A feasibility study is presented on the effectiveness of applying nonlinear multigrid methods for efficient reservoir simulation of subsurface flow in porous media. A conventional strategy modeled after global linearization by means of Newton's method is compared with an alternative strategy modeled after local linearization, leading to a nonlinear multigrid method in the form of the full-approximation scheme (FAS). It is demonstrated through numerical experiments that, without loss of robustness, the FAS method can outperform the conventional techniques in terms of algorithmic and numerical efficiency for a black-oil model. Furthermore, the use of the FAS method enables a significant reduction in memory usage compared with conventional techniques, which suggests new possibilities for improved large-scale reservoir simulation and numerical efficiency. Last, nonlinear multilevel preconditioning in the form of a hybrid-FAS/Newton strategy is demonstrated to increase robustness and efficiency.