In an underlay cognitive radio network (CRN), in order to guarantee that all primary users (PUs) achieve their target-signal-to-interference-plus-noise ratios (target-SINRs), the interference caused by all secondary users (SUs) to the primary receiving-points should be controlled. To do so, the feasible cognitive interference region (FCIR), i.e., the region for allowable values of interference at all of the primary receiving-points, which guarantee the protection of the PUs, needs to be formally characterized. In the state-of-the-art interference management schemes for underlay CRNs, it is considered that all PUs are protected if the cognitive interference for each primary receiving-point is lower than a maximum threshold, the so called interference temperature limit (ITL) for the corresponding receiving-point. This is assumed to be fixed and independent of ITL values for other primary receiving-points, which corresponds to a box-like FCIR. In this paper, we characterize the FCIR for uplink transmissions in cellular CRNs and for direct transmissions in ad-hoc CRNs. We show that the FCIR is in fact a polyhedron (i.e., the maximum feasible cognitive interference threshold for each primary receiving-point is not a constant, and it depends on that for the other primary receiving-points). Therefore, in practical interference management algorithms, it is not proper to consider a constant and independent ITL value for each of the primary receiving-points. This finding would significantly affect the design of practical interference management schemes for CRNs. To demonstrate this, based on the characterized FCIR, we propose two power control algorithms to find the maximum number of admitted SUs and the maximum aggregate throughput of the SUs in infeasible and feasible CRNs, respectively. For two distinct objectives, our proposed interference management schemes outperform the existing ones. The numerical results also demonstrate how the assumption of fixed ITL values leads to poor performance measures in CRNs.