occur in areas not judged to be at great risk (Freilich *et al.* 2001; Copeland *et al.* 2007), so that directing offsets at targets considered to be irreplaceable (ie sagebrush systems) will result in a higher conservation return.

In sites containing irreplaceable targets, however, greater emphasis will be given to avoidance or minimization (WebTable 1). For example, of the 27 sites that overlap areas of high development potential, five contain occurrences of both rare plants and animals that are critical to meeting ecoregional goals and are distributed across most of the site. This means that avoidance or minimization strategies should be considered, in order to maintain viability of the target species. The Flaming Gorge site, located in southwestern Wyoming, contains 37 separate rare plant targets, 20 rare animal targets, and 27 individual ecological systems. The site is critical to meeting the ecoregional goals involving six of the rare plants – Uinta greenthread (*Thelesperma pubescens*), Cedar Mountain easter daisy (*Townsendia microcephala*), Wyoming tansy mustard (*Descurainia torulosa*), Green River greenthread (*Thelesperma caespitosum*), Nelson's milkvetch (*Astragalus nelsonianus*), and Uinta draba (*Draba juniperina*) – and three of the rare animals – roundtail chub (*Gila robusta*), flannelmouth sucker (*Catostomus latipinnis*), and bluehead sucker (*Catostomus discobolus*). These target species are critical, as they are extremely rare (often 5–20 known populations), are experiencing very steep population declines, or face other factors that place them at risk. Because there is limited flexibility in where these target species can be conserved, impacts in this site would make meeting ecoregional goals difficult. Proposed developments at these sites would either be rejected or could only proceed if combined with efforts to minimize impacts, leaving little or no residual impact (Figure 1).

Mitigation funding fuels conservation

Offsets represent an opportunity to mobilize billions of dollars for conservation (McKenney 2005; Burgin 2008). When mitigation is a normal part of project costs, the level of funding available for conservation can greatly exceed other funding sources. For example, in Wyoming, $24.5 million was established as a mitigation fund for a single oil and gas field; compare this to the $4 million available for wildlife conservation from the Wyoming Wildlife and Natural Resource Trust (Kiesecker *et al.* 2009). Although this was the first application of offsets associated with oil and gas development in the WBE, the Bureau of Land Management, which oversees the management of over 260 million acres of land in the US, and administers the mineral estate for over 700 million acres, has recently adopted a change to its offset policy and now allows projects to include offsets associated with impacts resulting from development (US BLM 2008). Given the extensive amount of oil and gas development projected for the WBE, a requirement that development projects achieve no-net-loss could be the impetus that is needed to conserve biodiversity across the ecoregion as well as other energy-rich ecoregions. This may be important, as the US moves to exploit more of its domestic energy resources, in particular renewable energy. Internationally, several countries (eg Australia, Brazil, South Africa, and Colombia) are developing policies to improve the mitigation process by making planning more proactive and by including offsets as a stronger component for mitigating impacts (Gibbons and Lindenmayer 2007; Burgin 2008).

Figure 4. *Greater sage-grouse (*Centrocercus urophasianus*), a sagebrush obligate now under consideration for listing under the Endangered Species Act.*

Conclusions

Predictions suggest that there will be increasing pressure on natural resources as human populations grow (World Bank 2007). In order to balance these growing demands with biodiversity conservation, a shift from "business as usual" is clearly needed. By blending a landscape vision with the mitigation hierarchy, we move away from the traditional project-by-project land-use planning approach. By avoiding or minimizing impacts to irreplaceable biological targets and then ensuring that damaged ecosystems are restored on site, using the best available technology, and finally offsetting any remaining residual impacts, we can provide a framework that is consistent with sustainable development (Pritchard 1993; Bartelmus 1997). A landscape vision is essential, because it helps us to move beyond a business-as-usual approach to conservation. It ensures that the biologically

Figure 5. *Pronghorn antelope (*Antilocarpa americana*) in a Wyoming Basins gas field. Part of the greater Yellowstone ecosystem, the Wyoming Basins ecoregion contains some of the world's largest herds of mule deer (*Odocoileus hemionus*) and pronghorn.*

and ecologically important features remain the core conservation targets throughout the process. Without this vision, the overarching conservation targets are lost, prioritization becomes difficult, and scarce resources are wasted. Determining appropriate areas to preserve as habitat, as part of a conservation plan, is a challenging exercise; however, in reality, this is the easy part. The real challenge is identifying funding mechanisms to underwrite the conservation of these areas. By adopting the approach outlined here and requiring the application of the no-net-loss framework (Kiesecker *et al.* 2009), not only do we balance development with conservation, but we also provide the funding to support conservation commensurate with impacts from development.

To see the benefits of a comprehensive approach to mitigation we need look no further than at existing oil and gas development in the WBE. If a landscape-level plan had been used, this might have included recommendations to avoid or minimize impacts from the ten gas fields currently in production within the Flaming Gorge site. Out of more than 550 individual fields and 31 750 producing oil and gas wells in the WBE, the developers of only one field have been required to include offsets to mitigate for impacts. Although most individual fields do not represent substantial impacts, the cumulative damage is considerable, with a combined footprint of over 300 000 acres. If the no-net-loss goal had been required as part of each of these developments and offsets used to mitigate impacts where appropriate, the development that has already occurred could have resulted in a substantial benefits to conservation.

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WebTable 1. Portfolio sites from the Wyoming Basins Ecoregional Assessment that overlap with high oil and gas potential

Portfolio site	Size (acres)	Area with high oil and gas potential	Conservation targets: Ecological systems	Rare animals	Rare plants	Mitigation recommendation
Ace-in-the-Hole	1283	1235	×		×	Offset after Avoid/minimize impacts to rare plants
Bear Lake	188 061	36 570	×	×	×	Avoid/minimize
Calamity Ridge	7825	4447	×			Offset
Cherokee Basin	309 302	100 569	×	×	×	Offset after Avoid/minimize impacts to rare animals and plants
East Cody	66 671	2223	×	×	×	Offset
Ferris Mountain	33 804	4942	×	×	×	Offset
Flaming Gorge	716 947	192 985	×	×	×	Avoid/minimize
Flat Top Mountain	4908	667	×		×	Offset after Avoid/minimize impacts to rare plants
Green Mountains	23 767	1235	×		×	Offset
Greybull River Basin	317 387	16 308	×	×	×	Offset
Lower Green River	505 129	250 065	×	×	×	Avoid/minimize
Muddy Creek Basin	180 281	247	×	×		Offset
No Wood River	287 281	47 690	×	×	×	Offset
Overthrust Belt	431 830	124 291	×	×	×	Offset after Avoid/minimize impacts to rare plants
Pine Butte	83 129	94 639	×	×	×	Offset, area of potential impact does not overlap with targets of concern
Red Desert	34 302	17 888			×	Offset
Seedskadee	40 405	5436	×	×	×	Avoid/minimize
Shirley Basin	1 356 701	12 602	×	×	×	Offset, area of potential impact does not overlap with targets of concern
Sugarloaf	187 929	17 791	×	×	×	Offset after Avoid/minimize impacts to the one rare plant
Sweetwater River	997 775	141 094	×	×	×	Offset, area of potential impact does not overlap with targets of concern
Table Mountain	8935	8895	×	×	×	Offset
Uinta Benches	161 909	149 495	×	×	×	Offset after Avoid/minimize impacts to rare plants

continued

WebTable 1. – *continued*

Portfolio site	*Size (acres)*	*Area with high oil and gas potential*	*Conservation targets: Ecological systems*	*Rare animals*	*Rare plants*	*Mitigation recommendation*
Upper Green River	473 708	254 760	x	x	x	Avoid/minimize
Walton Canyon	7180	6918	x	x	x	Offset after Avoid/minimize impacts to rare animals
Western Wind River	607 425	73 141	x	x	x	Offset, areas of potential impact do not overlap with rare targets
Wind River Canyon	409 386	26 192	x	x	x	Offset, areas of potential impact do not overlap with targets of concern
Yampa River	528 690	85 496	x	x	x	Offset after Avoid/minimize impacts to rare animals

Notes: Included are the sizes of the sites, areas of high oil and gas potential within the sites, conservation targets within the sites (ecological systems, rare animals, and rare plants, as defined in Freilich *et al.* 2001) and mitigation recommendation. Complete target lists are provided for the three sites used as examples: **Ace-in-the-hole Draw targets:** *Ecological systems* (Basin big sage, Gardner saltbush flats, juniper woodland). *Rare plants* (Nelson's milkvetch). **Calamity Ridge targets:** *Ecological systems* (deciduous oak, Basin big sage, juniper woodland, pinyon–juniper woodland). **Flaming Gorge targets:** *Ecological systems* (foothills grassland, mixed grass prairie, mesic upland shrub, deciduous oak, mountain mahogany shrubland, Wyoming big sage, mountain big sagebrush, Basin big sage, black sage, salt desert scrub, Gardner saltbush flats, greasewood, aspen, sub-alpine forest, ponderosa pine, lodgepole pine, mountain fir, limber pine, juniper woodland, pinyon–juniper woodland, aspen/conifer forest riparian, grass riparian, and meadow shrub-dominated riparian wetland, barren). *Rare animals* (Uinta ground squirrel, black-footed ferret, white-tailed prairie dog, Idaho pocket gopher, ferruginous hawk, burrowing owl, sage grouse, roundtail chub, pygmy rabbit, flannelmouth sucker, peregrine falcon, dwarf shrew, Virginia's warbler, northern plateau lizard, northern tree lizard, midget faded rattlesnake, bluehead sucker, and important bat roosts). *Rare plants* (Crandall's rockcress, Daggett rockcress, Selby rockcress, Moab milkvetch, Starveling milkvetch, Nelson's milkvetch, precocious milkvetch, fullstem Ownbey's thistle, erect cryptantha, Echo spring-parsley, Wyoming tansy-mustard, Uinta draba, single-stemmed wild buckwheat, Utah greasebush, compact gilia, Watson's prickly-phlox, narrowleaved bladderpod, tufted cryptanth, Rollins cryptanth, Maybell locoweed, stemless beardtongue, Sheep Creek beardtongue, Payson beardtongue, Garrett's beardtongue, desert glandular phacelia, western phacelia, opal phlox, persistent sepal yellowcress, *Sphaeromeria argentea, Sphaeromeria capitata*, Green River greenthread, Uinta greenthread, Cedar Mountain easter daisy).

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