Chapter 6
Classification Criteria for Disturbance Events

An event is a simple process
with a well-recognized beginning and end
(Gotelli and Ellison 2004)

Disturbance events can be classified according to different criteria. Among them are the origin, the type of agent which triggers the event, the regime and impact modalities, the relative collocation and type of relationship with the environmental components, and the vagility of the latter.

Criteria Based on the Origin and Agent Type

A first classification can be made with respect to the origin and type of the event-triggering agent. According to this, disturbances can be distinguished into *natural* disturbances, when they are not, even indirectly, induced by human activities and *anthropogenic* (or *human-induced* disturbances) when they are either directly or indirectly caused by human action. Human intervention can potentiate or limit some natural effects, sometimes with indirect and complex modalities: in this respect there may be found many intermediate situations of uncertain attribution. For example, a flood caused by extremely severe weather conditions (natural disturbance) can show much higher duration, frequency, extent, and intensity when it occurs in an area subjected to deforestation (anthropogenic disturbance). Other examples can be drawn considering the meteorological events which, in an age of global warming, can be indirectly induced by human action. Therefore, if disturbances are classified according to such distinctions, an evaluation of the degree of human manipulation along a continuum scale or by categories can also be considered (e.g., by distinguishing the degree of natural event manipulation being it low, intermediate or high, Dornelas et al. 2011).

Maintaining focus on the causal nature of the perturbation event, disturbances (both natural and anthropogenic) can also be distinguished as biotic, if mainly

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caused by organisms, and abiotic if originated by physical, chemical, or climatic events (e.g., in the case of terrestrial, atmospheric, geological, geomorphological, and hydrological disturbances; White and Pickett 1985; Mackay and Currie 2001). Other authors (such as Davis and Moritz 2001; Dornelas et al. 2011) have preferred to make a distinction among mechanical, physicochemical, and biologic disturbances. Each class of mechanisms shows typical and distinctive characteristics with respect to their functioning and to the impacts exerted on different types of organisms.

Specifically, mechanical disturbances are often nonselective and their impact may depend on the organism's capacity to resist and by their collocation, size, and density. Generally in a site, mechanical disturbances cause biomass and resource withdrawal, increasing the patchiness of the affected area (Levin 1992).

In contrast to disturbances induced by mechanical agents, physicochemical disturbances may cause in situ biomass depletion through the action of physiological stress acting on single individuals or propagules (e.g., impact on cells, tissues, and organs). Such stress can interfere with organismic metabolism and growth, leading to variations in weight and physiological state. The impacts exerted by physicochemical disturbances are specific, and vary among different organisms. They depend on the tolerance (or sensitivity) of the species to which the organisms belong and, within the same species, on individual age, sex, and fitness (physiological state). In such a way, these type of events can operate a strong intra- and interspecific selection within communities.

On the contrary, the category of biological disturbances includes all those events operating through the action of consumer organisms (e.g., herbivores and predators), parasites and pathogens which remove biomass amounts, often in a selective way, at the scale of the individuals (they include the competitive interactions, those between predator and prey, host and parasite, and herbivore and pertaining plant species). Contrary to what happens with mechanical and physicochemical disturbances, in the case of biological disturbances biomass can be concentrated, converted, and redeposited often in different sites from the occurrence of the event.

Disturbance categories are not always so clearly recognizable. For example, some biological agents can also act as physicochemical and mechanical ones. They can actively modify the environmental mosaic and affect the distribution of vegetation and nutrients, alter water movements, and, more generally, the dynamism of the disturbed patches (e.g., through trampling, digging, and fecal deposition).

All those perturbations which are either directly or indirectly produced by human intervention constitute a peculiar class of biological disturbances. Human species have manipulated and altered natural ecosystems for many thousands of years causing different impacts on ecosystem structures and functions as well as on density and distribution of the individual populations, species, and communities. As mentioned, all human activities can in some way interfere with natural disturbances (as in the case of fires, floods, and other weather events and of the activities of many animal species) by deliberately or unintentionally altering, interrupting, or catalyzing them. The disappearance, conversion, fragmentation, isolation, and deterioration of natural ecosystems, the physicochemical and biological alteration of inland and marine waters and soil, the exploitation of biotic and abiotic resources constitute the extensive human-induced disturbance categories (*threats*) which intrude into natural processes and lead to a spatial-temporal alteration of their original regimes. The interrelationship between natural and anthropogenic processes may generate different feedbacks with various degree of predictability, thus hampering the recognition of their origin and complicating the analysis and definition of mitigation, control, and management strategies.

Criteria Based on Regime and on Impact Modalities

Disturbances can also be classified according to their regime characteristics. For example, the frequency of occurrence of given events and their extension can also become, respectively, temporal and spatial criteria for classifying disturbances. As far as frequency is concerned, disturbances can be classified into *chronic* (when they repeatedly occur over long periods of time with varying intensity and affecting sensitive targets; also compare *press* disturbances as in Gotelli and Ellison 2004), *acute* (when they occur for brief periods at high intensity, as in the case of *pulse* disturbances, Gotelli and Ellison 2004), *periodic* (when they occur periodically with varying frequency), or *episodic/occasional* (when they rarely occur and, either show a low degree of predictability, or are completely unpredictable; Martorell and Peters 2009). In all cases, the frequency and intensity of occurrence, and so the category to which the disturbances belong, according to the above-mentioned criterion, can be calculated both in an absolute way and in relation to the sensitivity of the environmental components which are affected by the event.

With respect to impact modalities, a distinction can be made between *species-specific* (or *target-specific*) disturbances: i.e. disturbances which specifically act on a single environmental component (a single population, plant community or ecosystem type) and *random* or *non-selective* disturbances (not species-specific) whose action on various environmental components within a definite spatial context is randomly and non-specifically put into effect (Mackay and Currie 2001).

In analogy with this classification, perturbations can be subdivided into *selective* and *catastrophic* events. Selective events, for example, cause selective individual and species mortality within target communities, increasing diversity or maintaining it at a high level. Catastrophic events produce catastrophic non-selective mortality leading to an overall severe imbalance in the systems (Mackay and Currie 2001). Certain kinds of catastrophic disturbances not only can alter animal and/or plant biomass in a site, but also affect the physical substrate and the abiotic components of the ecosystems (Blumstein et al. 2005; Mackay and Currie 2001). With respect to these kind of events, some authors (see Sousa 1984 for further references) have made a distinction between *disaster* and *catastrophe*, the first being considered as a perturbation of medium-high intensity which recur fairly often in a site, while the second is an event characterized by extension, frequency, and modality of exceptional level with respect to the spatial and temporal scale of sites and targets. Disasters can occur once or twice within the life cycle of one or more sensitive species and yield short/long-term consequences (also selecting resistant genotypes in the following generations and thus playing an evolutionary role). On the contrary, catastrophes show a very infrequent recurrence and so biological organisms may not evolve adaptive mechanisms. In this case, the evolutionary consequences, which are relevant for the physiological state (fitness) of the individual organisms in successive generations, can be limited. However, at least in certain conditions, such events may have medium- and long-term genetic and evolutionary consequences. For example, populations which have experienced a marked reduction in number following a catastrophic event may undergo a demographic bottle-neck effect with consequences on their genetic characterizations in the subsequent generations.

Among the disturbance characteristics, the extent, in relation to the target or to the reference site, allows us to subdivide disturbance events into at least two main categories: large-scale disturbances and small-scale disturbances. While the former can act on wide-ranging areas (e.g., on landscape and regional scales), the latter act only on the scale of the single environmental units (populations, plant associations, and/or patches). Clearly, there exists a series of intermediate conditions which do not belong to such extreme categories.

Criteria Based on the Relation Between Disturbance and Environmental Components

A distinction made on the relative collocation of disturbances with respect to the affected environmental component or system also allows further grouping of the perturbation events into either *endogenous*, when they are internal to the system, or *exogenous* if they are external (Davis and Moritz 2001; Mackay and Currie 2001; Blumstein et al. 2005; for the species level see Fig. 6.1). In endogenous disturbances, the probability of occurrence depends on the status of the system and on factors which are intrinsic to it. On the contrary, in exogenous disturbances, the probability depends only on factors and processes associated with the external environmental context.

Disturbances can also be defined on the basis of the indirect or direct relation with the environmental component on which they exert their pressure. *Direct* events are able to affect directly an attribute of a particular system or environmental component (e.g., the individual survival rate or the sex ratio of a certain target population; the predator species richness or a community's macro-benthic biomass; the salt concentration in a given water volume of a marsh ecosystem).

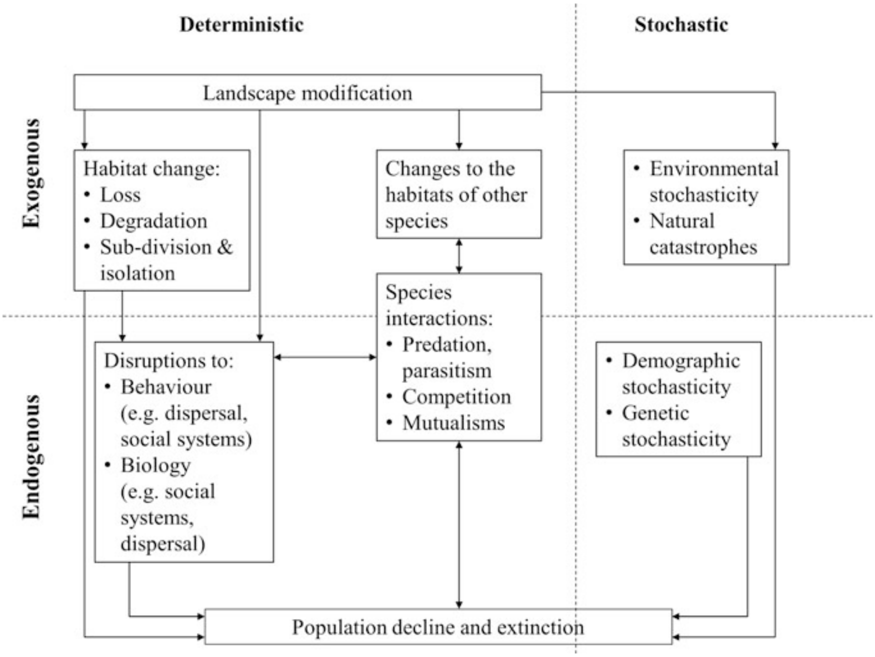

Fig. 6.1 This diagram has been extracted from a research paper about human-induced effects of landscape modification (fragmentation) on biological species (Lindenmayer and Fischer 2006). It highlights a distinction between deterministic versus stochastic events with respect to their being either exogenous (external to the reference system) or endogenous (internal)

Indirect events affect ecological system in an indirect way: in such cases disturbances may alter resource availability (or modify certain parameters and environmental conditions) and subsequently influence organisms and propagules (Brawn et al. 2001). For example, a river flooding can carry a huge amount of sediments. Such materials inundating the river bottom and the surrounding/adjacent areas may subtract resources to higher trophic level consumers (e.g., fish and birds), thus inducing a local demographic decline of their populations. Therefore, the flooding event represents an indirect disturbance which, reducing resource availability (and thus environmental suitability) for local bird and fish species, decreases their diversity.

Criteria Based on Target Vagility

In certain conditions and for certain types of events it can be useful to identify disturbances *on the basis of the vagility degree* or the *dispersion ability of the target components* undergoing the events.

Further classification criteria can be devised considering the dynamic state of the target component which has been affected by the impact (e.g., events on primary and secondary successions), the types of alterations induced by disturbances on ecosystem processes and services, the degree of predictability (*stochastic* or *deterministic* disturbances), and their ability to propagate (Davis and Moritz 2001).

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