Advanced Interagency Consultation Training

Study Guide for Exposure Analysis

Objectives of this Module

1. Explain the intent of an exposure analysis and its links with other components of consultation.
2. Explain the process of developing an exposure analysis, and variations dependent on the scope of analysis.
3. Develop an exposure analysis.

Glossary

Exposure: The contact, or co-occurrence, of a stressor with a receptor (EPA 1998).
stressor: any physical, chemical, or biological entity that can induce an adverse response.
receptor: the ecological entity exposed to the stressor.

Exposure analysis: the process of describing exposure in terms of concentration or intensity, duration, and frequency of exposure to a stressor that can affect an assessment endpoint (a receptor).

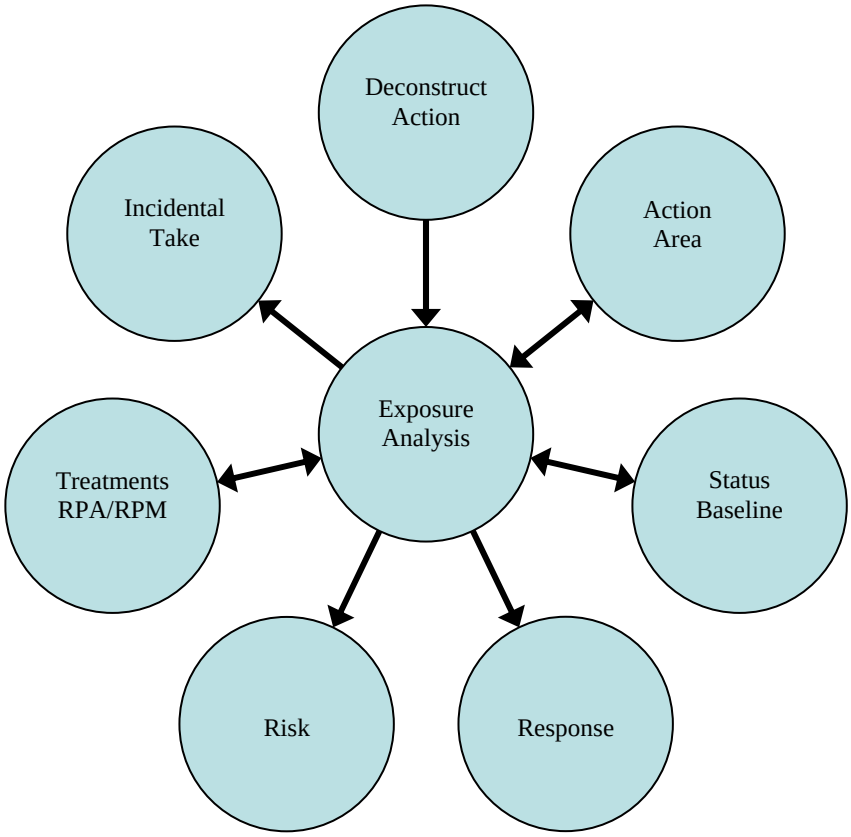
Exposure profile: the product of characterization of exposure in the analysis phase of ecological risk assessment. An exposure profile summarizes the magnitude and spatial and temporal patterns of exposure. Exposure profiles identify (a) how exposure occurs; (b) what is exposed; (c) how much exposure occurs; (d) when and where exposure occurs; (e) if exposure will vary depending on receptor attributes, stressor levels, or characteristics of the environment; (f) uncertainty associated with exposure estimates, particularly key assumptions and how they were handled, the magnitude of sampling or measurement error, the most sensitive variables influencing exposure, and uncertainties that can be reduced by collecting more information; and (g) the likelihood of exposure occurring.

Introduction

The exposure analysis is meant to establish and describe the set of resources (species, populations, individuals, life stages or forms, or habitat elements) that are present in the action area and that may be affected by the proposed action or interrelated or interdependent activities. If these resources "co-occur" with the stressors (*e.g.,* pesticides or degradants of pesticides, visual or auditory disturbance, loss of cover after herbicide application, etc.,) of the activities under consultation the resource is exposed to the stressor. This analysis provides the basis for discussions of conservation needs, possible and probable responses of exposed individuals, risk analysis, and potential treatments. Exposure is not equivalent to "adverse effect," but it is a determinant of "may affect." Individuals of a species or elements of CH may be exposed to the physical, chemical, and biotic stressors of an action, but suffer no ill effects (equivalent to "may affect, not likely to adversely effect").

Exposure is the key, or link, between an action and the risk the action poses to the species, its critical habitat, and its ecosystem (resources). Your exposure analysis highlights the critical information to utilize from your diagnosis of the status of the species/critical habitat and the base condition or baseline of these listed resources or, conversely, highlights the critical information and analysis that should be included in these assessments. Exposure also defines the range of

responses you would expect from individuals of the species or elements of critical habitat and the ultimate risk those responses pose to the likelihood of survival and recovery of the species and conservation value of critical habitat.



Establishing an Exposure Profile. Initially, the exposure analysis describes:

- The specific stressors associated with the action (physical, chemical, biotic)
- Where stressors may occur
- When stressors may occur
- How long stressors will occur
- The frequency of stressors
- What the intensity of the stressors will be

A complete deconstruction of the action provides the foundation of your exposure analysis. As the elements of the action are separated, and the stressors associated with each component are determined, a potential exposure area is defined. *Note: The combination of all of the potential exposure areas for the project should equate to the action area for the project (the area of direct and indirect effects of the action).* By focusing on this "area[1]" description, we can then determine who will be affected by what, which then tells us what information we should concern ourselves with in assessing response and ultimately risk. Potential exposure "areas" with no overlap between listed species or critical habitat, or the physical, chemical, or biotic resources listed

[1] Area is in quotes here to denote that the occurrence of stressors is spatial AND temporal, and may even vary over time as project phases proceed or end.

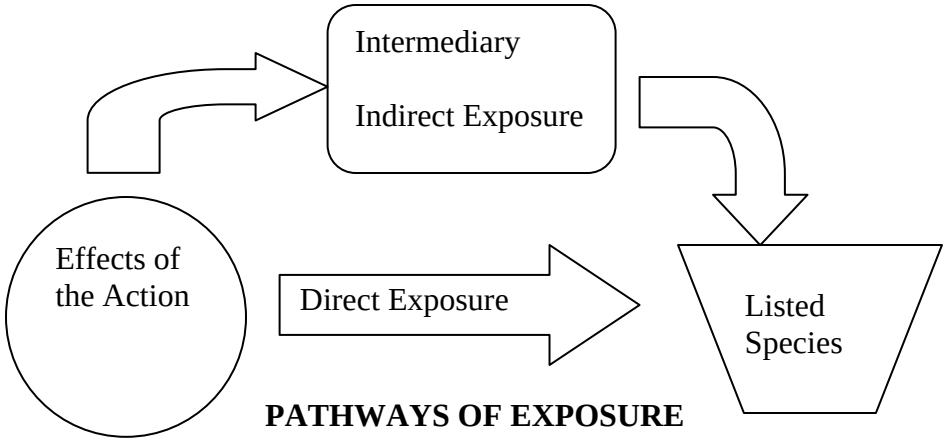
species or critical habitat depend upon can then be documented in the record, set aside, and require no further analysis.

This is an opportune time to work with the action agency, any applicant, and the other consulting Service to ensure that exposure "areas" are correctly defined and are consistent between assessments. In fact, much of this analysis could be done already by the action agency as part of their internal analysis to determine if the action "may affect" listed resources. Over time, and with experience and close coordination, action agencies could be responsible for preparing this analysis entirely as part of their request for consultation or concurrence. As you read this study guide and prepare your own exposure analyses consider the opportunities available to incorporate some of this assessment into action agency procedures. For example, action agencies could provide a complete action description that has already been deconstructed and that includes important information on the stressors associated with the various components of the action.

Following the delineation of a potential exposure area, evaluate the presence, use, and behavior of listed species, designated critical habitat, and the resources they depend upon in this potential exposure area to determine:

- What physical, chemical, or biotic features of the area may be exposed
- What life stages or forms of a listed species will be directly or indirectly exposed
- How many individuals of a listed species may be exposed
- Which populations of a listed species may be exposed
- What listed species (as listed or designated : DPS, ESU, Recovery Units) may be exposed
- What areas/constituent elements/functions of CH may be directly or indirectly exposed

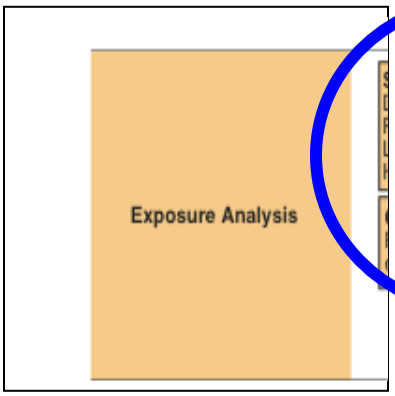
Remember that exposure may not always be obvious. Determine the potential exposure "area" for every project component to ensure that you have not missed impacts to listed resources. Exposure can occur along direct and indirect pathways, as illustrated below. A direct exposure pathway is one where the stressor acts directly upon the listed species or a primary constituent element (PCE) of critical habitat. For example, land clearing machinery may destroy nests and hatchlings, or remove forage vegetation. Indirect exposure pathways work through some intermediary species or habitat element – a vegetation management plan manages for different vegetation type or stages than that a listed species or PCE requires (e.g. grass height and survival of the ant species upon which the Large Blue Butterfly depends). Note that a listed species may be indirectly exposed to a stressor through changes in a PCE of critical habitat that is directly exposed to the stressor. The mere presence of the listed species in an exposure area may also not be sufficient to qualify as exposure. For example, a butterfly migrating through an area sprayed with pesticides may not be exposed directly or indirectly to those pesticides unless the butterfly contacts the chemicals or degradants or attempts to forage or shelter in areas impacted by the pesticides.



PATHWAYS OF EXPOSURE

All of this information together is the "exposure profile." The profile is used to establish the range of possible and probable responses to the action(s) and subsequently, the risk those actions pose to listed resources. Exposure profiles should include discussion of (a) variance in exposure depending on receptor attributes, stressor levels, or characteristics of the environment; (b) uncertainty associated with exposure estimates, particularly key assumptions and how they were handled, the magnitude of sampling or measurement error, the most sensitive variables influencing exposure, and uncertainties that can be reduced by collecting more information; and (c) the likelihood of exposure occurring. Consider any conceptual models you may be using when constructing a profile. For example, your understanding of how the species "works" – how its life history functions or how the population(s) persist and fluctuate over time and space help determine which populations, which life history stages, and how many individuals are exposed. Your conceptual model of the habitat (physical, chemical, and biotic resources) that the species depends upon or that makes up "critical habitat" aid in determining which elements are exposed and, importantly, help you determine indirect pathways of exposure and causal linkages between exposure of one element and the ultimate response of individuals of the species.

Available Information or Conceptual Models



Accurate reflection of the seasonality or phases of the action will add layers of complexity to this analysis. For example, the construction phase may impact juveniles during their molting season, whereas the operations of the project may affect all phases and stages, or only the adults during the breeding season. Periodic maintenance in subsequent years may also change the exposure profile. Cycles in population abundance or presence in response to predictable climatic shifts (flood/drought) will also modify the exposure profile. In addition, uncertainty as to the presence of the species in the action area, or even the life cycle of the affected species or processes affecting critical habitat elements, further increases the complexity in ways that can only be resolved via careful analysis of available evidence and development of arguments based on this evidence or similar case studies.

These exposure profiles rely upon our understanding of the listed resources to help us understand which individuals may be exposed and what the individuals may be doing while they are exposed (or what they expect from their environment – breeding sites of a certain quality and quantity, for example, which we then contrast with what they will get). This allows us to better focus both our discussions with the action agency and applicants and our written documents on

those aspects of the species life history, dynamics, and risk factors that are relevant to the assessment at hand. For analyses of critical habitat, the process is much the same, but the focus shifts to assessment of those areas, elements, or functions of critical habitat exposed to the action.

Response and Risk Analyses. Once we have determined which elements of habitat, species, populations, and life stages or forms are likely to be exposed to the stressors of the proposed action and interrelated or interdependent activities, we can identify the range of possible responses the exposed resources could exhibit. Examining possible responses for a life stage that based on all available evidence is not expected to be exposed to the stressor would be unnecessary. The range of behaviors possibly affected is also limited to those exhibited by the exposed life stage.

Through its effect on the response analysis, the exposure analysis provides sidebars on the possible range of responses. On its own, however, the exposure analysis describes: (a) which members (and how many, if possible) and populations of a listed species; and (b) which attributes of CH are likely to be exposed. This provides the framework for assessing the risk the expected responses will pose for the listed resources. In other words, our risk assessment is less likely to be based on reductions in reproductive behavior or reproductive rates if our exposed individuals are not the reproductive members of the population. By identifying the population members exposed to an action and their expected responses, we can better predict the likely effects to population dynamics, and therefore persistence. Importantly, the use of *alternative exposure scenarios* also allows us to determine if population and species-level responses to an action meet the jeopardy and destruction or adverse modification standards of section 7. In essence, we construct two exposure scenarios: one in which listed resources are directly or indirectly exposed to the stressors of an action and a second in which they are not. Comparison of species and critical habitat responses between the two scenarios aids in determining the outcome of the consultation. *Note: In those instances where we find that an action is likely to jeopardize a species or destroy or adversely modify critical habitat, we then also construct a third (or more) scenario in which we compare the responses of the listed resources given exposure to a proposed reasonable and prudent alternative to the original action in order to determine if the proposed RPA is viable.*

Incidental Take and Reasonable and Prudent Measures/Alternatives. The exposure analysis sets the stage for any incidental take statement included with the biological opinion. As highlighted by the Arizona Cattlegrowers case, if we have not established that a listed species will be exposed to the stressors of the action – and subsequently that the exposed individuals are likely to exhibit certain responses that may qualify as “take,” then we have not established that incidental take is likely to occur (and therefore non-discretionary terms and conditions are required). In other words, once an individual of the species is exposed to the stressors of the action, they will exhibit one of a possible range of responses (including “no response” or “no adverse response”). Therefore, exposure to stressors is a necessary requirement for eliciting a response. If the individual is not exposed, they will not exhibit the response.

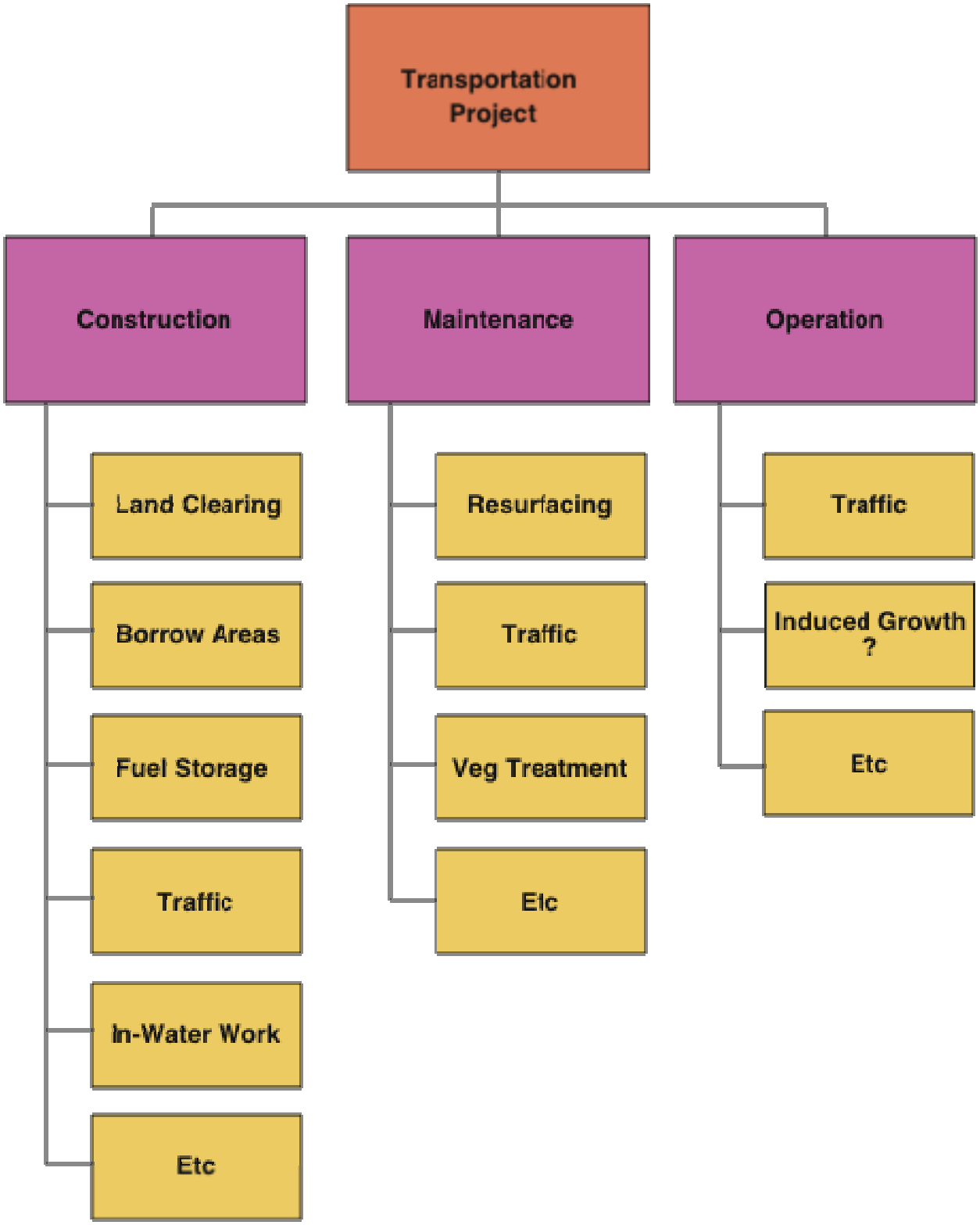
The exposure analysis provides a measure of the amount or extent of take – whereas the response analysis provides the form of take. For example, the number of individuals or a certain life stage (*e.g.* 20 juvenile steelhead) is the amount or extent of take established by an exposure analysis. Their fate (*e.g.* death or injury) is determined by the response analysis.

Exposure often dictates the type of treatments (conservation measures, reasonable and prudent alternatives, and reasonable and prudent measures) we may prescribe or negotiate for an action. For example, conservation measures incorporated into a project action often include measures such as construction windows meant to avoid or minimize the amount of exposure a listed resource has to a particular stressor. Reasonable and prudent alternatives are often designed to avoid or minimize exposure of a species or particular life stage to an action or some aspect of an action.

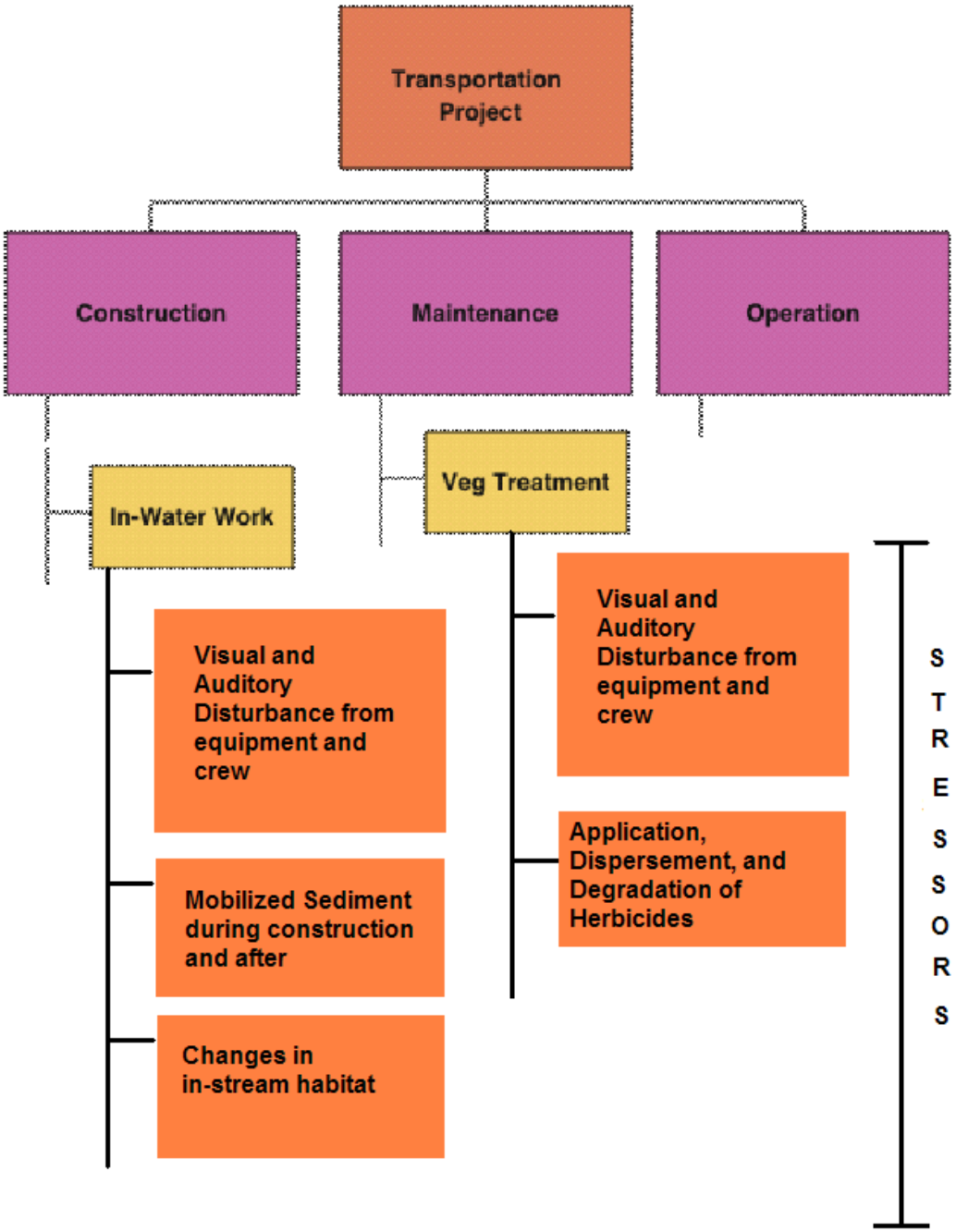
Conducting an Exposure Analysis

Once you have deconstructed the action and established your action area, describe the stressors resulting from each component of the action (for example, stressors that are temporary vs. those that persist or permanently change the environment, stressors that encompass the whole of the action area, and therefore more populations or individuals perhaps, than those stressors that remain at the project footprint). These descriptions aid in determining both what will be exposed to the stressors, and how the exposed resources will respond.

In the figure below, the proposed action is divided into three phases: construction, operations, and maintenance. Each of these phases is further subdivided into separate components that comprise the overall phase. The stressors associated with each of these components combine into an exposure profile for the proposed action as a whole. For ease of analysis, first determine response of species or habitat elements to the stressors of a component before combining responses or looking for additive, synergistic, or multiplicative impacts.


Transportation Project
Construction
Maintenance
Operation
Land Clearing
Borrow Areas
Fuel Storage
Traffic
In-Water Work
Etc
Resurfacing
Traffic
Veg Treatment
Etc
Traffic
Induced Growth ?
Etc

A brief assessment of two of these components, in-water work during construction and vegetation management during maintenance operations, indicates that some of the stressors associated with these components include visual and auditory disturbances (from equipment and human operators), disturbance of aquatic substrates, mobilization of sediment during and following the action, and application of chemical compounds to vegetation and soil surfaces.

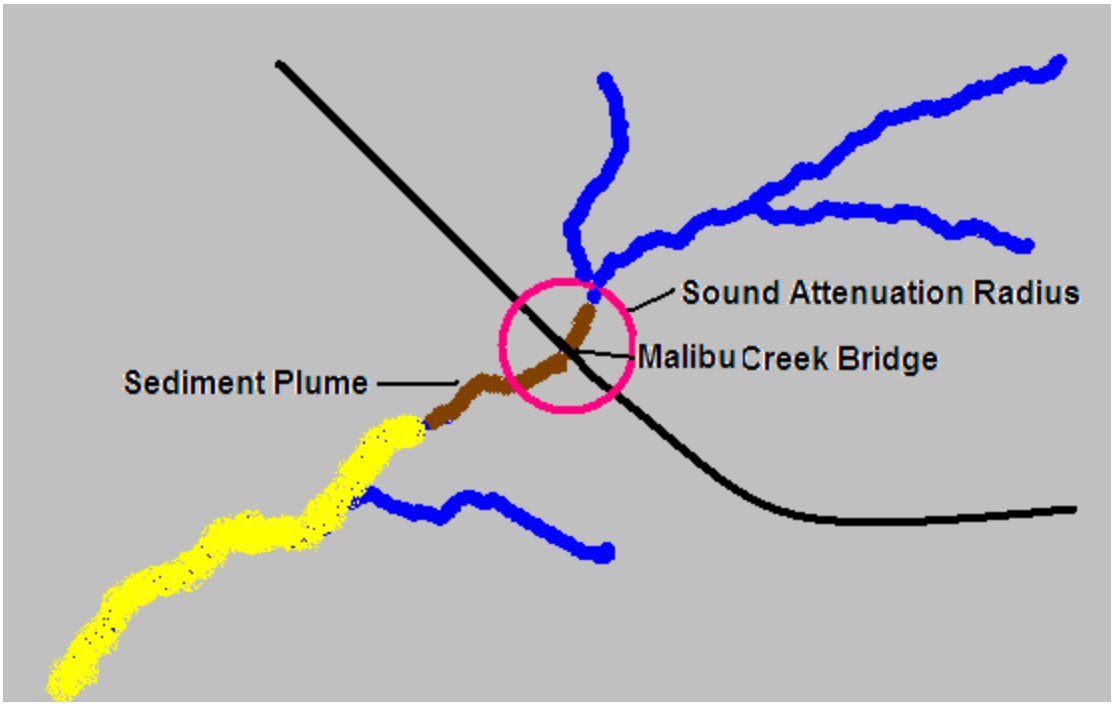


Starting with the construction phase, let's construct exposure profiles for the in-water work component[2].

In-water work:

- The stressors: Visual and auditory disturbances (from equipment and human operators), disturbance of aquatic substrates, mobilization of sediment during and following the action.

- Where stressors may occur: Malibu Creek, from the Malibu Creek Bridge downstream one mile and upstream 100 yards (the extent of detectable sediment mobilization, increased bed sedimentation, and changes to in-stream habitat). Plus the areal extent of sound attenuation from construction actions.



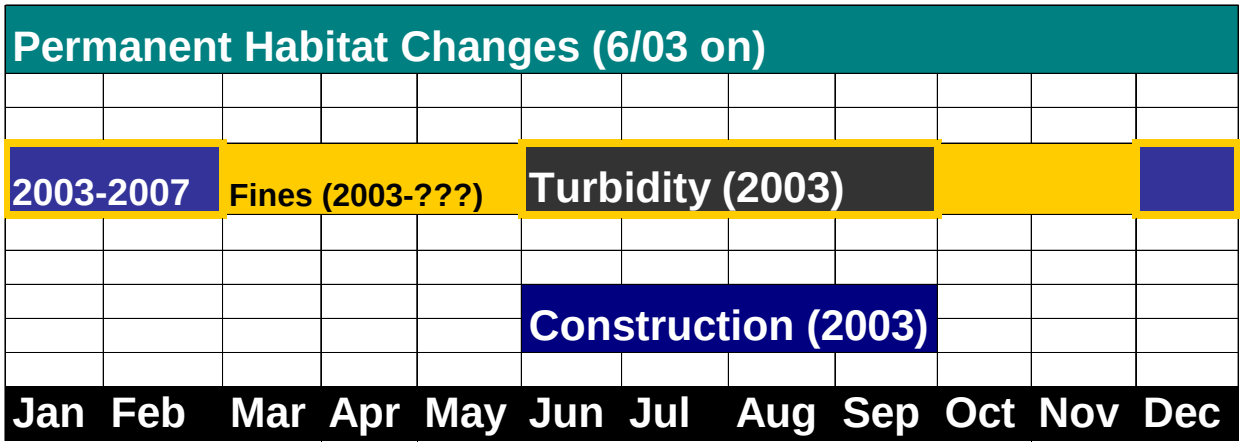
- When stressors may occur: Construction occurs June 1 through September 30, sediment mobilization expected to continue during winter flows above 500 cfs between 2003 and 2007. Stream morphology changes resulting from construction expected to occur subsequent to project completion and remain in perpetuity.

- How long stressors will occur: Direct stressors (construction impacts, sediment mobilization and settlement) expected to occur intermittently until Spring 2007. Indirect stressors (changes in habitat, settlement of sediment in spawning areas) expected to remain in perpetuity.

- The frequency of stressors: Visual and auditory disturbances occur daily during construction period only. Instream aquatic habitat changes are permanent and

[2] Please note that the examples are summarized for discussion purposes and are by no means an exhaustive analysis of the components, resulting stressors, and exposed resources.

continuous. Mobilization of sediments occurs during winter flows above 500 cfs between September 30, 2003 and Spring 2007.



- The intensity of stressor: Workers and equipment on site during construction period. Sound volumes of 120 dB expected during in-water construction periods (lasting up to two hours per day). Sediment inputs expected to range from 5 to 50 cubic yards per season, declining volumes over time. Habitat change in the form of lost sinuosity, conversion of varied riffle-pool gravel substrate to combination concrete substrate and simplified channel form (loss of thalweg).

At this point we have constructed an image of the spatial and temporal potential exposure area. Proceeding on to the resources that co-occur with the stressors in the area we find:

- What physical, chemical, or biotic features of the area may be exposed: The exposure area includes the upstream extent of spawning and rearing/holding habitat for steelhead. Channel substrate of small and coarse gravels, with fines, turbidity levels, embeddedness, pools, riffles, earthen streambanks, near stream and instream ruderal and small woody riparian vegetation, and aquatic macroinvertebrates.

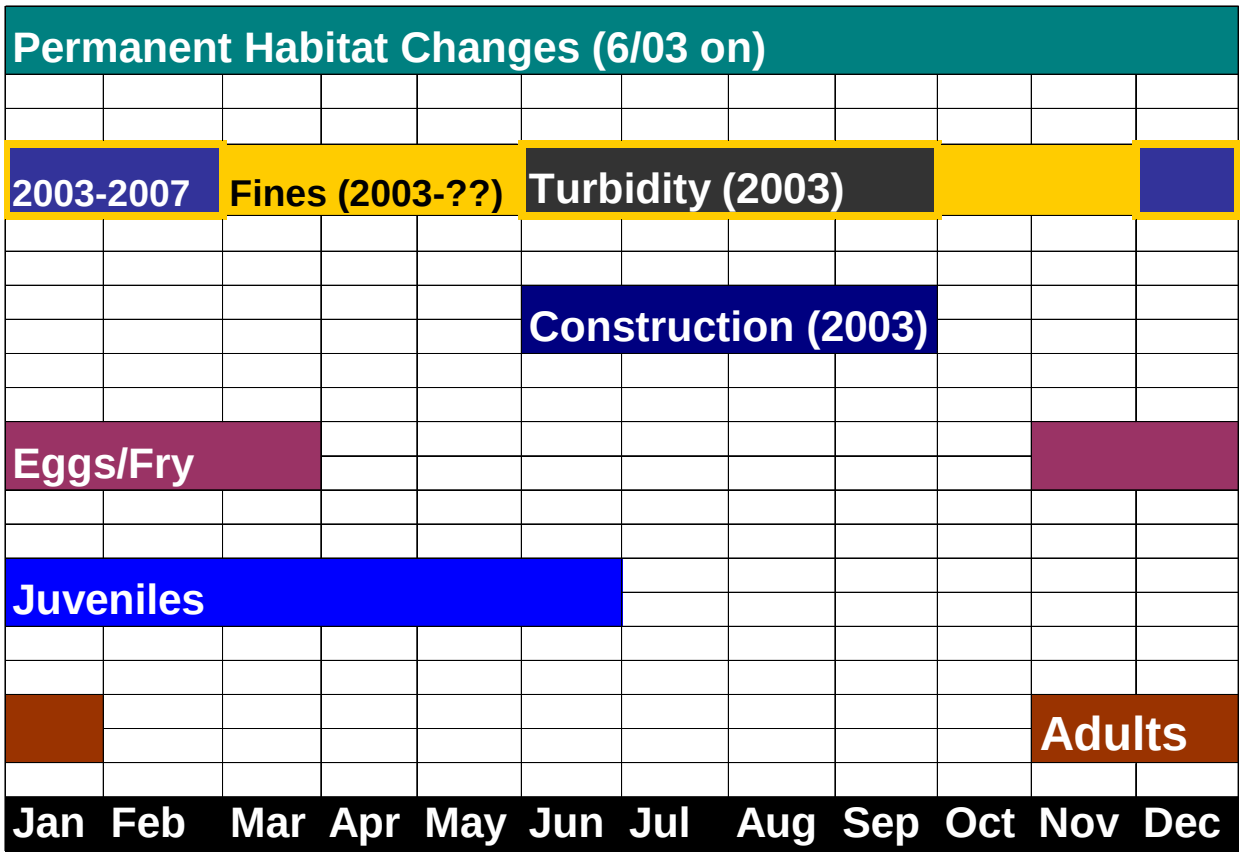
- What life stages or forms of a species will be directly or indirectly exposed: Juvenile steelhead present during early portion of summer construction season. Adult and egg/alevin steelhead present during winter sediment mobilization period. All life stages of population exposed to permanent changes in in-stream habitat (see Figure below.) Direct exposure occurs during construction actions and during sediment mobilization events, indirect exposure resulting from in-stream habitat changes due to new structure within and across the stream and sediment mobilization events.

- How many individuals may be exposed: Available data indicates an adult population of 20 individuals, sex ratio unknown. Seine surveys indicate presence of 100 juvenile steelhead in the area.

- Which populations of a listed species may be exposed: Malibu Creek population.

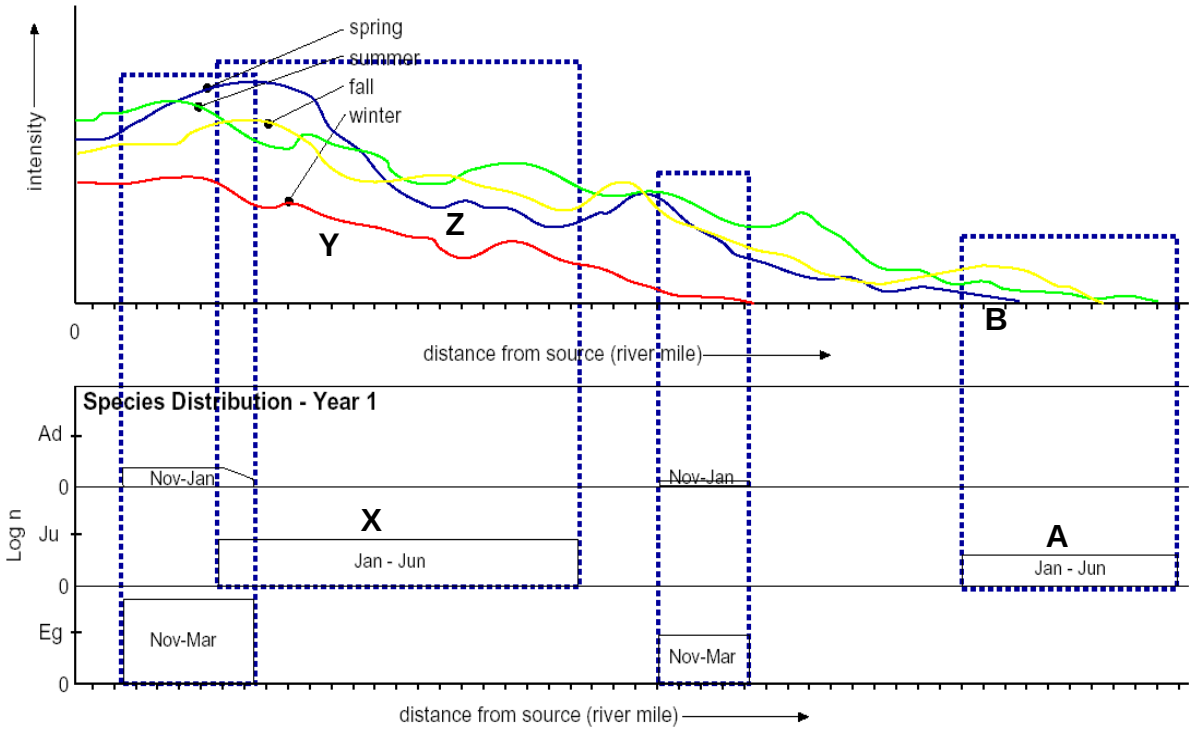
- What listed species (as listed or designated : DPS, ESU, Recovery Units) may be exposed: Southern California steelhead (*Oncorhynchus mykiss*), an endangered species.

- What areas/constituent elements/functions of CH may be directly or indirectly exposed: Critical habitat not designated.



As a result of this analysis, we have determined that all life stages of the Malibu Creek population of Southern California steelhead may be exposed to the stressors related to the in-water work component of the proposed action, but not all life stages are exposed to each stressor. For example, we have determined that only juveniles of the population will be exposed to the visual and auditory disturbance or sediment mobilization during the construction period, but that all adult steelhead that spawn in the exposure area and their progeny (eggs and alevins) will be exposed to sediments mobilized in the area during subsequent winter flows over 500 cfs. Adult and juvenile steelhead will be exposed to the permanent changes in in-stream habitat that occur as a result of the new structure across and within the channel. And all life stages are expected to be exposed to the increased levels of fine sediments settled onto the streambed. In addition, due to the expected physical changes within the exposure area, spawning habitat (gravels, stream morphology) and rearing habitat (cover, eroding banks, gravels) are exposed as well.

Exposure profiles do not have to follow a strict format. They can take a variety of forms provided the form aids you in determining what listed resources will be exposed to the stressors of an action. The assessment should be thorough enough to ensure you haven't missed aspects of the stressors or resulting exposed resources. Below is another example of an exposure analysis of sediment input from a construction site:



The dashed-line rectangles are the exposure profiles for the different life stages of the affected population found within the exposure area. The width of the markers within the adult, juvenile, and egg stages indicate the known or expected abundance of the number of individuals of that life stage in that area and at the times indicated within the markers. A summary of the exposure profile for the juvenile life stage rectangles would be: **X** number of juvenile steelhead are expected to be exposed to increased sediment levels of **Y** intensity during January through March and **Z** intensity during April through June in *the upstream portion* of the exposure area, and **A** number of juvenile steelhead are expected to be exposed to sediment levels of **B** intensity during April through June in *the lower portion* of the exposure area.

Repeating this exercise for the Vegetation Management component of the Maintenance phase will result in an additional exposure profile:

Vegetation Management:

- The stressors: Visual and auditory disturbances (from equipment and human operators), application of chemicals to vegetation and soil surfaces.

- Where stressors may occur: Highway 101 for 10 yards to either side of the Malibu Creek Bridge over Malibu Creek and extending 50 yards back from the streambanks (500 sq. yds of area at each bridge corner).

- When stressors may occur: Vegetation management treatments are scheduled on 5-year intervals following project initiation (and initial treatment). Treatment is conducted between August 15 and October 15 of each treatment year.

- How long stressors will occur: Project life cycle projected at 50 years.

- The frequency of stressors: Visual and auditory disturbances occur during treatment period only. Habitat changes are temporary, with lost values typically replaced by the fourth year following treatment. Treatment occurs every five years.

- The intensity of stressors: Workers and equipment on site during treatment period. Sound volumes of 80 dB expected during application. Habitat change in the form of complete loss vegetative cover within the treatment area, lasting until beginning of next growing season. Vegetative cover regrowth over next four years at rate of 25 percent replacement per year. Permanent change in diversity of vegetative species as native species are replaced by invasives or out competed by pervasive natives.

- What physical, chemical, or biotic features of the area may be exposed: Riparian vegetation along Malibu Creek for 10 yards up and downstream of the Malibu Creek Bridge and 50 yards back from each streambank (500 sq. yds at each bridge corner). Local vegetation consists of primarily willow and young cottonwood trees, non-native shrubs, and ruderal grasses. All plants within the total 2,000 sq, yds of area treated. All forms of riparian vegetation, from seeds, rhizomes, saplings, and up to mature plants. Aquatic and terrestrial macroinvertebrates.

- What life stages or forms of a species will be directly or indirectly exposed: All life stages of steelhead exposed to indirect stressors of habitat loss and change. No individuals present during application of herbicides. Direct exposure during application of chemicals, indirect exposure resulting from changes in habitat types and bioaccumulation in local forage insects.

- How many individuals may be exposed: Unknown numbers of individual steelhead. Maximum adult population estimate for the creek is 20 adults. Past seine surveys have sampled up to 100 juveniles (range: 0-100 fish) within the 1,000 foot reach below the bridge during sampling events each June since 1995.

- Which populations of a listed species may be exposed: Malibu Creek population.

- What listed species (as listed or designated : DPS, ESU, Recovery Units) may be exposed: Southern Calfornia steelhead, an endangered species.

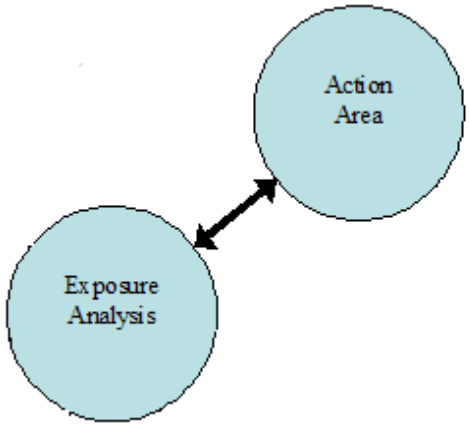
- What areas/constituent elements/functions of habitat or designated critical habitat may be directly or indirectly exposed: Critical habitat is not designated for this species.

In this last example we develop an exposure profile that indicates that only habitat elements (riparian vegetation) will be directly exposed to the proposed action. If we stopped our assessment at that point, we might determine that a listed species was not affected by the proposed action, since no critical habitat is designated for any listed species in this area. However, by following the initial response of the exposed elements (loss of vegetation due to treatment) we can see that the vegetation will be gone when our listed species is present. As a result, the listed species is indirectly exposed to the stressors of the treatment program.

These profiles should be developed and maintained within the administrative record for the consultation. Summaries of the exposure profile would appear in the actual biological opinion or consultation letter. Note that at this point, no judgments have been made as to how the exposed individuals will *respond* to these stressors, merely that the listed resources will be directly or indirectly exposed to the stressors. This is our first step in determining the risk the action poses to the species (may affect; not likely to adversely affect; likely to adversely affect; likely to jeopardize; etc.,) and the first step in determining the likelihood of incidental take.

Considerations

Determining the resources that co-occur with a particular effect is not as simple as looking at the topo map overlay of the action area and listed/designated resource boundaries. Consider the action from all perspectives (birds-eye/topo view, cross-section, downstream, downslope, upstream, upslope, the species' limit of visual, aural, or chemical detection – which in many cases is far greater than human capabilities). Note that some of these variables may expand your action area (see figure below). Add the temporal fourth dimension to include seasonal migrations, boom and bust abundance cycles, re/establishing populations, seed banks, dormant species, etc.



Remember to assess the evidence we have available to support these determinations for those cases where there have been no surveys or surveys failed to or cannot detect presence recently/historically/etc., (cryptic species, no protocol developed, protocols too destructive). This includes making reasoned inferences based on the species, similar species, the area or similar areas, and past experience. Construct your reasoned argument supporting the presence and therefore exposure of the species to the stressors of the proposed action and interrelated and interdependent activities. Don't forget to ensure that the administrative record supporting your consultation and resulting opinion or letter contains a clear discussion of this analysis!

Determine the life stages or forms exposed based on the spatial and temporal impacts of the action, the expected changes to the environment that individuals might respond to (changes in instream cover that juveniles not present during instream work would be exposed to, for example) and, if available, past information on the individuals or habitat elements exposed to an action.

Programmatic Exposure

Exposure analyses change depending on the nature of the action, particularly for consultations on programs or other actions where future activities are unknown. This analysis will tend to be more general in nature and limited to species-as-listed or population level depending on the size of the action area (entire continental US v. Humboldt County in northern California v. the world's oceans). We often cannot narrow the exposure analysis down to individuals or life stages exposed because the nature, timing, or location of future actions is uncertain. As a result, further analysis to establish species "actual" presence in an area and therefore its exposure to the action's stressors is often deferred until future project-specific information becomes available. Once this project-specific exposure is established, analysis of the likely responses of the exposed individuals and the ultimate risk to the species from the action can be completed.