

# Assessing and Managing Biological Risks of Plants Used for Bioremediation, Including Risks of Transgene Flow

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The plants used for phytoremediation pose special biological risks, whether transgenic or not, as most of the species: (a) are semi-domesticated; (b) are introduced from other habitats; (c) can become established in the contaminated site; (d) can spread and displace native species, and/or; (e) may introgress transgenes into related species. The addition of transgenes can reduce the risks, *e.g.* to sterilize or render the species and hybrid offspring hypersensitive to environmental effects (heat, cold), or to a chemical that will cull the species. Various measures can contain transgenes used in phytoremediation species to prevent gene flow, but most containment technologies are both uni-directional (prevent either outflow or influx), and are inherently leaky, even a concept specifically utilizable for phytoremediation – grafting non-transgenic scions on bioremediating transgenic rootstocks. Containment mechanisms should be either stacked with each other or with “mitigator” genes. Transgenic mitigation (TM) has mitigator genes added in tandem to the desired primary transgene (genetically linked) and the mitigator genes confer traits that are positive or neutral to the desired species but are deleterious to hybrids, keeping them at very low frequencies. The concept was demonstrated in tobacco and oilseed rape with a dwarfing mitigator gene that enhanced the reproductive productivity (harvest index) when cultured alone, but eliminated it from mixed populations. Besides the mitigator genes previously proposed for crop species (sterility, no seed shattering, dwarfing, no secondary dormancy) there are genes especially appropriate for phytoremediation, *e.g.* overexpression of cytokinin oxidase (reduces cytokinin levels) conferring reduced shoot systems (unfitness to compete) with a more extensive root system that is better for extracting toxic wastes as well as no-flowering for vegetatively propagated species. Thus, biotechnology can be harnessed to reduce risks from both non-transgenic and transgenic phytoremediation species.

*Key words:* Risk Assessment, Gene Containment, Mitigating Gene Flow