The Mitigation Hierarchy

The mitigation hierarchy is a widely used framework to inform conservation decisions. The hierarchy offers a structured set of steps for how projects can lessen negative impacts or lead to an increase in biodiversity (Figure 1). In its simplest form, the mitigation hierarchy includes three stages: (1) avoid creating impacts from the outset, (2) minimize the impacts that cannot be avoided, and (3) compensate for or offset the impacts that cannot be minimized. Proper application of the hierarchy should decrease impacts of the project over time, such that most of the impact is alleviated through avoidance, leaving a modest amount remaining to minimize, and only a residual to compensate. In practice, avoidance should be prioritized and can be a cost-effective means of mitigation. Whereas compensation should be considered the lowest priority and should only be applied in situations in which the previous mitigation steps were unable to fully alleviate undesirable impacts.

Many organizations and countries already have guidance for the mitigation hierarchy, but there is no standard terminology within or among stages, which may cause confusion (Table 1). In some cases, terms that have different meanings are used interchangeably, such as "minimization" and "mitigation." In other cases, similar terms can have different meanings or timing for implementation depending on the context in which they are used, such as "reduction" and "minimization." Thus, it is important for stakeholders to be clear when developing and overseeing mitigation plans for a project.

An American kestral, a migratory species that ranges from Alaska to South America. *Photo by Werner Slocum, NREL 75699*

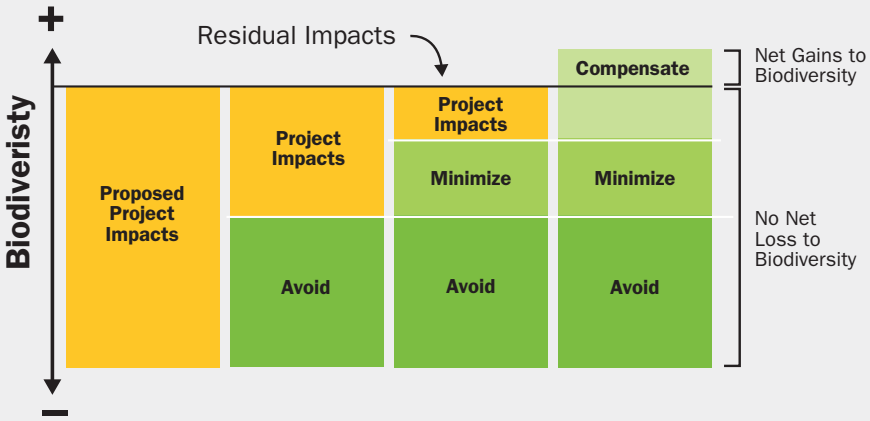

Figure 1. Visual representation of how each stage of the mitigation hierarchy can reduce potential biodiversity impacts from proposed developments. Offsets, restoration, and compensatory mitigation can lead to net gains in biodiversity. *Image adapted from Rio Tinto and Biodiversity (2008)*[i]

Portland General Electric Tucannon Wind Farm. *Photo by Josh Bauer, NREL 38029*

Table 1. Terminology Used for the Mitigation Hierarchy Among a Representative Set of Organizations

Location	International		Europe			USA		
Organization	IAIA	IUCN	EU Directive	May et al. (2017)	WindEurope	Smithsonian	EPA	CEQ
Stages of hierarchy	Avoid	Avoid	Avoid or Prevent	Avoid	Avoid	Avoidance	Avoidance	Avoid
	Minimize/ Reduce	Minimize	Minimize/ Reduce	Minimize	Reduce	Minimization	Minimization	Minimize
				Reduce				Rectify
								Reduce
	Restore and Offset	Restore and Offset	Offset	Compensate	Compensate	Restore	Compensatory mitigation	Compensate
				Restore	Offset	Offset		

IAIA = International Association for Impact Assessment; IUCN = International Union for Conservation of Nature; EU = European Union; Future research directions to reconcile wind-wildlife interactions in wind energy and wildlife interactions[ii]; Smithsonian = Smithsonian's National Zoo and Conservation Biology Institute; EPA = U.S. Environmental Protection Agency; CEQ = U.S. Council on Environmental Quality National Environmental Policy Act.

AVOIDANCE

The initial stage in the mitigation hierarchy—avoid or avoidance—is relatively consistent across entities. Avoiding impacts means not taking a certain action or parts of an action (Table 2). This step is typically considered during the planning phase of a project and can involve decisions on the spatial footprint of a project or the timing of construction. For example, offshore wind energy developers may choose a certain time of year to complete construction to avoid the negative impacts of noise on migratory marine mammals. Avoidance may also involve micrositing, such as reducing the number of wind turbines, altering the layout of turbines, or limiting the footprint of the wind farm (see the Reduction section).

MINIMIZATION

The second stage of the mitigation hierarchy differs across organizations. "Minimize" and "reduce" can sometimes be used interchangeably, but in other cases have distinct definitions. When used synonymously, the combined terms generally mean limiting the duration, intensity, and/or extent of unavoidable impacts. This stage of minimization may occur during the construction, operational, or decommissioning phases of a project. In the context of wind energy, minimization/reduction measures may include operational curtailment during periods of high risk or using effective deterrents to limit bat mortality. In cases where the terms "minimize" and "reduce" have different meanings, the timing of implementation distinguishes the two. As described by May et al. (2017), minimization is implemented during the design phase of a project, which may involve micrositing wind turbines based on preconstruction environmental study results (note that in other instances, micrositing is considered avoidance). For example, minimization might include following best practices for setback distances from eagle nest sites. May et al. (2017) describes reduction measures as being implemented if monitoring indicates a higher than predicted or desired impact. The U.S. Council on Environmental Quality (CEQ) defines minimization in a consistent manner with other organizations, but delineates that reduction involves eliminating the impact over time through preservation or maintenance during the life of the action. The CEQ also includes a step, rectify, which is not used by other organizations. This step occurs between minimization and reduction and involves repairing or restoring the affected environment. Rectify may equate to mitigation, compensation, offsets, or restoration by other organizations.

COMPENSATION/OFFSETS/ RESTORATION

The final stage of the mitigation hierarchy includes one or more steps, such as compensation, offsets, or restoration. In most cases, the different terms have similar meanings. The general intent is to address the residual impacts that remain after

Table 2. Stages of the Mitigation Hierarchy As Summarized by Organization.

	Organization	Hierarchy Stage	Definition
International	IAIA	Avoid	Avoiding the impact altogether by not taking a certain action or parts of an action
		Minimize/Reduce	Minimizing impacts by limiting the degree or magnitude of the action and its implementation
		Restore and Offset	Replacing or providing substitute resources
	IUCN	Avoid	Anticipating and preventing impact
		Minimize	Reducing the duration, intensity, and/or extent of unavoidable impacts
		Restore and Offset	Restoring addresses impacts from temporary facilities. Offsets are measures taken to compensate for significant adverse residual impacts that cannot be avoided, minimized, or restored

	Organization	Hierarchy Stage	Definition
Europe	EU Directive	Avoid or Prevent	(1) Changing means or techniques, not undertaking certain projects or components that could result in adverse impacts; (2) changing the site, avoiding areas that are environmentally sensitive; (3) establishing preventative measures to stop adverse effects from occurring
		Minimize/Reduce	1) Scaling down or relocating the project; (2) redesigning elements of the project; (3) using a different technology; (4) taking supplementary measures to reduce the impacts either at the source or at the receptor, such as noise barriers, waste gas treatment, and type of road surface
		Offset	Offsetting or compensating for residual adverse impacts that cannot be avoided or further reduced in one area with improvements elsewhere with site remediation, rehabilitation, restoration, resettlement, and/or monetary compensation
	May et al. (2017)	Avoid	Avoiding impacts while planning the project prior to siting
		Minimize	Minimize unavoidable impacts by adjusting the ecological footprint of a project during the design phase prior to construction. This can be achieved by adjusting the wind turbine configuration, micrositing, or development layout.
		Reduce	Enacting measures to further reduce impacts during operation. Examples of appropriate reduction actions include curtailment and deterrence.
		Compensate	Compensating for any residual impacts during operation; compensation should be tailored and scaled to address the specific impacts of the project (e.g., fatalities versus displacement)
		Restore	During decommissioning, the area should be restored by removing infrastructure, reestablishing vegetation, and recovering the ecosystem
	WindEurope	Avoid	Taking measures to avoid creating impacts from the outset (e.g., careful spatial or temporal placement of elements of infrastructure)
		Reduce	Reducing the duration, intensity, and/or extent of impacts that cannot be completely avoided as far as it is practically feasible, including direct, indirect, and cumulative impacts
		Compensate	Restoring the project site to its original (or near original) condition or replacing the habitat that was damaged at the project site with suitable habitat off-site
		Offset	Achieving measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts; the goal of biodiversity offsets is to achieve no net loss, or preferably a net gain, of biodiversity on the ground with respect to species composition, habitat structure, and ecosystem services, including livelihood aspects

	Organization	Hierarchy Stage	Definition
USA	Smithsonian	Avoidance	Taking actions like changing site locations, using alternative development practices, or shrinking area of impact (typically enacted during project planning)
		Minimization	Reducing the intensity of project impacts, such as incorporating new technologies to limit impact or strategically timing construction to limit effects on certain species and habitats
		Restoration	Restoring any remaining negative impact on habitat, such as soil degradation or increased erosion, back to its preproject state or boosting natural processes to recover the ecosystem
		Offsets	Taking various actions to balance out any negative impacts of the project; examples include providing funding for national parks, developing restoration projects in neighboring areas, or participating in local environmental initiatives
	EPA	Avoidance	Mitigating an impact by selecting the least-damaging project type, spatial location, and extent compatible with achieving the purpose of the project; avoidance is achieved by analyzing appropriate and feasible alternatives and considering the footprint of impact
		Minimization	Managing the severity of a project's impact on resources at the selected site; minimization is achieved by incorporating appropriate and feasible design and risk avoidance measures
		Compensatory Mitigation	Mitigating a resource impact by replacing or providing substitute resources for impacts that remain after avoidance and minimization measures have been applied, and is achieved through appropriate and feasible restoration, establishment, enhancement, and/or preservation of resource functions and services
	CEQ	Avoid	Avoiding the impact altogether by not taking a certain action or parts of an action
		Minimize	Minimizing impacts by limiting the degree or magnitude of the action and its implementation
		Rectify	Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
		Reduce	Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action
		Compensate	Compensating for the impact by replacing or providing substitute resources or environments

implementing the previous stages of the mitigation hierarchy. This generally involves repairing the impact created by the action or returning the area to its original condition. This stage may also focus on replacing any wildlife species impacted so there is no net loss. Typically, this stage is often implemented near the end of a project, such as during decommissioning when there is a clear understanding of the overall project impacts and the level of effort needed for remediation.

APPLYING THE MITIGATION HIERARCHY

Although the implementation of measures varies over the course of a project, all stages of the mitigation hierarchy should be considered during project planning. Traditionally, the stages of the hierarchy corresponded to the phase of the project (i.e., avoidance during project planning, and restoration during decommissioning). However, a recent focus on adaptive management has expanded the conversation on how the mitigation hierarchy can be applied iteratively through every stage of the development cycle (Table 3). For example, during the avoidance stage, potential sites should be assessed not only for their impact on sensitive species, but also for their potential restoration and offset opportunities. Implementation throughout the life cycle ensures impacts to biodiversity are kept below acceptable thresholds instead of only being accounted for toward the end of the project. Further, projects planning for repowering can use the opportunity to reevaluate their mitigation plans.

Table 3. Applying the Mitigation Hierarchy Through Different Phases of Project Development.

		Mitigation Hierarchy Application			
		Avoidance	Reduction/Minimization	Restoration	Compensation/Offset
Project Stage	Planning	✔		✔	
	Project Design	✔	✔		
	Construction	✔	✔	✔	✔
	Operation		✔		✔
	Decommissioning	✔	✔	✔	✔

CONCLUSION

In lieu of a universal consensus regarding the steps for each stage of the mitigation hierarchy, it is important that stakeholders agree on terminology and remain consistent in their usage throughout the project life cycle. This consistency helps ensure that stakeholders understand the objectives and actions associated with each phase of a project. Misunderstandings can hinder decision-making, leading to less efficient and potentially less-effective mitigation outcomes. Consistency also facilitates communication and promotes cooperation when developing conservation strategies that effectively address the biodiversity impacts of a project.

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For more information on Wren, visit https://tethys.pnnl.gov/about-wren

[i] Rio Tinto. 2008. *Rio Tinto and biodiversity: achieving results on the ground*. https://bobbloomfield.files.wordpress.com/2013/03/2008riotintobidoversitystrategy.pdf

[ii] May, Roel, Andrew B. Gill, Johann Köppel, Rowena HW Langston, Marc Reichenbach, Meike Scheidat, Shawn Smallwood, Christian C. Voigt, Ommo Hüppop, and Michelle Portman. 2017. "Future research directions to reconcile wind turbine–wildlife interactions." In *Wind energy and wildlife interactions: Presentations from the CWW 2015 Conference,* pp. 255-276. Springer International Publishing.

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